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# Evaluating efficacy of environmental education programming

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**Abstract**
The Clark Fork Watershed Education Program (CFWEP) goals are: (a) increasing students' understanding of the nature of ecological impacts within their watershed as related to historic mining damage; and (b) increasing students' sense of stewardship of newly restored landscapes. Data from 2012 to 2016 were evaluated for student knowledge gains (46 trials representing 2,395 student pre-surveys; 2,409 student post-surveys). Data from 2013 to 2016 were evaluated for students' attitudes toward science and disposition toward caring for the environment (38 trials representing 1,479 pre-surveys; 1,460 post-surveys). The results of this study support that the program's goals are being achieved. Students achieved statistically significant gains on knowledge surveys with a 33.4% overall gain pre- to posttest ($p < 0.0001$). Students also moved toward greater positive responses in both attitudes toward science and disposition toward caring for the environment with Cohen's $d$ effect sizes of "medium effect" for caring toward the environment ($d = 0.52$) and "small effect" of positive disposition toward science ($d = 0.24$).

**KEYWORDS**
environmental education, place-based education

## 1 | INTRODUCTION

In 1983, the Clark Fork Watershed was designated a Superfund site under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Shortly thereafter, the State of Montana filed a lawsuit against the Atlantic Richfield Company (ARCO) for recovery of damages to the watershed. The series of settlements from this suit marked the beginning of the era of Superfund in the Clark Fork Watershed, which has resulted in major changes in the landscape and ecosystems of the Clark Fork River and its headwater tributary, Silver Bow Creek (Connole, 2016). The Clark Fork Watershed Education Program (CFWEP) was founded in 2005 shortly after restoration work along Silver Bow Creek began. The program was founded to help students and local citizens better understand the nature of this watershed's Superfund status, and to create a legacy of environmental stewards who would ensure that the clean-up was successful in the short-term, and sustained for the long-term. Additionally, helping local citizens understand the nature of their Superfund status and engage in meaningful dialogue with the agencies and the potentially responsible parties was recognized as a need by CFWEP funders.

## 2 | LITERATURE REVIEW

Need for environmental education is of particular importance in the communities of the Clark Fork Watershed considering the high likelihood that people suffer from solastalgia due to devastating losses both in their economic futures and from the impacts to the local environment. Solastalgia is "the pain or sickness caused by the loss or lack of solace and the sense of isolation connected to the present state of one's home or territory" (Albrecht, 2005, p. 48). The problems associated with solastalgia are exacerbated by a sense of powerlessness or lack of control (Albrecht, 2005; Albrecht et al., 2007). Some of the negative effects can include drug abuse, physical illness, and mental illness (depression, suicide) (Albrecht, 2005). The negation of symptoms can occur by the direct involvement of people in fixing the problems with their "home" (Albrecht, 2005; Albrecht et al., 2007). By offering opportunities for students and citizens to become involved in the restoration process within the watershed, it is possible that the symptoms of solastalgia are addressed and may be evident in the attitudinal responses from students.

Although the program is unique in its setting within a Superfund site and resulting damaged ecosystem, it is, unfortunately, not unique in that many communities are faced with increasingly complex environmental issues. For example, as the negative effects of global climate change mount and impact more communities, there will be increased political and social pressure to find balanced approaches for energy production, mineral extraction, and development of land resources (Hollweg et al., 2011). Our communities need to ensure a sustainable ecosystem alongside a sustainable economy to support future generations (Howarth, 2012).

The theory of sustainable development (SD) states that human development goals must be able to sustain the ability of natural systems to provide the resources and ecosystem services upon which the economy and society depend (Christen & Schmidt, 2012; Hecht & Fiksel, 2015; World Commission on Environment and Development [WCED], 1987). In particular, as per the United Nations General Assembly (UN) SD summit in 2015, the most important factors associated with SD includes the interaction between human systems and natural systems; the dependency of humans on functioning natural systems (ecosystems); and the ability to expand human development without destroying the means (natural resources) needed to create that expansion and without compromising the ability of future generations to meet their needs. Seen as interdependent dimensions, SD currently focuses on interactions between economic development, social development and environmental protection for future generations (UN, 2015).

How can communities be helped with their environmental challenges and ensure a sustainable environment for the future? Environmental education is widely viewed as a means of achieving the goal of creating a scientifically and environmentally literate citizenry, and for addressing and teaching about SD. Unfortunately, evidence that supports that these outcomes occur is limited (Hollweg et al., 2011; Stern, Powell, & Hill, 2014). Environmental education providers need to develop systematic methods for assessing outcomes in order to ensure that efforts are reaching the intended goals for environmental literacy (Hollweg et al., 2011; Stern, Powell, & Hill, 2014).

Since youth in the Clark Fork Watershed are inheriting a future with extensive environmental issues, including the effects of climate change, damaged ecosystems, Superfund and other toxic waste sites, it is critical for them to get continued and systematic environmental education. Their attitudes about the environment matter, as they will be the future stewards of the watershed. Wray-Lake, Flanagan, & Osgood, (2010) emphasize transgenerational considerations, stating:

> We *must* care about young people's environmental attitudes, beliefs, and behaviors, as they are likely to be carried into adulthood, communicated to offspring, and expressed in leadership decisions as younger generations replace their elders as society's leaders. (p. 83)

The National Environmental Education Advisory Council (NEEAC, 1996) states that environmental education is concerned with knowledge, values, attitudes, and application. They define environmental education as a "learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address these challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action" (NEEAC, 1996, p. i).

Similarly, the U.S. government acknowledges that public awareness and knowledge about environmental problems can be increased through environmental education techniques ( United States Environmental Protection Agency [USEPA], 2018). Specifically, environmental education can provide the tools necessary for citizens to make informed decision and take action. They also recognize environmental education as a process that provides individuals with opportunities to explore issues, engage in solving those issues, and to take action on the issues (USEPA, 2018).

CFWEP has been collecting student outcome data on the effectiveness of its programming since 2008. This outcome data includes a brief survey of students' attitudes toward environmental stewardship and science, as well as a knowledge survey. Initially, the purpose of the knowledge questions and the attitudinal survey was to determine if the program's goals were attained, and were aimed at answering two fundamental questions: (a) Do students comprehend the nature of the contamination and issues within the watershed?; and (b) Do students develop a positive attitude toward caring for their local environment? As the program matured, key components were added to the education efforts in order to best reach the goals of developing student understanding of the nature of the issues within the watershed and developing positive stewardship toward the environment.

The key components of CFWEP programming rest in constructivist theory, a common approach in environmental education practices (Stern, Powell, & Hill, 2014). The constructivists, Jerome Bruner, John Dewey, Jean Piaget, and Lev Vygotsky, contend that learning is an active, experiential process that when facilitated well allows students to construct or create new knowledge from their experiences. CFWEP's program model has expanded constructivism to: (a) include place-based education practices; (b) provide direct connections with scientists both in the classroom and on fieldtrips; (c) engage students in an inquiry approach; (d) require student collection of and review of data; (e) discuss concrete actions that can be taken; and (f) provide direct experiences in the local environment. These programming pieces align to the North American Association for Environmental Education Excellence in Environmental Education Framework ( National Association for Environmental Education [NAAEE], 2004).

## 2.1 | Place-based education

According to Sobel (2013), place-based education involves utilizing all aspects of a particular place or environment as the foundation for learning. This foundation includes history, culture, the built environment, and the natural environment, and should connect directly to the students' experience of their place. Sobel (2013) identified that when students feel a sense of ownership in a particular place, they also tend to see themselves as persons who can contribute to their communities in a meaningful way. Furthermore, the National Research Council (NRC) has recommended that students be engaged in relevant and meaningful projects that relate to their environment and society (NRC, 2012). The NRC contends that students are more likely to engage in science content when it is personally relevant (NRC, 2012). Place-based education approaches can ensure personally relevant content due to the connection to local environments.

One can effectively argue that understanding one's own place is a critical component for developing pro-environmental behaviors (PEB). Clark, Kotchen, and Moore (2003) conducted research on internal and external influences on pro-environmental behaviors (PEBs). Their approach was innovative because it combined research approaches used in psychology (internal motivations) and in economics (external motivations). According to their findings, local concerns about benefits ranked higher than global concerns related to climate change; "greater importance attached to a local environmental issue, as opposed to a global issue, suggests that PEB may be more likely when associated with local, rather than global, environmental concerns" (Clark et al., 2003, p. 245).

## 2.2 | Increases in scientific knowledge

Often cited is Liberman and Hoody's (1998) empirical, large scale study that linked increases in student achievement on standardized tests for science to environmental education approaches. More recent studies include meta-analyses that allow us to look deeper into translation of skill sets from environmental approaches to mainstream science. For example, Athman and Monroe (2004) found that place-based approaches improve overall science literacy and critical thinking skills. Stern et al. (2014) completed another meta-analysis of the environmental education literature from 1999 to 2010. This study aimed to discover what works in environmental education programming. They found that assessment within the field includes looking at knowledge, awareness, skills, attitudes, intentions, behavior, and enjoyment (Stern et al., 2014).

Individual environmental education programs develop custom knowledge assessments and disposition surveys related to the particular program goals and objectives, which are then reported as outcomes for the program (Stern et al., 2014). Although there is a large body of research related to individual programs, very few researchers have designed large-scale studies that directly examine if place-based or environmental education programming is more effective for overall achievement (Coertjens, Pauw, & De Maeyer, 2010; Duvall & Zint, 2007; Liberman & Hoody, 1998; Semken & Freeman, 2008; Sobel, 2013; Stern et al., 2014; West, 2015).

According to Ardoin, Bowers, Roth, and Holthuis (2018), many existing environmental education programs have positive outcomes in terms of environmental knowledge, attitudes, dispositions, and skills, as well as outcomes not directly focused on the environment, for example, academic achievement and civic engagement. More research is needed that focuses on behavior and dispositions, as well as research that is designed for longitudinal study (Ardoin et al., 2018). Environmental education is about "relationships, processes, and providing opportunities for transformative experiences" (Ardoin et al., 2018, p. 14); therefore, research in environmental education needs to have a broader perspective on what is measured, including action-taking following educational intervention.

## 2.3 | Attitudes toward science and stewardship

In a Flemish case study that utilized the Programme for International Student Assessment (PISA) scores to examine the relationship between school type and the environmental awareness of students, school type had a positive correlation to environmental attitudes when the research controlled for student characteristics and background (Coertjens et al., 2010). The school that was associated with the positive correlation utilized a cross-curricular approach to science, which involved more natural sciences and encouraged environmental education topics in the curricula (Coertjens et al., 2010). Athman and Monroe (2004) concluded that student motivation toward science can be significantly increased through place-based approaches, specifically when those approaches incorporate relevant curricula. Students involved in the study who were engaged in projects that they deemed purposeful or relevant to their community demonstrated positive attitudes toward science and developed critical thinking skills in general (Athman & Monroe, 2004).

## 3 | RESEARCH QUESTIONS

The focus of this research was to analyze the data collected by CFWEP from 2012 to 2016. Since the original purpose of the evaluation was formative, the partners turned their focus to examining the existing data set to determine if the objectives of increasing knowledge and increasing stewardship attitudes were met. A second goal was to examine the data for trends in order to position the research team for future research questions.

> **Research Question 1:** Is there a measurable difference between students' attitudinal responses toward the environment pre- and post-survey?
> **Research Question 2:** To what extent do students' attitudes toward science change pre- and post-survey?
> **Research Question 3:** Is there a measurable difference in students' knowledge gains pre- and post-survey?

## 4 | MATERIALS AND METHODS

This study analyzed the data collected from fall semester 2012 through spring semester 2016, and includes 46 trials, representing 2,386 student pre-surveys and 2,365 student post-surveys for the knowledge questions. The 46 trials represent the 46 classes of students who took the pre- and post-surveys. Each class is considered one sample. For the attitudinal items, data collected from fall semester 2013 through spring semester 2016 were examined and includes 38 trials and represents 1,479 pre-surveys and 1,460 post-surveys. Again, the 38 trials represent 38 class of students who took the pre- and post-surveys.

### 4.1 | Participants

The CFWEP Restoration Education Program (REP) takes place within classrooms located within the 120-mile Upper Clark Fork Watershed corridor, and includes nine schools within the Upper Clark Fork. Students from grades 5, 7, and 10 are included, as determined by the participating school districts. For the REP programming, there are no classrooms that are multi-grade level. Each school that participates in REP receives five days of service; four days in the classroom and one day in the field. The four days of classroom visits include activities related to understanding the history and the science of the watershed. Depending upon location, the fieldtrip includes a trip to a local creek (Silver Bow Creek) or local river (Clark Fork River) in order to conduct assessment of water quality, identification and assessment of aquatic macroinvertebrates and riparian habitat health. The students are also provided a landscape/history tour of damaged areas. The majority of teachers who participate with CFWEP programming have been given extensive professional development and are encouraged to utilize the CFWEP model and materials beyond the five-day program.

### 4.2 | Procedures

CFWEP utilizes a Scantron answer sheet to record and score both the attitudinal and knowledge items of the survey (see Appendix A). Scantrons were scored using the Apperson Grademaster 600 scanner. Teachers are asked to give the pre-survey at least 1 week prior to CFWEP's visit and administer the post-survey within one week following the visit. Students are not asked to complete homework exercises or otherwise study for the test. Students' scores are not matched for pre- and post-survey; rather, all scores are grouped by classroom and school. CFWEP staff do not require teachers to pre-teach content before the visits, however, there is variance between school districts. For example, some teachers have been with the program since its inception and include longer units and follow-up than teachers who recently joined the program. For this study, teacher effects are not examined and all scores are aggregated for each class.

### 4.3 | Measures

The measurement tools utilized for this study were developed by former and current education coordinators for CFWEP and have been reviewed by professional evaluators at Education Northwest. The surveys have been administered to students pre- and post-visit since 2008, with some revisions being made to the survey in 2012 following a major revision of the CFWEP curriculum. Although validity and reliability testing have not been completed for these measures, the tools have been utilized by the program for the past 10 years, yielding similar results. For the purposes of this study, data from 2012 to 2016 were analyzed for the knowledge gains (46 trials, representing $n = 2,395$ pre-surveys; $n = 2,409$ post-surveys), and data from 2013 to 2016 were analyzed for the attitudinal responses (38 trials $n = 1,479$ pre-surveys; $n = 1,460$ post-surveys). As mentioned, the survey data are not matched to individual respondents, but are matched by school, teacher and year.

The survey utilized in this current study consists of 18 items. Eight of those items are attitudinal survey questions—four about stewardship and four about the science process. These survey items were scored on a Likert rating of 1–5, with *1* representing strongly disagree, and *5* representing strongly agree. Analysis of the attitudinal items was completed by calculating Cohen's *d* effect sizes (Cohen, 1988). Each item was analyzed individually for changes toward positive attitude and graphed to illustrate shifts in attitude from pre- to post-survey.

The remaining ten items on the survey are questions of knowledge presented in the curriculum (riparian health, biodiversity, biological indicators, specific problems with contamination, history of the watershed, and geography). The score for these 10 items range from 0 (no answer correct) to 10 (all answers correct). The test for outliers revealed that pre-tests scores of *9* and *10* and post-tests scores of *0* and *1* should be eliminated, resulting in the elimination of 1.5% of student scores (43 pre-survey and 30 post-survey scores were eliminated). Analysis of the knowledge items was completed by calculating a matched-pair *t* test. All descriptive and statistical analyses were completed using Microsoft Excel 2016.

## 5 | RESULTS

Overall, attitudinal data (Table 1) reflected positive gains toward stewardship and science processes. Students generally report positive or neutral disposition on all eight items on the pre-survey, with movement toward greater positive disposition, for example, moving from neutral to agree or strongly agree, on the post-survey. On the pre-survey, students do not highly report disagreement with any of the attitudinal items, but do demonstrate greater affinity for the neutral score pre-survey as compared to post-survey (Figures 2 and 3).

Questions 2, 5, 7, and 8 reflect attitudes toward science or scientific practices. Questions 1, 3, 4, and 6 reflect attitudes toward stewardship and care for the environment. When the percent gain for questions related by topic are collapsed to examine overall change related to science or the environment, students report on pre-survey science questions 63% agreement, 29% neutral, and 8% disagreement, and move on post-survey to 73%, 22%, and 6%, respectively. For ease of graphic interpretation, strongly agree and agree are grouped to reflect agreement and strongly disagree and

**TABLE 1** *Results of the attitude portion of the survey (pre n = 1,479; post n = 1,460) for study years 2013–2016.* Shown are the percent of respondents that selected specific levels of agreement or disagreement to environmental and scientific statements pre-treatment and post-treatment

| Item # | | Strongly Agree (5) | Agree (4) | Neutral (3) | Disagree (2) | Strongly Disagree (1) |
|---|---|---|---|---|---|---|
| Environmental Attitudes Pre- and Post-Survey 2013–2016 | | | | | | |
| #1: I care about the health of rivers and streams in Montana | Pre | 56.0 | 35.0 | 8.1 | 0.5 | 0.4 |
| | Post | 69.5 | 25.4 | 4.7 | 0.3 | 0.1 |
| #3: I am aware of ongoing restoration projects in the Clark Fork Watershed | Pre | 15.8 | 28.6 | 29.7 | 17.8 | 8.0 |
| | Post | 47.0 | 37.0 | 12.3 | 3.0 | 0.7 |
| #4: I think that restoration of the Clark Fork watershed is good for the environment and for my community | Pre | 42.7 | 35.2 | 18.7 | 2.4 | 1.0 |
| | Post | 67.1 | 23.2 | 7.9 | 1.2 | 0.5 |
| #6: I understand that I have a responsibility to keep stormwater clean in order to protect our rivers and streams | Pre | 39.1 | 38.2 | 17.0 | 4.2 | 1.5 |
| | Post | 52.7 | 35.1 | 9.5 | 1.8 | 1.0 |
| Scientific Attitudes Pre- and Post-Survey 2013–2016 | | | | | | |
| #2: I want to learn more about watershed science and/or riparian habitats | Pre | 15.4 | 38.2 | 39.3 | 5.5 | 1.6 |
| | Post | 25.4 | 39.2 | 29.2 | 4.2 | 1.9 |
| #5: I enjoy learning from and working with scientists in the classroom and in the field | Pre | 36.4 | 34.5 | 22.4 | 4.7 | 2.0 |
| | Post | 45.0 | 33.9 | 16.8 | 2.9 | 1.4 |
| #7: I enjoy learning to use and working with different scientific tools and equipment | Pre | 46.3 | 31.0 | 18.5 | 3.1 | 1.1 |
| | Post | 51.8 | 29.8 | 15.1 | 2.3 | 1.0 |
| #8: I find it interesting to go over field data and to figure out what the data mean | Pre | 18.5 | 30.7 | 34.6 | 12.5 | 3.7 |
| | Post | 31.4 | 36.1 | 25.4 | 4.7 | 2.4 |

disagree are grouped to reflect disagreement. However, for calculation, each Likert response rating was tabulated to calculate pre- and post-mean, standard deviation and standard error. The Likert scale for this survey is 5 for strongly agree, 4 agree, 3 neutral, 2 disagree, and 1 strongly disagree. On the pre-survey, students were slightly below *agree* in this category (Mean = 3.81, $SD = 0.99$, and $SE = 0.01$). On the post-survey, students moved to agreement in this category (Mean = 4.04, $SD = 0.94$, $SE = 0.01$). The Cohen's $d$ effect size for this category is 0.24, which is considered a small positive effect (Figure 1).

In the category of environmental attitudes, students on pre-survey report 72% agreement, 18% neutral, and 9% disagreement. For post-survey, students report 89%, 9%, and 3%, respectively. On the pre-survey, students were in agreement for this category (Mean = 3.99, $SD = 1.03$, and $SE = 0.01$). On the post-survey, students moved closer to strongly agree in this category (Mean = 4.46, $SD = 0.76$, $SE = 0.01$). The Cohen's $d$ effect size for this category is 0.51, indicating a medium positive effect for this category (Figure 2).

The largest measurable effects of CFWEP programming are demonstrated in the knowledge survey. The data set included 46 trials (representing a total of 2,395 student pre-surveys and 2,409 post-surveys). The mean pre-survey score was 42.0% ($SD = 5.7$; $n = 46$) and the mean post-survey score was 75.4% ($SD = 7.5$; $n = 46$). One-tailed $t$ test for matched pairs revealed that the difference between the knowledge survey portion of the pre- and post-surveys are highly statistically significant ($t = -28.54$, $df = 45$; $p < 0.001$). The difference between pre- and post-survey scores, which averages an increase of 33.6, is consistent across years (Figure 3).

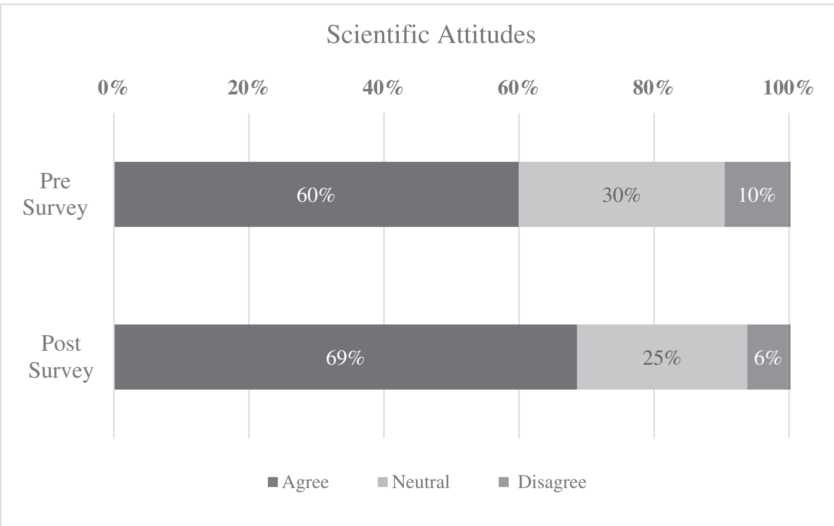


**FIGURE 1** Pre- and post-survey results for *Scientific Attitude Items* graphed by percent of respondents in each category. Displayed here are items 2, 5, 7, and 8 aggregated, and categories collapsed to *agree*, *disagree*, and *neutral* for 2013–2016 (pre-survey: mean = 3.81; $SD = 0.99$; *post-survey*: mean = 4.04; $SD = 0.94$; Cohen's $d$ effect size = 0.24)

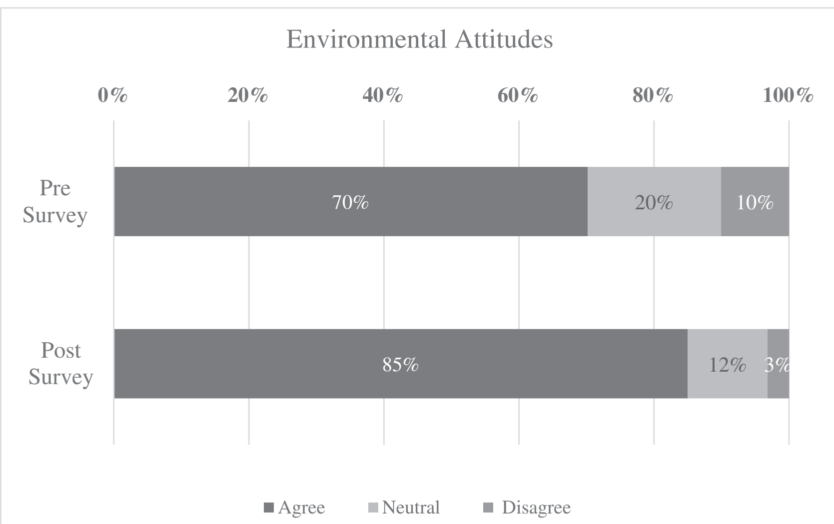


**FIGURE 2** Pre- and post-survey results for *Environmental Attitude Items* graphed by percent of respondents in each category. Displayed here are items 1, 3, 4, and 6 aggregated and categories collapsed to *agree*, *disagree*, and *neutral* for 2013–2016 (pre-survey: mean = 3.99; $SD = 1.03$; *post-survey*: mean = 4.46; $SD = 0.76$; Cohen's $d$ effect size = 0.51)

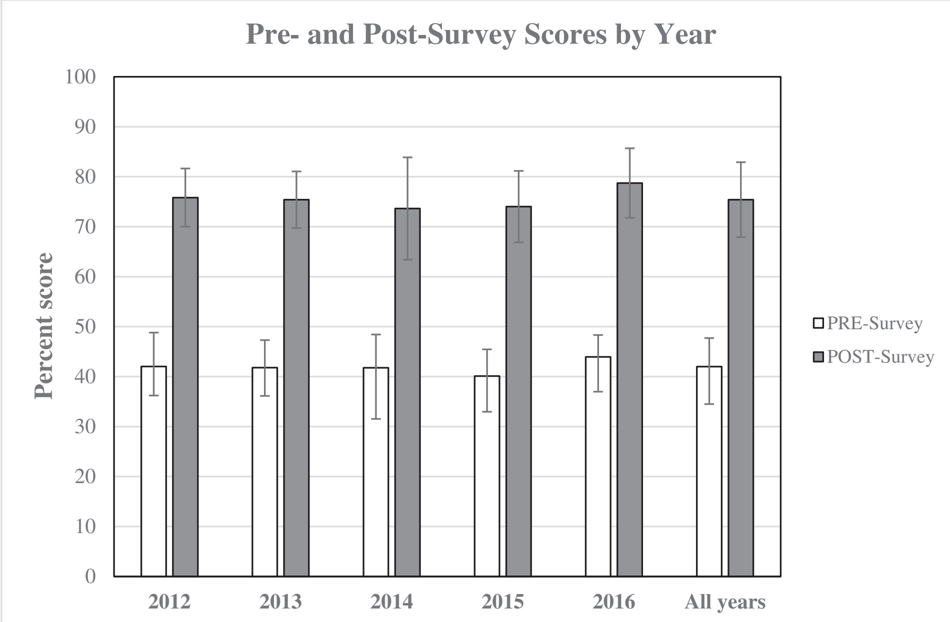


**FIGURE 3** Pre- and post-survey scores by year for knowledge items (questions #9 through #18) for 2012–2016. For all years combined, post-survey scores were statistically different from pre-survey scores (matched pairs $t$ test: $t = -28.54$; $df = 45$; $p < 0.001$)

## 6 | DISCUSSION

This study examined survey data collected from the CFWEP. Three questions guided the analysis:

> **Research Question 1:** Is there a measurable difference between students' attitudinal responses toward the environment pre- and post-survey?
> **Research Question 2:** To what extent do students' attitudes toward science change pre- and post-survey?
> **Research Question 3:** Is there a measurable difference in students' knowledge gains pre- and post-survey?

The differences pre- and post-survey are measurable with the gains from pre- to post- survey on each question. Positive attitude toward the environment are high on pre-survey, which is a possible indication that students wish to reflect an attitude that supports CFWEP facilitators. The gains from pre- to post-survey in this category are impressive in that 85% of students report positive attitude toward the environment and particularly their responsibility for maintaining a healthy environment. One confounding question in the environmental category is the question related to knowledge or understanding of the issues related to the Clark Fork Watershed. Students report low agreement on this question pre-survey, which is reasonable given their lack of experience with the issues. This question rates the lowest agreement on pre-survey and possibly skews the gains for the environmental attitudes category.

Scientific attitudes also demonstrate gains, however, the gains are smaller than in the environmental sciences category. Question 8, which addresses enjoyment for using data is the question that reflects the highest gain in this category. Students report 45% agreement on pre-survey as compared to 61% on post-survey, which is a gain of 16%. The REP programming includes a field trip during which students immerse in data collection and analysis. This change is likely reflective of the experiential aspect of the field trip. This finding is consistent with the findings of Athman and Monroe (2004) where students' demonstrated positive attitudes toward science following activities that were environmentally based and deemed relevant by the students. These findings are also consistent with self-efficacy studies completed by Lofgran, Smith, and Whiting (2015) that found that overall, seventh grade students demonstrate higher self-efficacy toward science than their ninth-grade counterparts.

Knowledge gains were impressive with an overall increase of 30% pre-survey to post-survey for the aggregate data, which was highly statistically significant. When the data are examined per school, the trends of pre- to post-survey hold true, with the exception of one school, Drummond High School. The instance of Drummond High School presents an interesting circumstance for study as students receive programming twice, once in 7th grade and again in 10th grade. The Drummond 10th-grade students consistently have higher pre-survey scores than the overall aggregate, which leads to the question of retention of knowledge and/or programmatic differences within this school. The Drummond science teacher engages his students in follow-up activities and data collection between 7th and 10th grade.

Deeper analysis of the 7th grade to 10th grade Drummond scores reveal that students are retaining knowledge from the 7th-grade visit in some areas.

### 6.1 | Limitations

The surveys are program developed and have not been tested for validity outside of the population of students being served. In addition, the attitudinal survey is very brief and may not include enough questions to identify students who are reporting positive responses in order to appease CFWEP facilitators and/or teachers. The knowledge surveys are given within 1 week of the intervention and are reflective of short-term gains for students. Validity and reliability testing is planned as part of future research.

### 6.2 | Future research

Ardoin et al. (2018) found that most environmental education research they reviewed showed a tendency to focus on knowledge and dispositions, rather than competencies and behaviors, and suggested that this can lead to "doom-and-gloom" conditions that might "overwhelm students without concurrently providing skills and opportunities to undertake meaningful action" (p. 11). The CFWEP goes beyond knowledge and dispositions by leading students on fieldtrips in which they collect data, and assist them in summarizing and evaluating the data in order to illustrate the science process. In addition, students are asked to write about what actions they can take to improve their places. The program partners facilitate this discussion and provide students with concrete ideas for actions. Further research for the programming should focus on the action-taking behaviors.

Second, a case-study design that examines the differences between Drummond 10th grade students and the aggregate data set may be beneficial to assess long-term changes in both disposition toward caring for the Clark Fork Watershed and knowledge retention. In addition, self-efficacy studies regarding science could be included as part of the Drummond case analysis. Do these students retain self-efficacy toward science or demonstrate decline? An analysis of the data grouped by question and teacher could prove beneficial for identifying trends and beginning to understand the teacher effects. For example, some teachers have been with the program since its inception while others have joined recently (2017). Are there noticeable differences between students of teachers who have had professional development related to the Clark Fork as compared to those who have not? A longer, follow-up survey possibly given the next school year to assess whether positive disposition toward the environment remains intact could help the program facilitators understand when and if there are dips in stewardship attitude.

Finally, a study on the existence of solastalgia in Clark Fork Watershed communities is warranted. While a causative study is unrealistic, a correlational one may provide interesting information. The first step would be to analyze health reports for Clark Fork Watershed communities before the clean-up started, and during the years since the clean-up started. If improvements in various health measures are found, it would warrant interviewing community members, young and old, to try to gain an understanding of how environmental improvements affect their attitudes toward their place.

## 7 | CONCLUSION

CFWEP programming has a positive impact for students' attitudes and disposition, as well as their understanding about the issues related to the Superfund status of the Clark Fork Watershed. Programming like CFWEP's requires a time commitment from teachers and school districts. The essential question for administrators and teachers is whether or not the programming is effective. In other words, do students benefit from the programming or is the programming ineffective in terms of knowledge gain? The results of this study indicate that not only is the programming effective in terms of knowledge gains about science topics, but also effective in helping students develop a positive attitude toward science overall. Because students are engaged in meaningful, relevant data collection related to something they already care about (the environment), they begin to display more positive disposition toward collecting and analyzing those data. The context of the environment and their local community is powerful for engagement and interest.

The National Resource Council's guide for science educators, *A K-12 Framework for Science Education*: *Practices, Crosscutting Concepts, and Core Ideas* specifically calls upon practitioners to ensure that students are engaged in meaningful learning that is relevant to their personal lives (NRC, 2012). Environmental education approaches that include place-based, integrated subject matter lend themselves naturally to meeting the goals of the K-12 Framework. The call to action for educators is to ensure that students are also gaining meaningful content within the experience. Understanding what our students gain from these experiences is critical. Additionally, global challenges to the environment are becoming increasingly more complex, and perhaps to a child, increasingly more overwhelming. Place-based approaches, such as the CFWEP model may help students not only develop a positive attitude toward the taking care of the environment, but may also help to create agency and positive attitude for creating solutions for our global challenges.

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**APPENDIX A**

**CFWEP Knowledge and Attitude Survey**

**Instructions:** For statements 1 to 8, choose the answer that best describes how you feel.

**Choices for your answer are:**

A **Strongly Agree**
B **Agree**
C **Neutral**
D **Disagree**
E **Strongly Disagree**

1. I care about the health of rivers and streams in Montana.
2. I am interested in learning about riparian habitats and other watershed topics.
3. I am aware of restoration projects in the Clark Fork watershed.
4. I think that restoration of the Clark Fork watershed is good for the environment and for my community.
5. I enjoy learning from and working with scientists in the classroom and in the field.
6. I have a responsibility to keep stormwater clean in order to protect our streams and rivers.
7. I enjoy learning to use and working with scientific tools and equipment.
8. I find it interesting to go over field data and to figure out what the data means.

**For questions 9 to 18,** the choices for your answer are **A**, **B**, **C**, or **D** (no E). Be sure to READ all the answers, and then pick the one you think is BEST.

9. **A watershed is ___________________.**
   A. a large storage shed that holds all the water from a certain area.
   B. a landform that sheds its water into a common network of streams and rivers.
   C. the land that borders streams, rivers, ponds, and lakes in an area.
   D. all the waters of the world including the waters that are stored in clouds.
10. **___________ drains into the Clark Fork River, which then drains into the _______ River, eventually draining into the _______ Ocean.**
    A. Silver Bow Creek;Columbia; Pacific
    B. Basin Creek; Mississippi; Atlantic
    C. Grasshopper Creek; Missouri; Atlantic
    D. Flint Creek; Colorado; Pacific
11. **What played a role in the Clark Fork watershed becoming a Superfund site?**
    A. The variety of fun things to do in the area like hiking, skiing and snowmobiling.
    B. The large amounts of money made from the copper mines.
    C. The community members asked for that title to increase tourism.
    D. Historic copper mining and smelting practices, and the great flood of 1908.
12. **When iron pyrite ("fool‘s gold") is exposed to air and water it usually causes _______.**
    A. mold and citric acid to form.
    B. heavy metals such as copper and gold to rise to the surface.
    C. rust and sulfuric acid to form.
    D. the pyrite to become very shiny and easy to find.
13. **What are tailings?**
    A. Toxic smoke that was released during the smelter step.
    B. Fine-grained waste from the milling and concentrating step.
    C. Large ore rocks that were left over from the mining step.
    D. The various heavy metals removed from ore during all steps.
14. **What are biological indicators?**
    A. Certain plants and animals that are sensitive to pollution or can tolerate pollution.
    B. Tests used to measure metals, ores, or tailings in a given area.
    C. Measurements related to plants or animals, such as height, weight, length or volume.
    D. Areas of land that are capable of supporting certain types of biological life.

15. **What are the functions of healthy riparian habitats?**
    A. Store toxic waste material that flows from high mountain areas.
    B. Provide acidic water to pollution tolerant plants and animals.
    C. Send water to the upland areas to support upland grasses and trees.
    D. Keep water clear and cool, reduce streambank erosion, and support biodiversity.
16. **Historic mine wastes and the 1908 flood resulted in _______________ throughout the Clark Fork Watershed.**
    A. an increase in the diversity of riparian plants, fish species and macroinvertebrate species
    B. the spread of contaminants, acidic (low pH) waters & soils, and decreases in biodiversity
    C. a decrease in the number of people living, building homes and starting businesses
    D. the federal and state governments keeping people out by building fences and walls

17. **Which of the following describes the most healthy riparian habitat for Western Montana?**

| | pH | Macros | Plant species | Ground cover | Water |
|---|---|---|---|---|---|
| A. | 7.0 | Medium diversity | Mix of pollution intolerant and tolerant | Some bare ground | Warm and clear |
| B. | 4.5 | Low diversity | Mostly pollution tolerant | Lots of bare ground | Warm and muddy |
| C. | 7.0 | High diversity | Mostly pollution intolerant | Little bare ground | Cold and clear |
| D. | 4.5 | Medium diversity | Mix of pollution intolerant and tolerant | Some bare ground | Cold and muddy |

18. **Which of the following is true about remediation and restoration?**
    A. Restoration is a higher level of environmental cleanup than remediation is.
    B. For restoration cleanup to work, toxic waste must first be removed.
    C. Remediated sites must be monitored forever; restored sites are self-sustaining.
    D. All of the above statements are true (A, B and C)