THESIS

THE CACHE LA POUDRE AQUABLITZ: EXPLORING WATERSHED ECOLOGY WITH ELEMENTARY AND MIDDLE SCHOOL STUDENTS

Submitted by

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ABSTRACT

THE CACHE LA POUDRE AQUABLITZ: EXPLORING WATERSHED ECOLOGY WITH ELEMENTARY AND MIDDLE SCHOOL STUDENTS

Evidence suggests that experiential environmental education is both effective and influential on student knowledge and attitudes. The Cache la Poudre AquaBlitz, was designed as a rapid-assessment of watershed health and as an educational experience for 4^{th}-6^{th} grade students combining current best practices in environmental education and citizen science with a local, place-based focus. This manuscript provides a summary of the project curricula and an assessment of knowledge acquisition by students. Data analysis suggests that the curricula were successfully written for the targeted grade levels and that student understanding of watershed ecology was increased.

ACKNOWLEDGEMENTS

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Introduction

In 1879 Geologist and explorer John Wesley Powell authored and submitted a prescient report that outlined a strategy for settlement and development of the arid western United States (Powell, 1879). He argued that an insufficient supply of water existed in the west to support agriculture and settlement at levels common in the eastern United States. He stressed efficient utilization and conservation of water by organizing settlements and state boundaries based upon natural catchments, by watersheds.

It can still be argued that the watershed is the basic landscape unit and an important geographic concept poorly understood by many (Elfin & Shaeffer, 2006). In particular, elementary through high school age students have been shown to have only a basic understanding of this concept (Rickinson, 2001; Shepardson et al, 2006; Çoban et al., 2011). In all likelihood, Powell would agree and advocate for increased understanding of watersheds and their function in the landscape, for watershed based environmental education.

Environmental education projects have demonstrated benefits to students, in particular, hands-on or outdoor activities increase student comprehension and retention of ideas, and have been proven to facilitate college careers in environmental or stewardship related fields (Poudel et al, 2005; Elfin & Sheaffer, 2006). Further integrated environmental education has been shown to improve scores in writing, math, and listening as well as improving analytical skills and critical thinking (Bartosh, Tudor & Ferguson, 2006).

Common goals of environmental education projects include affecting student attitudes or behaviors regarding the environment or involve community activism and service learning (Bogner, 1998; Rickinson, 2001; Bodzin, 2008; Kinne, 2011). Other projects focus primarily on science education, and in some, environmental education is secondary to being outdoors (Kenney, Militana & Donahue, 2003; Thomas, 2005, Kinne, 2011).

Events oscillate from endeavors such as the National Geographic and National Park Service's annual 24-hour BioBlitz, to longer-term projects with committed facilitators who collect data over time (Donahue et al, 1998; Bartosh, Tudor & Ferguson, 2006; Bodzin, 2008). These projects vary in size and scale from schoolyard ponds to national citizen science data collection networks involving student and community volunteers (Kenney, Militana & Donahue, 2003; Bodzin, 2008, Mullen & Newman, 2013).

Notable water-based environmental projects, such as the Global River Environmental Education Network (GREEN) or RiverWatch, focus primarily on water quality monitoring projects, and have been successful both in collecting long-term data sets and encouraging student involvement in community activism (Donahue et al, 1998; Donahue et al, 1998; Stapp, 2000; Elfin & Schaeffer, 2006; Kinne; 2011). Fewer projects incorporate additional watershed ecology, history, or information on the socio-economic history of the place that has affected the environment over time (Bodzin & Shive, 2004; Cole, 2007; Kinne, 2011).

Furthermore, teachers, school districts and their science programs are increasingly subject to national and state standards, it is important that intra-classroom and ancillary science education activities support and supplement the framework that teachers work within (Gruver & Luloff, 2008, Payne, 2006). Educators commonly rely on national or regional online curricula that are not as comprehensive as localized place-based watershed curricula. Effective watershed education projects take into account mandated standards and other requirements as well as incorporating activities designed to build upon existing lessons; increased access to local watershed ecology lesson plans could help incorporate this topic into classroom and extracurricular science programs (Kenney, Militana & Donahue, 2003; Bodzin & Shive, 2004; Gruver & Luloff, 2008).

Purpose & Research Questions

The purpose of this environmental education project was to conduct and test the efficacy of a watershed ecology module with 4^{th}-8^{th} grade students, focusing on the Cache la Poudre basin and its biophysical and socio-cultural connections.

The project was envisioned as a rapid assessment Blitz style project to assess watershed health with students (Karns et al., 2006; Lewington & West, 2008). The name BioBlitz, or biodiversity blitz, derives from rapid biodiversity assessment events combined with public outreach and provide a snapshot of current biodiversity (Lundmark, 2003). While no overarching protocol exists for Blitz events, generally events focus on identifying as many species as possible, both flora and fauna, during a pre-determined time frame. (Lundmark, 2003; Karns et al., 2006). Events often include an aquatic species component; however, no event focusing on rapid assessment of watershed health was found in current literature.

Two research questions were developed to direct the course of the project and to assess its success:

> **Research Question 1:** What are the efficacy of the AquaBlitz curricula for teaching elementary and middle school students about watershed ecology and the history of the Cache la Poudre basin?
>
> **Research Question 2:** What is the utility of utilizing elementary and middle school-age students as citizen scientists for data collection during a Blitz style event on a watershed-wide scale?

Specific objectives were designed to elucidate and complement the overall research questions:

1. Provide hands-on environmental education learning opportunities for students with ecological and local foci, incorporating watershed and stream ecology, water quality and chemistry, history and human impacts, and connectivity between these components.
2. Provide a set of lesson plans consistent with Colorado State educational standards, usable across the Cache la Poudre watershed and Colorado Front Range, for testing water quality, completing stream health assessments, exploring the watershed concept, and simultaneously investigating the history of water use in the watershed.
3. Work with students to capture the elevational, watershed-wide, variation in water quality and stream health.
4. Utilize and introduce schools and students to technology in science, specifically that associated with typical water quality and stream assessment field-testing procedures and utilization of online databases.

AquaBlitz Development

Prior to curricula development, this project's first task was to evaluate both need and interest for a watershed ecology educational unit from local teachers. During the summer of 2014 the City of Fort Collins' WaterSHED program hosted their annual teacher training which focused on exposing participants to watershed ecology; they agreed to a partnership for this research. Training participants consisted primarily of teachers from the Poudre School District. While the Weld RE-4 District comprises much of the lower elevations of the watershed, including its confluence with the South Platte River, they declined to participate in both the training and the AquaBlitz activities citing similar commitments with other organizations.

Participating educators were given a survey to assess their comfort level and knowledge on a variety of watershed topics before and after the training. Assessment results were consistent with similar trainings; the teachers showed increased comfort levels with all of the topics presented (Bodzin & Shive, 2004; Gruver & Luloff, 2008). Teacher trainings have been shown to positively affect student performance (Rickinson, 2001; Forbes & Zint, 2010; Kinne, 2011). Additional interaction with educators, science department heads and school district staff supported the formation of place-based curriculum, providing that the educational material supported state-mandated requirements. Supporting literature additionally indicates the importance of incorporating mandated requirements into intra and extracurricular educational activities (Gruver & Luloff, 2008).

Resulting AquaBlitz activities and curricula for students were designed based upon best practices in inquiry, prior projects and recommendations cited in the literature (Payne, 2006; Forbes & Zint, 2010). Three lessons were developed specifically to introduce students to the ecology and water use history of the Cache la Poudre watershed while simultaneously considering requirements of the Colorado Department of Education (Shepardson et al, 2006). The AquaBlitz curricula addressed the following state science and social studies prepared graduate competencies and each activity lesson plan addressed specific science and social studies standards for grades four through six (cde.co.state.us, accessed 4.15.15).

Four science programs from three schools participated in the one-day AquaBlitz at two sites during the first week of May 2015. One event cancelled for weather related reasons.

Approximately 175 students from 4th, 5th and 8th grade attended three disparate events.[1] Over the course of each morning smaller groups of students rotated through three stations: Water Quality, Stream Assessment and Local Watershed History, though stations could be conducted consecutively with a small group of students. Curriculum from these stations, and a follow-up data lesson, were incorporated into a lesson booklet that can be utilized for future watershed ecology education.

The Stream Assessment lesson introduced students to the geographic concept of a watershed and connectivity of water as it flows from upland areas though groundwater, streams and their riparian areas and eventually into the ocean. Students were also exposed to a stream ecosystem and learned about assessing the health of a stream by conducting a qualitative stream health assessment as part of learning about overall watershed health.

During the Water Quality lesson students completed water quality tests for temperature, pH, dissolved oxygen, carbon dioxide, phosphates and nitrates on site, and learned about variation in Colorado Front Range water quality parameters. This lesson utilized Hanna Industries Backpack Labs©, though could be adapted for other equipment. The participants discussed how these parameters might be different throughout the watershed, and how water quality can be affected by addition of natural or anthropogenic pollutants.

During the Local Watershed History lesson students learned about history specifically related to water use in the watershed through a reading activity and scavenger hunt. This lesson was specifically written for the Cache la Poudre basin and is unique to the area. Unlike the previous,

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[1] Despite the focus on standards for grades 4-6, only one middle school, an 8th grade class, requested to participate, resulting in participants from grades 4, 5 and 8.

more adaptable, lessons supplemental material would need to be entirely re-written to accommodate the local history of a different watershed.

A fourth lesson, Exploring Your Data, was designed to be taught in the classroom after the field activities, where students would upload and compare their data to that of the other AquaBlitz sites. However, project timing at the end of the school year coincided with a rigorous testing schedule and despite pre-scheduling, some of the teachers were not able to incorporate this into their schedules. For those that retained the follow-up lesson, it was reduced to an approximate 20 minute long review of key points. It is highly suggested that a lesson of this nature be incorporated into future AquaBlitz activities, which also addresses state math standards.

Reviewing data collected by the students revealed further issues with incorporating this follow up lesson as initially conceived. At all grade levels, data was inconclusive and varied widely amongst groups. This was clear simply by reviewing their data and recognizing the variability between groups' responses. This was true for the quantitative data collected at the Water Quality station and likely due to issues with precision and accuracy. It was also true of the more qualitative data collected during the stream assessment. Students tended to be biased toward stream health. This is not surprising, as subjectivity of elementary age students has been shown to vary from that of professionals during tree health assessments (Galloway, Tudor & Haegen, 2010). It would be beneficial to have students work with a trained professional who is proficient with water quality testing as well as stream assessment and who has a exposure to relevant reference conditions. Discussion occurred during the stream assessment about student results, however, the project facilitators collected no reference data set. A reference data set should be collect by an experienced facilitator during future events for more accurate data.

In order to facilitate a follow-up, data based, lesson from a one-time Blitz project, it would be necessary to use data sets collected by adult supervisors. Longer-term educational projects where students have the opportunity to practice both qualitative and quantitative data collection would likely produce more accurate results.

AquaBlitz Assessment

Evaluation of AquaBlitz activities and curricula occurred via a pre- and post-assessment for students utilizing Google Forms as a collection method. Such assessments are the common method for analyzing the success of similar projects involving youth (Donker & Markopoulous, 2001; Leech & Onwuegbuzie, 2011). Evaluation emphasized knowledge acquisition rather than alteration of student attitudes toward the environment.

Assessment questions were developed directly from the lesson plans and state standards. In order to strengthen the validity and integrity of the assessment instrument several questions relating to each lesson were written and were tested through the talk aloud method with a female 5th grade student not participating in the AquaBlitz (Donker & Markopoulos, 2001). Based upon the talk aloud results, ineffectual questions were eliminated from the assessment resulting in one specific question addressing each of the three sessions, an overall watershed question, and several questions about how often the student visits the river with their class and with their family. Additional questions about student enjoyment of AquaBlitz activities were included in the post-assessment. Both assessments included a hard copy drawing exercise where students were asked to draw and label the Cache la Poudre Watershed, similar to other studies relating to understanding of watersheds (Shepardson et al, 2006; Galani & Rock, 2014). Assessments were administered by the students' teachers the week before and the week after the AquaBlitz activities.

Other than grade level, no demographic data was collected about the students. Demographic effects on prior environmental knowledge and exposure has been widely linked to both knowledge level and attitude toward the environment (Castillo, Garcia-Ruvalaba & Martinez, 2002; Shepardson et al, 2006; Bartosh, Tudor & Ferguson, 2006; Coban et al., 2010). Results of this activity may be different depending on student demographics.

Table 1: Assessment Questions

Assessment Questions
1. How does water quality change as it flows downstream?
2. What makes a stream healthy for plants and animals that live in and nearby the stream?
3. Describe the path water takes as it goes through a watershed.
4. How do people use the Cache la Poudre and it's streams differently today than in the past?
5. How often do you go to the river or a natural area with your class?
6. How often do you go to the river or a natural area with your family?
7. Draw the Cache la Poudre watershed. Label your drawing.
Additional Post-Assessment Questions
1. Which was your favorite session of the AquaBlitz?
2. During which AquaBlitz session did you learn the most?
3. What did you enjoy most about the AquaBlitz?

Results & Discussion

Overall Assessments

Data was analyzed utilizing QSR International NVivo 10.2.1 software. Using software to assist in qualitative data analysis has been shown to increase rigor and validity of results, especially when analyzing large data sets and keeping large amounts of data organized (Walsh, 2003; Ozkan, 2004; Bandara, 2006; Wiltshier, 2011). NVivo also allows for flexibility in exploring themes within data (Walsh, 2003; Bandara, 2006). Before importing into NVivo was organized to optimize analysis and coding, as is common practice; see Appendix One for specific details (Beekhuyzen, Neilsen & von Hellens, 2010):

A total of 171 students completed the pre-assessment, not including the responses of the cancelled event, and 164 students completed the post-assessment. During the pre-assessment there were a total of 59 fourth grade, 67 fifth grade, 43 eighth grade and two blank grade level responses. Post-assessment counts were 56, 65, 41 and two, respectively. Count-based data are expressed as a percentage (ex 00.0) to account for the different numbers in respondents between the assessments. Italic red numbers (ex *0.00* or *-0.00*) represent a negative difference contrary to what was expected. For example, an increase in inconclusive answers or a decrease in mentions of biodiversity would be considered a negative difference.

The data consisted of classifying data, primarily the grade level information and questions asked, and codable data, the written responses to the thematic questions. A two-part data analysis was conducted on the codable data. This consisted of word frequency counts as a method of evaluating general understanding of the topics covered during the AquaBlitz, and cross analyzing manually categorized, or coded, data for specific themes addressed in question (i.e. each lesson) (Beekhuyzen, Neilsen & von Hellens, 2010).

Results of the word frequency counts were encouraging. Word frequency counts have been shown to elucidate overall understanding of key concepts (Wiltshire, 2011, Leech & Onweugbuzie, 2011). For example, the word ocean, and its associated stemmed words, was mentioned 17 times during the pre-assessment and 48 times during the post-assessment (9.9, pre; 29.3, post). By searching additional context words (ocean, sea, Pacific, Atlantic, Gulf of Mexico, Mississippi and Platte) that describe the continental path water originating in the Cache la Poudre basin takes, the pre- and post-count increases from 18 to 77, respectively (10.5, pre; 47.0, post), an increase in coverage of 36.5%.

Figure 1: A word tree, from the post-assessment, resulting from a word search for "the Gulf of Mexico."

Running a similar query, utilizing the names of the specific water quality parameters tested by the students, shows an increase from three mentions during the pre-assessment to 51 in post-assessment answers (1.8, pre; 31.1, post), a 29.3% increase in usage.

Table 2: Word frequency results for select key words from the AquaBlitz curricula indicate knowledge acquisition.

Word	Pre-Assessment	Post-Assessment	Percent Change
Ocean	9.9	29.3	19.3
Mountain	15.2	54.3	39.1
Snow	7.6	28.0	20.4
Diversity & biodiversity	3.5	3.0	*-0.5*
Beaver	1.8	6.1	4.3
Native American	1.8	7.3	5.6

Before coding each of the thematic questions individually, both assessments were coded for indecisive answers where the student simply wrote any version of “I don’t know,” or were left blank. This included answers where students admitted they did not know but attempted an answer after, resulting in some cross-coded “I don’t know” responses. Inconclusive answers, where the intent of the answer was unclear, were coded as a sub-category of the “I don’t know” response.

Table 3: Initial coding of "I don't know," blank or inconclusive responses to questions.

Question	I don’t know		Blank		Inconclusive		Totals	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post

How does water quality change as it flows downstream?	11.7	9.1	0.6	0.00	15.8	*18.9*	**28.1**	**28.0**
What makes a stream healthy for plants and animals that live in and nearby the stream?	8.2	6.7	1.8	0.6	1.7	7.9	**26.9**	**15.2**
Describe the path water takes as it goes through a watershed.	35.1	12.2	5.8	1.8	18.7	*20.1*	**59.6**	**34.1**
How do people use the Cache la Poudre and it's streams differently today than in the past?	20.5	10.4	3.5	1.8	23.4	20.7	**47.4**	**32.9**

By grade level, all categories elicited lower percentages of indecisive answers. Fourth grade students showed the largest improvement from 164.4 to 100.0[2] a 66.4% reduction in indecisive answers, Fifth grade students went from 153.7 to 100.0 and Eighth grade students went from 176.7 to 139.0.

Overall reduction in indecisive answers combined with increased incidents from the pre-assessment to the post-assessment elicited by the word frequency counts indicates increased comprehension of the curricula. However, rote memorization may be responsible for some of the increase in word use and may not correspond to increased comprehension of the subject matter. Coding and analysis of the complete answers further elucidated learning themes as well as areas where curricular refinement

Figure 2: An example of the drawing exercise done by a fifth grade student (pre-assessment, upper left).

[2] Percentages reflect greater than 100% coverage because this number includes all questions. Some students answered, "I don't know" to multiple questions.

or additional thematic education would be useful (Beekhuyzen, Neilsen & von Hellens, 2010; Leech & Onweugbuzie, 2011).

After initial coding and word frequency analysis each question was broken down and coded into multiple components. Components were derived from the purpose and learning objectives from the associated lesson plan as well as language utilized by the students to express overall lesson concepts. To avoid research bias or changing thoughts over time, coding for each component was done concurrently for both assessments before moving on to the next component or question. Some components were straight forward to code, while others relied on inferring the intent of the students' answers. When analyzing data demographically, responses that left their grade level blank on the assessment were disregarded. This included one response for the pre-assessment and two on the post-assessment.

Typically, the best answers consisted of multiple components, however some answers fell into one component category but appeared well thought out and understood in depth by the student. For example, the following response was coded for the water quality related component of the Stream Assessment question,

> "Many things are required for a healthy stream. One thing is that the plants in or around streams need a certain level of carbon dioxide and nitrogen to stay healthy and to complete photosynthesis. Animals in the stream need to have a good level of oxygen to breathe too. Like I said, many things are required."

Results of each question are addressed individually, details on the specifics of each component can be found in Appendix Two and Three.

Water Quality

Question: How does water quality change as it flows downstream?

The components coded for the Water Quality lesson were water quality parameters as mentioned in the lesson, natural pollution, and human pollution. Two common misconceptions were coded, one for the stream getting cleaner as it flows downstream and one for speed related responses, a final category was included for “It depends” answers.

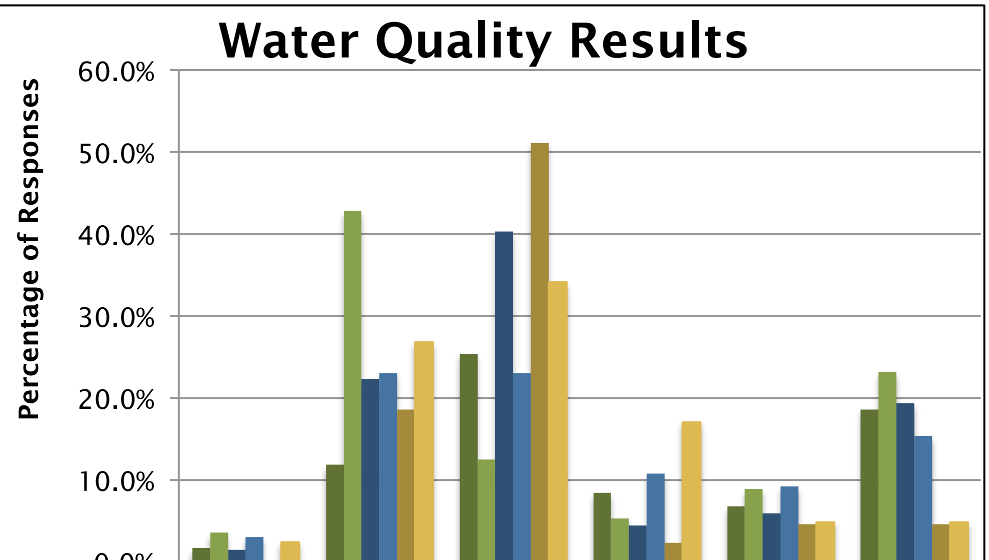
The water quality parameters were mentioned twice during the pre-assessment, both instances relating to a change in temperature. In the post-assessment however, students tended to utilize this new knowledge more while answering the stream assessment question. If correct, answers utilizing this knowledge were valid for both questions. For the Water Quality question the increases on the post-assessment were mild (1.2, pre; 3.0, post), at 1.8%.

Both human pollution and natural pollution reflected the expected improvements, an increase of 12.4 and reduction of 16.6 in coverage respectively, though neither showed an exceptional change. The increase of *4.6* in the water gets cleaner component is likely due to conversations about vegetation and habitat being a healthy part of the ecosystem because it helps keep water clean.

Relating speed to water quality was a common misconception of the students. Responses mentioning speed as a primary tenet of water quality were coded as a component and were mentioned equally in both assessments (15.2, pre and post). It is likely that no improvement occurred for this component because it was not specifically addressed by the curriculum. Responses that had speed as one of multiple components usually contained a rationale for why water speed affected water quality, i.e. “It changes by making it cleaner because the water is moving and not sitting in place.”

None of the students mentioned all three primary components, human or natural pollution and water quality, in either assessment. The largest improvement was increased mention of water quality parameters, but most of the others were inconclusive or showed only minor improvements, the overall trends matched grade level trends.

It is difficult to discern whether the inconclusiveness in improvement for some of these concepts could be ameliorated through improved language in the question wording, or if it is primarily related to the curriculum.



	Water Quality	Human Pollution	Natural Pollution	It gets cleaner	It depends	Speed
4th Pre-Assessment	1.7%	11.9%	25.4%	8.5%	6.8%	18.6%
4th Post-Assessment	3.6%	42.9%	12.5%	5.4%	8.9%	23.2%
5th Pre-Assessment	1.5%	22.4%	40.3%	4.5%	6.0%	19.4%
5th Post-Assessment	3.1%	23.1%	23.1%	10.8%	9.2%	15.4%
8th Pre-Assessment	0.0%	18.6%	51.2%	2.3%	4.7%	4.7%
8th Post-Assessment	2.4%	26.8%	34.1%	17.1%	4.9%	4.9%

Figure 3: Pre- and post-assessment responses, by grade level, to the water quality question. Percentages represent the number of occurrences each component was mentioned.

Stream Assessment

Question: What makes a stream healthy for plants and animals that live in and nearby the stream?

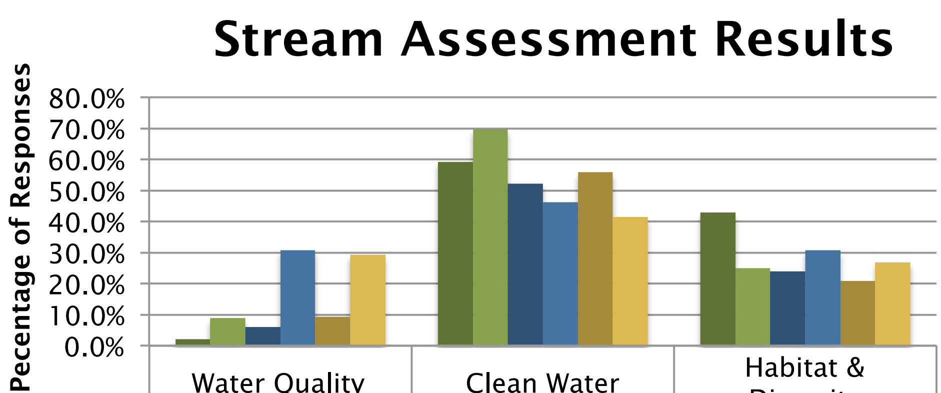
The stream assessment answers were coded for four components. First a healthy stream is free of pollution and contains clean water, second specific mention of the water quality parameters or abiotic factors, third the biotic components of a stream such as vegetation, habitat and the physical components, and finally biodiversity.

Relating stream health to clean water was essentially unchanged between the assessments whereas water quality and habitat concerns both showed improvement. It was surprising however, that mentions of diversity were reduced between the pre- and post-assessments (19.9, pre; 15.9, post; change, *-4.0)*. This may have been related to a focus on understanding how surrounding areas affect streams and understanding connections within the watershed. This suggests room for improvement in curricula, i.e. stressing not only species diversity but habitat diversity as well. There was improvement in some areas related to diversity. Students were introduced to the concept of riparian areas during this lesson as areas that host large numbers of species. A word search reveals that no mentions of the word riparian occurred before the AquaBlitz and 4.2% coverage occurred after.

By grade level, fourth grade students seemed to have more difficulty understanding the diversity and habitat concepts, and showed minor decreases in these two components while fifth and eighth grade showed minor increases. All grade levels had increased understanding about water quality parameters, though fourth grade showed the lowest improvement. Similarly fourth grade had increased mentions of clean water and fifth and eighth grade reduced mentions.

Demographically, this indicates that fourth grade students may need a simpler version of the curriculum.

A common misconception illuminated by student responses to this question involved the correlation of stream health and plant and animal health. While these are indelibly related, it was common for the students to believe that a stream was only healthy if the plants and animals were healthy. Some of the student responses illustrate the confusion, "Healthy animals make streams



	Water Quality	Clean Water	Habitat & Diversity
4th Pre-Assessment	2.0%	59.2%	42.9%
4th Post-Assessment	8.9%	69.6%	25.0%
5th Pre-Assessment	6.0%	52.2%	23.9%
5th Post-Assessment	30.8%	46.2%	30.8%
8th Pre-Assessment	9.3%	55.8%	20.9%
8th Post-Assessment	29.3%	41.5%	26.8%

Figure 4: Pre- and post-Assessment responses to the stream assessment question, by grade level. Percentages indicate percentage of times each component was mentioned.

healthy," versus understanding that wildlife can be an indicator of stream health, "Bugs macroinvertebrates because living things cannot live in an unhealthy stream and neither can green plants."

Watershed

Question: Describe the path water takes as it goes through a watershed.

Responses were first coded for answers where students related watershed to a constructed entity such as “a shed with water,” or built structures such as a water treatment plant. Responses were further coded for basic elements of a watershed: a water source; rivers as the primary part or central portion of a watershed; and a larger body of water where the water ends up.

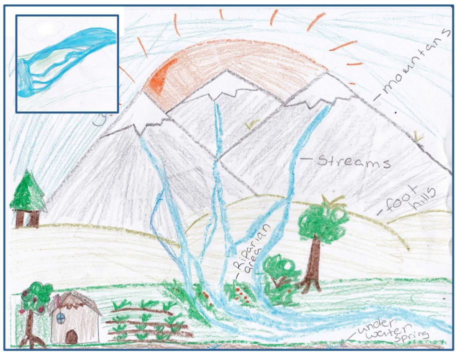


Figure 6: A Fifth grade sample drawing of a river segment (pre-assessment, upper left), and a more complex drawing of a watershed (post-assessment).

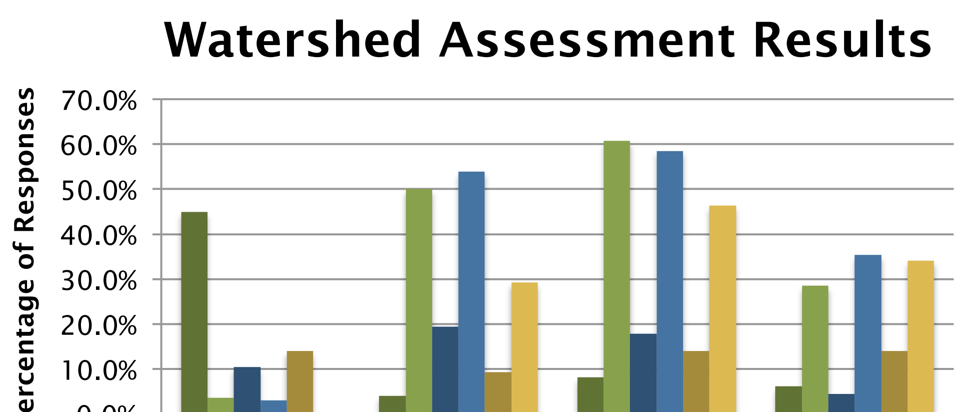
Each of the individual components was mentioned more often during the post-assessment by all grade levels. Combined instances where students mentioned all three components increased by grade level, fourth grade began at 1.7 and ended at 17.9, 1.5 to 23.1 by the fifth grade, and 4.7 to 22.0 by the eighth grade with a total change from 2.3 to 20.7, an overall increase of 18.4%. The drawing exercises reflected similar trends to the watershed question. Many of the preliminary drawings included a built structure or a simple river drawing. Post-assessment drawings included more detail overall and reflected the source, streams and larger water body ideas.


Figure 5: A Fourth grader's pre-assessment (left) and post-assessment (right) drawings of a watershed.

A watershed as a “shed” was a common response during the pre-assessment (21.6, pre; 2.5, post) as students were utilizing previous knowledge and word association to break down the meaning of novel words and concepts, most commonly mentioned by the fourth grade students, 37.3, and only moderately mentioned by the fifth and eighth graders, 10.4 and 14.0 respectively.

The overall decline of 19.1% between the two assessments indicates increased comprehension of the correct idea, a watershed as a geographic unit. Fourth grade students showed the largest improvement, a 33.7% reduction in mentions. Fifth grade showed modest improvements at a 7.3% reduction and the eighth graders had zero mentions on the post-assessment, a 14% reduction.

Common confusion with this question related to branching of stream networks. While it was clear that some students grasped the concept of streams, they mistakenly thought that larger streams divided into smaller streams, rather than streams joining to form larger rivers. Increased attention during the lesson, or a visual aid, may help reduce this confusion.



	Watershed as a Shed	Source	Streams	Larger Waterbody
4th Pre-Assessment	44.9%	4.1%	8.2%	6.1%
4th Post-Assessment	3.6%	50.0%	60.7%	28.6%
5th Pre-Assessment	10.4%	19.4%	17.9%	4.5%
5th Post-Assessment	3.1%	53.8%	58.5%	35.4%
8th Pre-Assessment	14.0%	9.3%	14.0%	14.0%
8th Post-Assessment	0.0%	29.3%	46.3%	34.1%

Figure 7: Pre- and post-Assessment responses to the watershed question. Responses by grade level. Percentages represent mentions of each component.

Local Watershed History

Question: How do people use the Cache la Poudre and it's streams differently today than in the past?

First, both assessments were coded for incorrect responses, due largely to confusion of tenses, where the difference between past and present were indeterminate or confusion about when a use occurred. The answers were then coded into past and present examples. This included two sub-categories for each, examples specifically from the curriculum, and other examples.

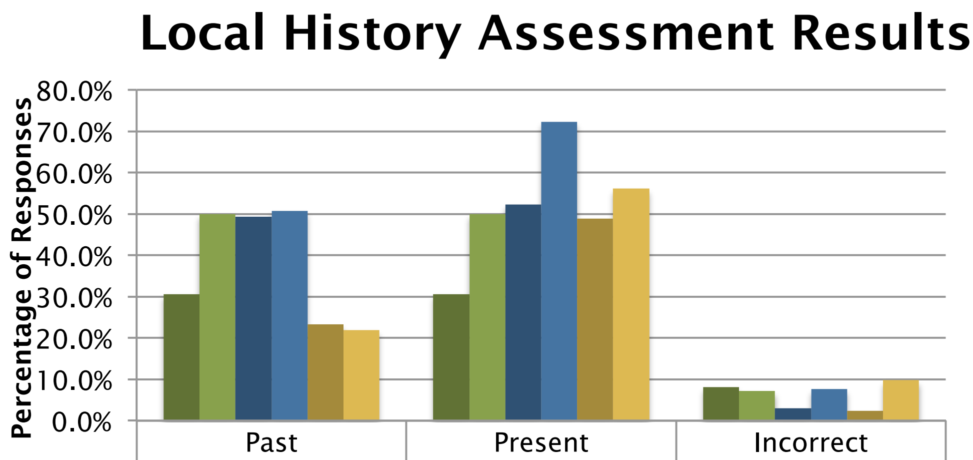
Improvement, as measured through sheer number of mentions of past and present were nominal. Examples from the past, both covered by the curriculum as well as non-curriculum examples, not including incorrect answers, covered 33.9 of the pre-assessment and 42.7 of the post-assessment responses respectively. Before the event students were generally familiar with the origin story of the Cache la Poudre, which was also covered during the lesson. It was often cited as a past use during the pre-assessment and may account for the small increases. Usage examples from the present components accounted for 39.8 coverage of answers in the pre-assessment and 52.4 in the post-assessment, usually involving a response relating to recreation.

By grade level, the fourth grade students had combined responses of 50.8 on the pre-assessment and 100.0 on the post-assessment, again the largest improvement. Fifth grade responses were 101.5, 123.1 and eighth grade were 72.1, 78.0. These percentages suggest that curriculum should include extra, more complex, activities for the older students.

In the author's opinion, a common theme is a belief that in the past the water was utilized directly, such as drinking water or irrigation, while in the present uses are indirect, such as recreation or hydroelectricity. This suggests students remain disconnected from the ways in which we use water today, consistent with similar studies that indicate a disconnect between the natural and human components of the landscape (Shepardson et al, 2006). One response demonstrates: “Well in the past people would use the river for drinking water or to water their [sic] crops or even wash their [sic] clothes. But now a days people use it for rafting or looking at and not using it too [sic] much for things that they absolutely need.” However, many answers directly contradict these ideas and state that use now is direct and that water wasn’t used in the past, “Today they do not put gun powder under trees. They also use the water to drink now.”

It is likely that difficulty coding this section arose from ineffectiveness of the assessment question. The session materials focused primarily on historic timeframes and how the watershed as a whole was used in the past and the question focuses on the river itself during present day, which is a potential cause of the vague responses. A question more appropriate to the lesson content may have provided better information on what students learned about the watershed’s history.

However, a word query did provide additional illumination about student learning. Utilizing key words (“Native American”, Indian, trap, trapper, beaver, farm, ranch, cattle, livestock, irrigation, French, “fur trapper”, European, and settler) from the lesson materials resulted in an increase of mentions 10.5 of the time in the pre-assessment to 82.8 of the time in the post-assessment, a robust 72.3% increase.



	Past	Present	Incorrect
4th Pre-Assessment	30.6%	30.6%	8.2%
4th Post-Assessment	50.0%	50.0%	7.1%
5th Pre-Assessment	49.3%	52.2%	3.0%
5th Post-Assessment	50.8%	72.3%	7.7%
8th Pre-Assessment	23.3%	48.8%	2.3%
8th Post-Assessment	22.0%	56.1%	9.8%

Figure 8: Pre- and post-Assessment responses to the history question divided by grade level. Percentages represent mentions of each component.

Recommendations

While the AquaBlitz overall fell short of meeting the rapid assessment goals of a traditional Blitz event, with slight modifications repeat events could diverge in one of two directions (Karns et al., 2006; Lewington & West, 2008). With a coordinated effort within a large organization like a school district or watershed council the event could become the envisioned Blitz, or at a smaller scale either a teacher or department may expand upon the curricula to form a longer educational unit.

Utility as a Blitz event could be increased through coordination within a specific school district(s) or organization by including a training or practice event utilizing the specific curricula, as was done during this project and others with similar objectives (Kenney, Militana & Donohue, 2003). This pilot event was taught over the course of a week by the same three session facilitators. For a true AquaBlitz, events would be held concurrently across the watershed and teachers at each participating school would conduct sessions. BioBlitz events are typically done in concert with local scientists, inviting relevant professionals to future AquaBlitz' would increase data reliability as well as provide students with a correct data set for post-event lessons. Because of the time and cost for exposing students to multiple streams, i.e. reference conditions, attending professionals could help fulfill this aspect of stream assessment protocol.

As a discrete event, the organizer or educator should incorporate lessons prior to the outdoor activities to increase learning retention and comprehension. Specifically focusing on key ideas that would be new concepts to participants. Useful hindsight from the pilot events that could be incorporated into advance lessons includes:

- Defining and understanding the concept of a watershed as a geographic unit.
- Utilizing Google Earth or other spatial software to locate the site in the context of the watershed and main stem river.
- Introducing water pathways and connectivity.
- Defining vocabulary from all three lessons in advance.

For younger students, a less complex water quality testing kit would be advised. Accidents including spilling or overuse of the testing chemicals were common. While the Backpack Labs© are comprehensive, they may also be cost prohibitive for large events. The younger students struggled with accuracy and precision, these issues may be ameliorated by working in smaller groups or adding additional adult support. This station was widely enjoyed by participating students and utilization of a kit that facilitated comparable results amongst the disparate groups through ease of use would increase the functionality of the lesson objectives.

As an organization, working with the participating educators further in advance or having a more robust education team would allow for incorporating the additional Exploring Your Data lesson and sharing data between sites. With these minor modifications the AquaBlitz would be easily incorporated into a school district wide project. After the culmination of the project a voluntary survey about the project was submitted to the participating educators. The responses were largely positive and informed and reinforced the recommendations cited above.

Data analysis indicates that overall the fourth grade students showed the largest improvement suggesting that for the most part the curricula was at grade level. Fifth grade showed moderate improvement, however, this may be circumstantial. Both the fourth and fifth grade participants were from the same school which has a strong science program introducing students to stream ecology with an annual BioKidz event. This year the AquaBlitz acted as the kickoff event for this educational unit and was the first introduction of these ideas to the fourth grade students. The fifth graders had completed the BioKidz event in the previous year and had some background knowledge. One of their teachers indicated that, "One of the most positive aspects (of the AquaBlitz) is the fifth graders were able to extend and apply their knowledge from the fourth grade BioKidz! event in new situations and build upon their previous learning." The eighth grade students also showed moderate improvement, however, near the end of the school year, close to their transition into high school may not be the most effective time for this type of event.

Conclusion

Overall the AquaBlitz provided predominantly positive results to the project's first research question. Based upon the student assessment results, the curricula proved adequate in fulfilling the individual lesson plan purposes and objectives. Of the few instances where the data was inconclusive or indicated incorrect knowledge acquisition, some of this may be attributed to flaws in the assessment instrument. Furthermore, the assessment analysis has indicated areas for curriculum improvement and subsequent events will only benefit from this research.

In regards to the second research question, the event as conducted did not fulfill the premise of a Blitz event. It was held over the course of a week, during which time water quality parameters or features assessed during the stream assessment can change drastically depending on weather related events such as increased flow from snowmelt. Additionally, the water quality and stream assessment data collected by the students was imperfect and could not reliably be compared amongst participating schools. In order to provide a true watershed wide snapshot of conditions, more participating schools would be required. However, issues successfully meeting the premise of the second research question could be ameliorated through increased coordination with local scientists and between participating schools.

Evidence suggests, from this event's data, as well as myriad examples from the literature, that experiential education is both effective and influential. Environmental education, particularly outdoor education, has been shown to have benefits beyond the immediate, including critical thinking and analytical skills, not to mention physical benefits or increased sense of place, all of which were designed and direct or indirect benefits of the AquaBlitz. Hopefully, output from this project will prove useful to local educators as well as act as a template for similar subsequent watershed environmental education events.

Results, in the form of a story map can be accessed at the following website:

http://csurams.maps.arcgis.com/apps/MapJournal/?appid=48404a1ce89246d1b1b49c1f5df322e3

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Appendices

Appendix One: Data Organization

Before importing into NVivo the following steps were taken to organize student assessments.

1. Google Forms was saved as an Excel Document
2. The pre-assessment responses of the cancelled event, repeat responses and three post-assessment responses where students stated the did not attend the AquaBlitz were deleted
3. Auto-spell check for obvious spelling mistakes was completed and a manual spell check for homonyms, malapropisms, typographical errors and other grammatical errors like adding apostrophes, or pluralization issues, etc. During coding and analysis it was noted that some grammatical errors were missed, however, NVivo does not allow editing of imported spreadsheet documents and it was determined that it would be ill advised to spend too much time editing and possibly change the spirit of the student responses.
4. Streamlined compound words and phrases (i.e. down stream to downstream, or IDK to I don’t know), removed emoticons
5. Filled in blank multiple choice items where possible (i.e. Fourth Grade)
6. All of the data was read, multiple times, before coding commenced.

Appendix Two: Coding Details

Water Quality

The water quality question was coded for both misconceptions as well as positive aspects.

- First the question was coded for key words from the lesson plan, the water quality parameters.
- Three components were pollution related. One component was for decreased water quality due to human impacts utilizing words like pollution, trash, etc. Another was for decreased water quality due to natural impacts, utilizing key words like dirt, bugs, sticks, and mud. Non-specific pollution related answers were put into the natural pollution category. The final pollution component was for responses that stated water gets cleaner, by any method, as it travels downstream.
- One component was a misconception relating speed to water quality, generally stating that the stream goes either faster or slower as it flows downstream, which is not directly related to water quality.
- A final category was included, "It depends," which was for answers that provided reasoning for why water quality would get better or worse. This is different from inconclusive water quality responses where it was unclear if the student thought water quality changed as it flows downstream.

Stream Assessment

The stream assessment answers were coded for four components. While misconceptions did occur, none were common enough to rate an individual component.

- The most simple and easy concept to grasp is that a healthy stream is free of pollution contains clean water and is not negatively affected by human impact.
- The second incorporated more advanced ideas about water quality, including water quality parameters, or generally speaking, the abiotic factors of a stream system.
- Third, ideas relating to the biotic components of a stream such as vegetation, habitat and the physical components of stream health were coded.
- Finally, the most complex ideas, which incorporated biodiversity, the larger ecosystem and effects from surrounding environments as well as ideas about balance and connectivity, were coded.

Watershed

Responses to the watershed question were coded for four components.

- Responses were first coded for answers where students related watershed to a constructed entity such as "a shed with water," or a built environment like a water treatment plant.
- Responses were further coded for basic elements of a watershed:
    - Mention of a water source like rain, snowmelt, or mountainous areas where streams begin, or streams as the beginning of water flow;
    - Small streams that flow into larger streams and larger rivers, or rivers as the primary part of a watershed;
    - A larger body of water where the water ends such as the Cache la Poudre, Mississippi, or the ocean. Responses that mention both a lake and the ocean as the end point were counted; those that only mention a lake were not.

Local History

The history section was most difficult to code into components. Responses varied widely and presented a multitude of examples for past and present uses that often didn't fall into easy categories, or often contradicted. Students would also mention activities, such as utilizing water for drinking, and incorrectly state that this only occurred either in the past or present.

- First, both assessments were coded for incorrect responses, due largely to confusion of tenses, where the difference between past and present were indeterminate or confusion about when a use occurred.
- The answers were then coded into past and present examples. This included two sub-categories for each, examples specifically from the curriculum, and other examples.

Appendix Three: Component Tables

These tables show, in percentages, the number of times two components overlap. These represent instances where students mentioned multiple components in their response to the assessment question. Pre-assessment responses are in dark grey, post-assessment in light grey and individual component occurrences are in white cells.

Table 4: Water Quality Overlapping Components

Water Quality Overlapping Components		Pre-Assessment				
		Water quality parameters	Human pollution	Natural Pollution	Water gets cleaner	It depends
Post-Assessment	Water quality parameters	6.4, 25.6	0.6	0.00	0.00	0.00
	Human pollution	1.2	18.1, 30.5	4.7	1.2	1.8
	Natural pollution	0.00	4.9	38.6, 22.0	1.8	3.5
	Water gets cleaner	0.00	1.2	1.8	5.8, 10.4	1.2
	It depends	0.6	4.3	1.2	0.6	6.4, 7.9

Table 5: Stream Assessment Overlapping Components

Stream Assessment Overlapping Components		Pre-Assessment			
		Clean water	Water quality	Habitat	Diversity
Post-Assessment	Clean water	52.6, 52.4	3.5	1.8	7.0
	Water quality	7.3	6.4, 25.6	1.2	0.00
	Habitat	6.7	1.2	9.9, 14.6	2.9
	Diversity	5.5	3.0	3.0	19.9, 15.9

Table 6: Watershed Overlapping Components

Watershed Overlapping Components		Pre-Assessment		
		Source	Streams	Larger Water Body
Post-Assessment	Source	11.1, 45.7	5.8	3.5
	Streams	37.2	12.9, 55.5	4.1
	Larger Water body	22.6	27.4	7.0, 32.3