Chapter 11

Mediated Pedagogy in a Blended Environment: Impact of Processes and Settings during Environmental Monitoring of Dam Removal

Timothy Kieran O'Mahony

Previous attempts by other investigators (Young & Kinner, 2008) who focused on middle school students' performance on tasks that were associated with knowledge in the outdoors, failed to demonstrate strong results of any learning measures. Their efforts, and earlier results from a pilot study that this author carried out in the same vicinity (O'Mahony 2008), helped refine ways to test the effects of different kinds of "expert mediation" for linking school–based and experiential learning methods and to test the effects of these methods on students' thinking and motivation. A philosophical framework that encompassed ecojustice ideals and sustainability of environmental habitats served as a backdrop to the study. A quasi-experimental two-group design was used to test whether different mediating tools would affect student-learning outcomes. Quantitative and qualitative tools were used in a mixed methods approach to collect and interpret data during a pedagogical intervention that posited better learning outcomes for students where mediation tools aligned teaching processes and settings in a purposeful way. We discuss how tools and contextual artifacts help learners notice key dimensions of their experiences (in the natural world) that "make visible" entrenched preconceptions; enable a process of conceptual change, and foster an emergent comprehension of everyday knowledge. Further, this study demonstrates how intentional alignment of instructional "processes" with "settings" facilitates student learning by linking counterintuitive concepts in the natural world to very real aspects of their culture and lives. But, more importantly, through energizing a sense of students personal agency and deep-seated engagement around their sense of place, the outdoor learning experience appeared to activate not only joy in learning in situ, it went a long way to enhancing a preparation for future learning.

EcoJustice Science in Middle School

Science is typically popular with middle school learners. Teachers and parents will readily confirm a chorus of positive comments from their middle school students who say they "love" science, that it might even be their favorite subject. Yet, as described in many prominent educational journals (e.g., AERJ: Xu, Coats and Davidson 2012) many students often view "science" as foreign, distant, inaccessible, boring, irrelevant, and alienating (Basu and Barton 2007; Lee and Luykx 2005). There is evidence too, that science is equally inaccessible to students that are not normally classified as "minority" and who also find science irrelevant and boring (Mehan 1985; National Research Council [NRC] 2009; O'Mahony 2010). Inaccessibility is related to lack of interest, and indeed research has shown that students tend to invest in or withdraw from learning, depending on their level of interest (Singh, Granville and Dika 2002). Interest is indeed key for learning according to a number of prominent educators (e.g., see: Xu et al. 2012) and has been found to promote a "variety of desirable outcomes" in children (p. 125), with evidence for learning through persistence (Renninger and Hidi 2002), task completion (Xu 2008), and science achievement (Hidi and Renninger 2006).

In many rural areas (and especially where this research project took place), there tends to be high levels of drop-out among high school children (rates as high as 51% were reported in the school district where this project occurred). Educators and parents are often intuitively aware that children's interest in middle school academics influences future educational opportunity and career choices and indeed this trend has been borne out in empirical studies (Krapp 2000). It was not surprising then, that teachers and parents were very supportive of the Elwha intervention that we initiated locally, because the impetus momentum that science and engineering had received in the local community was prominent especially since dam removal and habitat restoration were headline news.[1] Indeed many studies appear to reinforce this notion; that an interest in science early in children's lives influences their decision to pursue a science-related career. Xu et al. (2012) report on findings from a National Science Education longitudinal study where researchers (Tai, Liu, Maltese and Fan 2006) found that students who reported an "interest in science careers in 8th grade were three times more likely to obtain a college degree in a science field than were those who did not show that interest" (p. 126). Xu and his research team further describe a study where researchers examined the experiences reported by 116 scientists and graduate students regarding their earliest interest in science. The majority (65%) of the participants reported that the root of their interest in science took place before the middle school years.

It follows therefore, that meaningful criteria for student performance and classroom success might be associated with creating and maintaining interest in science in middle school years. Many researchers have identified successful strategies for increasing interest in the classroom, including offering evocative choices to students, especially those who displayed no interest in academics (Schraw, Flowerday and Lehman 2001). In this project, we focus on creating and maintaining interest in middle school science through the strategic use of ideas, which capitalize on pedagogical tools and mindsets that connote ecojustice in practice. Students in middle school years are typically not averse to taking on challenges that offer substantive change to the world as they perceive it. It is engaging to carry out work that bears civic and social responsibility in a local or indeed global arena. Ecojustice principles were no strangers to this community; social themes relating to justice and reform were well enunciated in the community where activists continuously evaluated very real connections between tribal culture and the natural systems that flowed from the river reconstruction, and often spilled into environmentalism, sustainability and geosciences (Cornwall 2009). In the implementation of this intervention, it seemed plausible that youth activism was a prominent attribute that contributed to interest particularly for participants (the historical cohort, described later) who exercised a significant degree of agency over their science endeavor. Likewise, this cohort of students seemed to be more fully cognizant of and individually involved in decisions concerning events and programs that tended to affect their community, their siblings and familial relations, and their local environment. Indeed, as final moments relating to the removal of the dams drew near, ecojustice and sustainability principles seemed to unite teachers, community members and students, inviting them to come together in order to evaluate and make decisions about critical issues that impacted (or were about to impact) their livelihoods, their sense of place and their wellbeing (Allaway 2004). This philosophic standpoint provided an encompassing lens for working through some really thorny issues that had evolved into divisive community problems (Freilich 2010). Ecojustice issues relating to the restitution of confiscated tribal lands to the Elwha Nation, once the lakes had drained away (this involved 100s of acres of open silt-laden landscape that had belonged to the tribe prior to their confinement in the reservation) were discussed in class and were prevalent in the home also (Valadez 2010). Interest in local issues of habitat restoration and land management was high among discussions in the home at dinnertime and beyond (O'Mahony 2009). There is a solid body of evidence that suggests that parents play a vital role in children's performance in school and in career choices in the sciences. Jon D.

Miller (2012), director of the International Center for the Advancement of Scientific Literacy at the University of Michigan, offers empirical evidence that parents are the "essential root of scientific literacy" (p. 64).[2] We defer to Miller's view of scientific literacy as a child's capacity to engage with the world from a scientific standpoint, to ask questions, measure and assess their world using a scientific method.

This study, therefore, opens a new avenue of investigation where we identify a number of critical areas for connecting learning, motivated by issues of ecojustice and sustainability, with science relevance, interest and accessibility. In this next section we outline the settings and the situation that prompted this study. We compare two different approaches to experiential inquiry learning in an environment where expectations of engagement in learning were especially high. The Elwha River dam removal project turned out to be the largest dam removal project in the world. Thanks to the rapid response capability of an NSF Rapid grant (NSF# 1014508), we were able to engage students in sustainability and environmental explorations prior to the dams being removed (two structures were brought down simultaneously at miles 12 and 23 up river from the mouth), with the expectation that later research would allow them and others to understand how the ecosystem had changed once the dams were down, and allow them create artifacts for teaching other students about the processes that took place.

Data were drawn from 217 middle school science students in the Port Angeles Educational Service District (referred to here as Valley Middle School), an area near the dam removal project. The participants were eight graders, many of who had low science achievement scores at pretest. This region is marked by high (~48%) drop out rates and mixed ethnicity, including Caucasian, Native American and Asian. Student science achievement, as measured by Washington State's Measure of Student Progress (MSP), typically averages in the high forties to low fifties (%). From the point of view of interest in science and love of outdoors schoolwork, these participants were fairly typical of middle school children everywhere. The following two figures indicate the students' (i) assessment of field trips for science in to the Elwha River valley – 95% said they wanted more, and (ii) attitude to work when they are interested in the topic – 93% were willing to work hard in this situation.

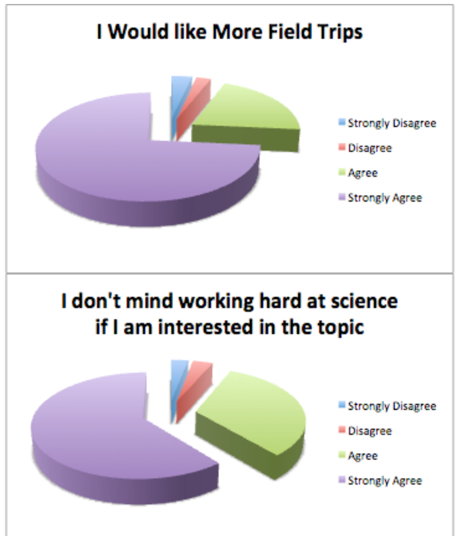


Figure 1a and b. Participants Assessment of Outdoors Schoolwork and Science

We compared two different approaches to scientific inquiry. The first approach (referred to as Piecemeal), used widely by local park rangers and also by teachers in many other parts of the country (e.g., Young 2009), assigned students different topics related to environment and water quality (e.g., students were told to measure dissolved oxygen, pH, turbidity, and so on). Students gathered data in the outdoors and wrote up their project using a scientific framework that was derived from classroom texts supplied with Foss Kits (Chin et al. 2010). The end product was a PowerPoint production that each group (typically 4/5 persons) was responsible for delivering to peers and teachers.

The second approach (which we refer to as Historical) asked students to take a historical frame for their science inquiry and involved answering questions such as why the dams were there in the first place and for how long; how they affected the lives of people living in the community, and what kinds of changes in conditions were predicted once the dam were taken down. Similar to the first approach, these students did inquiry projects before and during the dam removal, but they had more choice with respect to historical information to include in their work, indicators to study, and techniques for showing their work (e.g., students created movies that integrated science in a historical frame rather than individual PowerPoint presentations on piecemeal water quality findings such as pH).

This research provided time and equipment for both groups of students to explore the Elwha river system and the environmental habitat prior to and as the dams were being taken down, and to make predictions about the future (after the dams were taken down). For example, for the relatively near future, major impact was anticipated in the upper regions of the river once the river was again naturally connected with the ocean and marine derived nutrients would be brought back into the ecosystem (through returning salmon) after almost a century cut-off from this source (there were no fish ladders in the original dam structures). At the same time, scientists and students anticipated major changes to the emerging lake beds where massive amounts of sediment (30+ million cubic yards of silt) remain once the lakes are drained down. Significant changes were also predicted to occur at the mouth of the river where the Elwha enters the Strait of Juan de Fuca, because silt deposition and tidal exchanges should initiate the development of sandy beaches once more (Casey 2006).

Overall, all students spent 10 weeks on the Elwha project, which included taking the classroom outdoors for inquiry activities, bringing discoveries inside the classroom for small and large group discussions to prepare either a PowerPoint presentation or a historical movie. The multimedia work was undertaken with the help of the technology instructor in the school who integrated his classwork with that of the science teachers.

Measuring Students' Knowledge

We developed an instrument to measure students' knowledge before the intervention and again once the students had been exposed to several units of curricular materials and a field event. The instrument consisted of ten items that focused on the impact of dam construction and removal over time. For instance, the initial portion of the instrument (three questions) was oriented towards the past and focused on why the dams were built in the first place. The second portion (three questions) situated the student in the present - asking why the dams were being taken down brick-by-brick instead of blowing them up? Finally, the third section (four questions) had a futuristic orientation in its makeup and asked students to imagine that it was 2015 and that one morning their drinking water comes out of the tap like tar. The questions assessed students' ideas on what might have caused this to happen. We examined the twenty items using a statistical model (Cronbach's a) that verified the reliability of the instrument. Item reliability measured high at 0.886 (c.f., Nunnally and Bernstein 1994, pp. 232, 251-252).

Scoring

Four scorers, each blind to treatment group and time of test, independently used a rubric to score a common set of 20 randomly selected tests. Total test scores from each pair of scorers correlated at $\geq$ .80, and interrater reliability among all scorers was .89. Disagreements were resolved through discussion with experts in the subject matter. Scorers then divided the remaining tests equally amongst themselves for independent scoring.

Here we describe findings that result from data collection in the classrooms and in the field. Measures include (1) Quantitative results of the paper and pencil knowledge test administered at pretest and posttest by teachers and scored by "blind" raters; (2) video analysis of students' interactions in the outdoor environment and as they prepared for their small group presentations; (3) assessments of the nature of students' presentations in the two instructional groups. In addition, we recount pertinent reactions by each teacher of their experiences and their observations of the experiences of their students.

Pre/Post Knowledge Test

As stated earlier, subjects consisted of 8th grade science students from a small rural population in western Washington that happens to be adjacent to a massive dam removal and habitat restoration project. Four science teachers and their students took part in the study (N=217); two classes participated in the historically-framed science inquiry (Historical) condition, and two were in the comparison (Piecemeal) condition. Descriptive statistics (see: Table 1) outline the mean, standard deviation for both piecemeal (n=107) and historical (n=110) cohorts' pre and posttest scores.

Table 1
Learning Performance Descriptive Statistics

	Piecemeal (n = 107)				**Historical (n = 110)**			
	Pretest		*Posttest*		*Pretest*		*Posttest*	
Content area	***M***	***SD***	***M***	***SD***	***M***	***SD***	***M***	***SD***
Question 1	1.90	2.60	5.59	3.22	5.50	3.00	7.30	2.85
Question 2	2.40	2.30	5.62	3.25	4.00	2.50	7.07	3.03
Question 3	2.60	2.40	7.38	2.87	4.48	2.70	8.27	2.48
Question 4	0.80	2.40	7.00	4.08	3.70	3.20	8.39	2.65
Question 5	3.00	2.00	7.97	2.83	5.00	2.00	8.08	2.55
Question 6	2.00	2.00	6.71	3.43	4.00	2.00	6.84	2.87
Question 7	0.50	1.30	4.05	3.27	2.10	2.00	4.20	3.27
Question 8	1.01	1.97	4.90	3.68	2.10	2.09	5.09	3.09
Question 9	1.23	1.92	5.59	3.70	2.28	2.21	5.83	3.08
Question 10	0.94	1.93	4.06	3.90	1.68	2.03	4.92	3.46

Table 1 Learning Performance Descriptive Statistics

A one-way analysis of variance (ANOVA) was calculated on participants' scores of learning performance. The test showed significant gains for the historical group over the piecemeal group in learning measures: $F\ (1,216) = 5.557$, $p>.05$, $r = 0.12$. This test of between subject effects indicates that on average, students who were taught with a historical context showed greater measures of learning than the comparison group.

Learning Interactions in the Field and Classroom

In addition to pre/post knowledge tests, we also examined differences between the two conditions by analyzing data in a qualitative paradigm. The latter provided a more sensitive approach to investigating how students interacted as they gathered data and prepared their presentations; for example data showed that those using the historical narrative achieved a deep understanding of the dam removal process and began to appreciate nuances involved in habitat restoration. We looked for indicators that might suggest greater engagement, deeper investment in their work and an ability to synthesize and abstract from local observations and theory. We undertook frame-by-frame video analysis of excerpts that highlighted data capture, data processing and project presentation.

Content logs (Jordan and Henderson 1995), which captured key moments of activity and discourse were created from the videotapes to aid analysis. Two researchers used these logs and video recordings to independently identify significant interactional episodes. Using standardized transcription conventions, content logs, and field notes, we reconstructed in writing what the learners said and did in relation to one another, preserving the temporal sequence of the interactions. Participant verbal interactions were transcribed and coded. Emergent categories and themes in relation to course content and participant engagement (through questions that stemmed from discussions and interactions) were documented. Verbal interactions were analyzed for sequences that captured participant meaning-making. Students in the Historical cohort appeared to view the world in a different way than students in the Piecemeal comparison cohort. Historical students exercised agency over their choice of project—they chose topics that had meaning for them. For instance, a typical choice is illustrated in the following segment, which comes from students interviewed on the shore of Lake Elwha: (11/07/2010_Lake_Elwha_Site).

> Interviewer: What is your study about?
> Student_1: We are looking to see if eagles are more plentiful here near the lake or up at the other dam or down at the mouth.
> Interviewer: Why did you choose this study?
> Student_1: I wanted to see if the dam has any impact on where the eagles hunt. My dad said there were a lot more eagles long ago.
> Student_2: We like eagles. I like to take videos of them.
> Interviewer: What do you think you will find?
> Student_1: Well, so far we didn't see any eagles here today.
> Student_2: We think we saw one earlier and I think I heard one … but it might have been something else.
> Student_1: Yeah, a raven … there was probably one here earlier.
> Interviewer: What about up at the upper dam?
> Student_2: We saw three eagles up there.
> Student_1: Two were circling high up. The other one we saw later… it might have been one of the first two again. Hard to say.
> Interviewer: What about down at the mouth?
> Student_1: We expect to find some down there. My friend says he sees them down there always. He lives near there.

Piecemeal Presentations

Ostensibly, the class teacher assigned topics to the control Piecemeal cohort – they didn't exercise any choice over the topic of their study. Each topic was made to fit the curricular material that was tasked with explicating the "Scientific" approach to learning science. In this approach, groups studied something like PH, salinity, turbidity etc. of the river. The following episode describes the understanding of a typical Piecemeal group gathering field data taken from live data: (11/07/2010_Between_Dams_Elwha_River_Site).

> Interviewer: What is your study about?
> Student_1: We are measuring PH.
> Interviewer: What is PH?
> Student_1: Um. Ahmmm PH is... I don't really know (laughs)
> Student_2: Um… it is about acid... acidity.
> Student_3: We are checking to see if the water has high or low PH.
> Interviewer: Why did you choose this study?
> Student_1: Um. Our teacher …
> Student_2: It's our science project.
> Interviewer: What do you think you will find?
> Student_3: Um. Ahmmm… well the river is very muddy here so it'll probably be high PH. (laughs again)
> Student_2: Yeah… probably.
> Student_3: Maybe has high or low PH.

Overall, the students who had agency over their choices seemed to be more invested in their work and investigation, whereas students who were assigned projects by their teachers, while generally invested in the work, didn't appear to understand the reasons for undertaking the work. This kind of muddy thinking about why children are doing their school work fits with models that detail a misalignment of processes and settings (e.g., O'Mahony 2010). This model (See figure 2, Learning Processes and Settings) connects learning settings with learning processes and details performance results (i) when a good alignment enhances a learning moment, (ii) explains how a misalignment of settings and processes causes degradation to deep understanding and student performance. In the case of piecemeal teacher generated topic assignment, settings were outdoor, but process emanated from the classroom- a clear example of "turn in for grade" exercises or sequestered problem solving as described by Schwartz et al. (2005).

A similar finding was evident during the presentation of student projects at the end of the unit. All students prepared and presented as part of their small collaborative group. Presentations were first for classroom members; later for parents and teachers and in the case of some students there was a public opportunity to present at the local community college. This came about because of the interest in the dam removal by community members. Many interesting factors emerged as a result of the presentation format and enactment. We describe the highlights here. A number of observations are common to all participants across the board regardless of whether the student was in the piecemeal or historical cohort. All students participated. All students really enjoyed being part of the science and multimedia challenge. Teachers agreed that the opportunity to perform in public (in front of peers, parents, teachers and some public) was “very beneficial to children and especially those who were introverted and withdrawn normally” (O ' Mahony 2011).

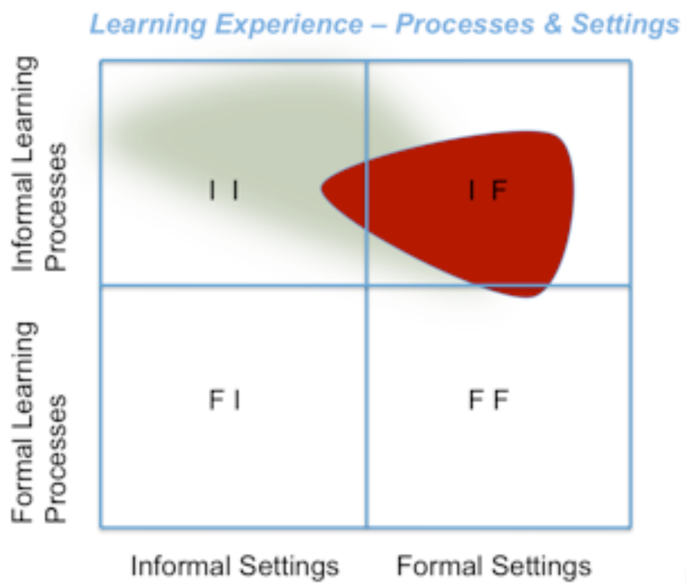


Figure 2. Learning Processes and Settings (O’Mahony, 2010). II denotes Informal Process and Informal Settings; IF denotes Informal Processes and Formal Settings; FI denotes Formal Settings and Informal Processes; FF denotes Formal Settings and Formal Processes. The Shadow cast by the Informal Process and the Formal Setting sometimes impacts the activities and attitudes in another arena (e.g. what happens in the Informal setting where informal processes are expected).

Beneficial as it may have been for all students to take part in, and present a project (using PowerPoint or video), there were significant differences between results of presentations from each cohort. The most common distinction occurred in the piecemeal group and centered on meaning and understanding as regards to the work that the students were presenting. This aligns with findings described earlier with regard to students’ perceptions of what they were measuring and why they were measuring it. For instance, whereas participants in the historical group connected deeply to their projects through narratives and questions that centered on ecojustice for their community, the students in the piecemeal group presented finished projects that reflected an arbitrary surface-level knowledge that appeared to have been gleaned from books and internet without fully comprehending why or what they were doing. The following example is a pervasive occurrence of this phenomenon. A PowerPoint slide (shown in Figure 3) described the scientific "classification" element, which was prescribed by the scientific method used by the teacher pertaining to indigenous salmon species that the students were asked to describe. Three students read their PowerPoint in front of their peers.

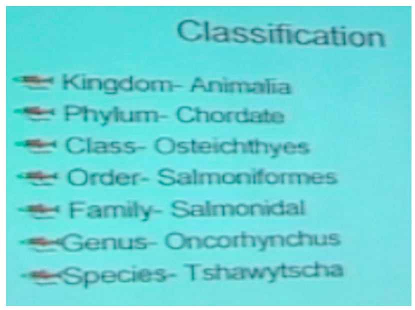


Figure 3 Piecemeal Science Project Presentations

1. Reader_2: Ahmmm this is our classification slide. The kingdom is … an… animalia ((struggles to get the word out))
2. Pullium ((sic)) is Cho…chodray. Class is um oo-ss. I don't know that word.
3. Reader_3: Order ---
4. Reader_2: ((uncomfortable laugh)) I don't know any of them.
5. Reader_3: Those words!
6. Reader_2: Yeah. ((giggle))
7. Reader_1: ((moves on to the next slide))

Many additional observations suggested a level of surface understanding exhibited by students in the "piecemeal" condition where the focus appeared to be on completing the teacher-assigned work rather than on a deep understanding of the concepts within the study.

Historical Presentations

Presentations were much different for students in the historical cohort. The greatest difference stemmed from the fact that participants anchored their video productions in a narrative that involved ecojustice questions and theories that sprang directly from the colossal dam removal life episode in which they were living. Their videos contained footage of themselves, family and friends including interviews of people from the local tribal community.

The historical "video" group productions were different in two other respects also. First, since everything had to be encapsulated in the production (there was no narrator standing in front of the class introducing each piece), there was an expectation that the production was a movie with a beginning, middle, and end. This was not so apparent with piecemeal PowerPoint productions (indeed, some of these productions seemed to just stop at nowhere in particular), maybe because they ran out of material, or time, or both. Second, a movie came with a title, usually a subtitle, and start-up music. Then it entered into the body of the production where most of the content was configured within the narrative framework already mentioned. Finally, the videos were brought to a finish with a scrolling assemblage of contributors and actors accompanied by the students' choice of music again. Some students included an "outtakes" section that really captured the imagination of all involved and usually replayed scenes from the day in the field (lakebed mud and beach). One thing was sure, reported their teachers, "these kids won't forget this project anytime soon…" (O ' Mahony 2011).

All students in this cohort framed their videos in a narrative that described when and why the dams were put-in; what the impact of the dams had been on humans, flora and fauna, and landscape; and, finally, what might be the repercussions to all these stakeholders when the dams are taken down. Many of the students interviewed people (including Native American locals) and other local inhabitants to understand the history of the dam construction. As an example, the following interview was captured by three students (one worked the camera, two carried out the interview) and a couple of fishermen who stood waist-deep in the river mouth, their lines taut in the water. First they asked permission (the fishermen were delighted to talk to the students); then they set up microphone equipment and cameras and began the interview. (transcript:Hist_Gr_3_Elwha_Mouth_11/12/2010).

43. Student_1: Today, November 12, 2012 we are at the um, mouth of the Elwha river. We met these two fishermen and asked them some questions. Good day.
44. Fisherman_1: Good day.
45. Fisherman_2: Howdy.
46. Student_1: Have you caught anything today?
47. Fisherman_1: No. Not today. It is a little unusual, because the fish are in there.
48. Fisherman_2: Yeah – they're in there sure enough, but they're avoiding two old men.
49. 46. Student_1: And what kind of fish are you seeing today.
50. Fisherman_2: Oh, salmon, Chum.
51. Student_2: We are wondering what do you think will happen when the dams are gone, will that affect the fishing.
52. Fisherman_1: When the dams are gone! You bet it will. When those dams are gone there will be lots more fish here. I remember when you could walk across the river on the backs of Sockeye.

> 53. Fisherman_2: Well maybe not on their backs, but there were lots more fish in the past. They can't spawn up there anymore. The big question will be – if they remember how to get up there. It has been nearly 100 years you know.
> 54. Student_1: What about the sediment? Won't that hurt the fish?
> 55. Fisherman_2: Yeah. That is true. When the dams first come down the sediment will probably be too heavy. Today, there is a lot of sediment, but not too much to hurt the fishing. But much more would be bad.
> 56. Fisherman_1: But over time, that sediment will go away, it will probably make nice beaches down here.

This excerpt describes a deep interest and local knowledge expressed by people who are engaged in living in the community. The narrative reflecting ecojustice principles including contentious questions that revolved around sediment, safe potable water supplies, whether the local tribes should own the land that emerged from the drained lakes as they did in the past, and other issues that had the potential to be divisive for the community. These were the questions and issues that emerged in the video productions. These issues did not surface in the PowerPoint productions. We posit a theory that overbearing prescribed formulaic teaching models prevented the students from engaging in the social and ecojustice issues that were ubiquitous in the community and readily available for their consumption and engagement.

In general, the video productions reflected a level of engagement and interest in the subject matter, because the students had chosen their own topic of investigation and were using their own resources to collect data and create their finished projects. What was most illuminating was the level of attention and engagement expressed by the audience for video productions, with music, scrolling list of "actors" and especially the "outtakes".

Students' Role in An Ongoing Ecological Project

This study sought to understand different ways of making connections between outdoor learning experiences and classic classroom instruction. We asked if we anchored instruction in questions related to EcoJustice and habitat restoration; would it impact students' understanding of big ideas and their role in an ongoing ecological project. A large dam removal development provided the catalyst for controversial, often divisive, events and animated discourses that held the attention of just about all members of the community, including parents of the middle school students involved in this study and other stakeholder groups (e.g., local tribal members, agri-business, fishery and industrial investors). Questions we studied focused on whether engagement in issues of ecojustice and ecology might succeed in connecting traditional classroom learning with the natural world in a way that would help students gain a deep understanding of the issues involved and help prepare them for future learning.

Findings from this study suggest implications for teachers and learners. Results suggest that there are foundational advantages for teachers who approach their students' learning space with a solid understanding of how alignment of process and settings enables deep understanding and a preparation for future learning. What we found reinforces the idea that intentional alignment of processes and settings facilitated deeper connection to real-world concerns; and, a deeper understanding of the science and math involved in enacting local engineering projects (e.g., largest dam removal and habitat restoration in US history). A further take-away for learning scientists was that "agency" matters; middle school students who had choice over the selection of science projects were more engaged, more attached and, indeed, more connected to immediate situations and predictive investigations in the real world. These students demonstrated deep understanding of questions relating to ecojustice and environmental issues that cropped up around local decisions and outcomes of events in their communities and beyond. In addition, middle school students who approached their science projects from a historico-narrative cognitive envelope demonstrated an ability to connect their ideas and methods easily with meaningful knowledge that made their end-product presentations rich and meaningful to them and their fellow students. This was in stark contrast to similar middle school students who carried out work in a piecemeal fashion that was guided by the classroom teacher. These students followed a traditional prescriptive model that enabled them to produce presentations that met grade requirements for science exploration and method understanding. But in comparison with their "historical" classmates, their knowledge was more in line with what Whitehead (1929) referred to as disconnected facts, which were "inert" and consequently, they were less engaged in ecojustice and environmental questions that made meaning within a local community perspective. Finally, questions of ecojustice, ecological impact, and habitat restoration catalyzed lively discussions and enabled a deep understanding of concepts and issues within schoolwork that connected them to local environment and community questions. Discussions with students indicated that this facility with a deep understanding of real questions in their natural world, had an important impact for enabling a manifest identity around geo-sciences and STEM-related work and life opportunities that were otherwise outside the scope of their career radars.

Incidental measures, which had not been anticipated by the study team, appeared to corroborate the findings that are described above. These measures were of interest to the study principally because they were highly significant for the students since they raised visibility of their science projects for parents, teachers, and school administrators. While we cannot claim causality (we were not able to compare interventions/methodologies in other schools across the system), eighth grade results for state-administered science tests improved to an extent that captured the attention of everyone associated with the school and the study.

The following graphic illustrates a small sliver of a large banner that the principal had posted on the outside of the school after State of Washington MSP (Measures of Student Progress) results revealed a solid leap for student performance in 2010 – the year they were engaged in the Elwha science investigation.

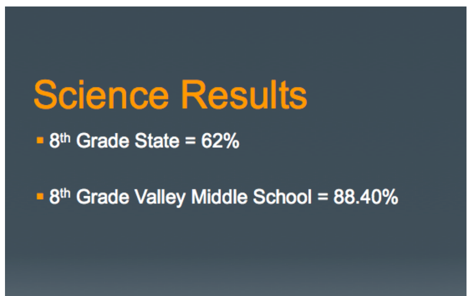
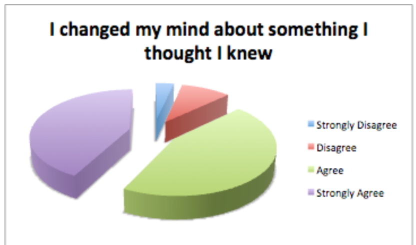


Figure 4, Portion of Banner displaying 8th Grade Science in State Tests (MSP)

Independent MSP measures showed that a significant number of students in the project passed the State administered 8th grade science test compared to previous years and in comparison to same grade schools in the state. Year by year, state averages for passing these tests ranged around the low to middle fifties. For instance in 2008-09 8th grade science results for the State of Washington were 51%, Valley Middle School was just below that at 49%. In 2009-10, 8th grade science results for the State of Washington increased slightly to 54%, Valley Middle School remained in line at 55%. Once again, in 2010-11 8th grade science results for the State of Washington jumped into the low sixties ~61%. But this time, Valley Middle School displayed a conspicuous increase outstretching all previous performances to reach 88.4%. While we do not claim responsibility for this positive outcome, the principal, teachers, students and parents were convinced that the results were directly responsible to the increased engagement, interest and knowledge about ecojustice questions that arose as a result of the dam project. From the perspective of school administrators, students and parents (who had witnessed high drop-out rates for years), this strong increase in science scores was a very welcome sight for the community. The enthusiasm that was shared by and among teachers who partook in this program is captured in exit interviews that elicited their comments and thoughts about the effectiveness of the intervention.



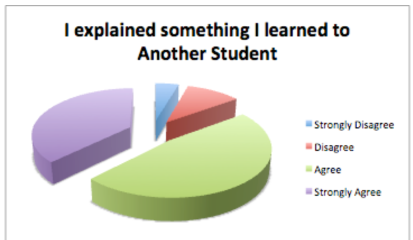


Figure 5a and 5b. Peer-to-Peer Learning

Figure 5 offers two samples of how teachers describe improved learning for students based on effective blending of classroom teaching methods with outdoors experience coupled in ecojustice concepts and ecology topics. It is evident that ~90% of learners experienced a metacognitive moment by realizing their conceptual change with regard to letting go of preconceptions and gaining a new understanding of questions relating to this landscape and the science around dam removal. Similarly, a very high percentage (~95%) of students were able to explain a scientific topic relating to their work to fellow students during the course of the study.

Next Steps

Future plans for this research endeavor include deepening the inquiry around issues of concern with regard to learning in informal and blended environments. For example, although this study was conducted in middle school science classes, it is conceivable that a well thought-out program might effectively engage younger children also. We believe that similar interventions in junior grades would enable children to become more engaged in aspects of science and that they would gain skills that might remain life long and life deep.

Finally, the notion of scaling-up this project is appealing – to make skills and knowledge that a community learns in a project of this breadth and depth available to other communities where dams are being taken down and habitats are being restored (approximately 300 dams will have to be removed in the US over the next decade, for reasons that include safety and environmental degradation). Internationally, ecojustice questions around dam removal and habitat restoration are allied with serious ecosystem questions about sustainability and survival in a world that is quickly experiencing over-population and a consequential scarcity of resources. Lessons from Native American tribal people in the Elwha valley include managing meager resources, efforts to establish a revived fishing industry, and bringing geosciences to the fore in schools and classrooms. These are questions this study has experienced where new knowledge and resources might offer a voice for communities who are approaching this place in time.

Acknowledgements

My colleagues Dr. John Bransford, and Dr. Nancy Vye at the University of Washington LIFE (Learning in Informal and Formal Environments) Center, deserve huge credit for their vision and profound support in the design, implementation and analysis of this "dam" project. I would also like to thank the members of the Elwha community who shared their experience and knowledge with me during the implementation of the study. Finally, to the teachers and students in Valley Middle School I owe a huge debt of gratitude for opening their classrooms to investigation and analysis without prejudice or fear.

*This study was partially funded by NSF RAPID Grant 1014508.

Notes

1. This research took place at the same time and in the same location as the largest dam removal and habitat restoration project in the US. By Federal decree, two dams were ordered removed from the Elwha River in Northwestern Washington, and to restore the river to its natural state.

2. Miller stated that; "Those who value science reflect that value in their choice of toys and books, in their use of zoos and museums, and in their own curiosity about the world in which they live. And their knowledge and interests have a profound influence on their children. Recent data from the Longitudinal Study of American Youth, through which my colleagues and I have been following 4,000 Generation Xers since 1987, show that 40 percent of children whose parents actively encouraged them in math and science planned to major in a STEMM (science, technology, engineering, mathematics or medicine) subject in college, as compared with only 8 percent of children who did not receive the same level of encouragement" (p. 64).

References

Allaway, J. (2004). Understanding the Elwha: A strategy for research and education programs on the Elwha River (pp. 1-32). Spokane: Huxley College of the Environment.

Basu, S. J., & Barton, A. C. (2007). Developing a sustained interest in science among urban minority youth. Journal of Research in Science Teaching, 46, 50-73.

Casey, J. (2006, January 6th). Storm continues eating away at Angeles Point, Peninsula Daily News, Port Angeles, WA.

Chin, D. B., Dohman, I. M., Cheng, B. H., Opezza, M. A., Chase, C. C., & Schwartz, D. L. (2010). Preparing students for future learning with teachable agents. Educational Technology, Research and Development, 58, 649-669.

Cornwall, W. (2009, April 22). Stimulus money will speed Elwha dam removal, The Seattle Times.

Freilich, J. (2010). Glines Canyon Dam Lecture. Seattle: University of Washington.

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. Educational Psychologist, 41, 111-127.

Krapp, A. (2000). Interest and human development during adolescence: An educational-psychological approach. In J. Heckhausen (Ed.), Motivational psychology of human development.

Lee, O., & Luykx, A. (2005). Dilemmas in scaling up innovations in elementary science instruction with non-mainstream students. American Educational Research Journal, 42, 411-438.

Mehan, H. (1985). The structure of classroom discourse. In T. van-Dijk (Ed.), Handbook of Discourse Analysis (Vol. 3, pp. 119-131). London: Academic Press.

Miller, J. (2012). The value of bringing science home. Scientific American, August, p. 64.

National Research Council. (2009). Learning science in Informal environments: People, places and pursuits. Executive summary. In P. Bell, B. Lewenstein, A. Shouse & M. Feder (Eds.), Learning science in Informal environments: People, places and pursuits. Washington: The National Academies Press.

Nunnally, J. C., & Bernstein, I. H. (1994). Psychometric Theory (3rd ed.). New York: McGraw-Hill.

O ' Mahony, T. K. (Producer). (2011, 9/15/2012). Elwha watershed learning sciences project. University of Washington: In the news. [Science Report]

O'Mahony, T. K. (2009). Stream: Research that advances STEM. Paper presented at the American Education Research Association, San Diego, CA, San Diego.

O'Mahony, T. K. (2010). Connecting formal and informal learning experiences. (PhD Dissertation), University of Washington, Seattle.

Renninger, K. A., & Hidi, S. (2002). Student interest and achievement: Developmental issues raised by a case study. In A. W. J. S. Eccles (Ed.), Development of achievement motivation (pp. 173-195). New York: ACADEMIC.

Schraw, G., Flowerday, T., & Lehman, S. (2001). Increasing situational interest in the classroom. Journal of Research in Science Teaching, 38, 211-224.

Schwartz, D. L., Bransford, J. D., & Sears, D. (2005). Efficiency and innovation in transfer. In J. Mestre (Ed.), Transfer of learning: Research and perspectives (pp. 1-51). Greenwich: Information Age Publishing.

Singh, K., Granville, M., & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interest and academic engagement. Journal of Educational Research, 95, 323-332.

Tai, R. T., Liu, C. Q., Maltese, A. V., & Fan, X. T. (2006). Planning early for careers in science. Science, 312, 1143-1144.

Valadez, J. (2010). Best Practices for Education with Native Students: Making History in the Elwha. Paper presented at the Olympic Park Institute Teaching Skills with Native Americans, Olympic Park Institute, Port Angeles, WA.

Xu, J. (2008). Models of secondary students' interest in homework: A multi-level analysis. American Educational Research Journal, 45, 402-436.

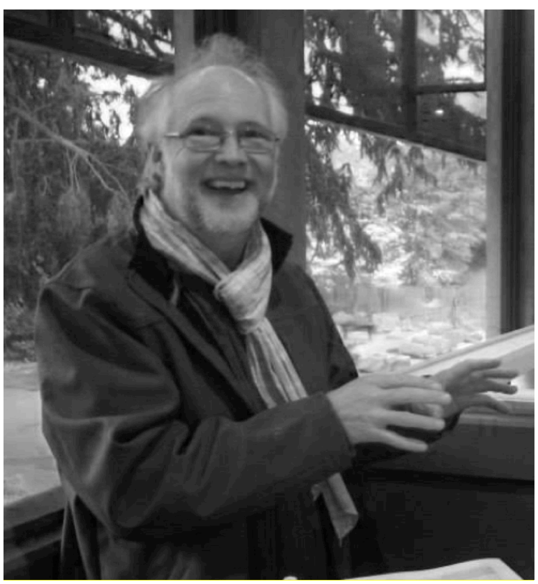
Xu, J., Coats, L. T., & Davidson, M. (2012). Promoting student interest in science: The perspective of exemplary African American teachers. American Educational Research Journal, 49, 124-154.

Young, R. S., & Kinner, F. (2008). *The Elwha Education Project (ESEP): Engaging an entire community in geoscience education*. Paper presented at the American Geophysical Union.

Abstract

Extended experience living in an environment is not sufficient to ensure even basic levels of learning about the natural world. The majority of individuals, including teachers, parents, and middle school students associated with the research project described here, demonstrated a shallow and superficial knowledge with respect to the place where they live. This proved remarkably surprising, given the enormity of the engineering project that was, and still is, going on in their back yard, especially considering a growing awareness of persistent issues that were rooted in EcoJustice and sustainability frames, which made their way down to every level of the local community. We investigated how different ways of making connections between outdoor learning experiences and classroom instruction impact students' learning performance. The study took place in the context of a large dam removal project (two dams were brought down brick-by-brick, and simultaneously) in a major National Park, and in land adjacent to tribal members of the Elwha Nation—a project that provided a simple opportunity to connect school learning and the natural world.

BLACK and WHITE photo HERE



Biography (approximately 50 words HERE)

A fellow of the Royal Geographic Society UK, and a research fellow at the LIFE Center, University of Washington, Dr. O'Mahony explores the intersection of learning sciences, environmental education, and neuroscience. Recent research focuses on socio-cultural perspectives on cognition, learning, and technology in formal and informal learning environments.

Contact information for Author HERE

Timothy Kieran O'Mahony, PhD, FRGS

PO Box 17222

Seattle WA 98127

Ph: (206) 499-0176

tko2@uw.edu

D19 Form: Yes

(YES/NO)