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Forward & Acknowledgments

It has been six years since I wrote the work herein, and seven years since I attended IslandWood as a graduate student in the Environmental Education and Community Program. Since that time I have been teaching full-time in the public schools system. One further constraint that I was not aware of at the time of publishing is the impact that the number of students has on the ability to do things in an outdoor education setting.

The point I am trying to make in this work is, simply, that no matter where one is teaching it is imperative that the curriculum be adapted to meet the need of your current students. Too often the curricula that are written and presented as kits do not consider the place in which one lives; very often that place is rich in geologic or ecological resources but the teacher must find those resources. Further the teacher must feel secure that by amending the curriculum to meet the needs of their students it is acceptable to modify and/or change the lessons provided and that this will help students in the end.

I am grateful for the careful readings of Tom, Ginny, Shira, Rob, and Tina. I could not have completed this project without each students' thoughtful comments. To each respondent of the questionnaires I deeply appreciate your candor.

Thanks, Matthew John Brewer

"The American Association for the Advancement of Science urges teachers to take science *out of the textbook and into reality* and to help students *do science* rather than learn about it" (OSPI 2004:24, emphasis in original).

"Teaching geosciences must not only mirror the language distinction between fifth grade students' ability to know and describe and eighth grade students' ability to *identify* and *explain* geological processes, but must also be enhanced with tangible evidence… Above all, teacher of geosciences must continually amend, adapt, and integrate tangible examples into instruction" (conclusions from this study)

Introduction

What role does tangible evidence and place-based education have in fourth and fifth grade earth science curricula? Given the complex, abstract modeling activities needed to comprehend geosciences, what is the most effective way to teach and understand these complexities? Do the curricula that exist correlate with Washington State Essential Academic Learning Requirements (EALRs) and Grade Level Expectations (GLEs) as well national standards [American Academy for the Advancement of Sciences (AAAS), National Science Education Standards (NSES)]? What should teachers do with curricula that do not provide enough tangible evidence?

Existing K-8 Earth Science curricula that teach earthquakes, volcanoes, plate tectonics, and tsunami often require a middle school level understanding. Fourth grade students are able to grasp complex earth science concepts with tangible evidence. What cognitive maps and perceptions does inquiry-based, experiential learning provide upper elementary (i.e. fourth and fifth grades) students? Will tangible evidence of earth processes enhance student understanding?

My estimation is that upper elementary students who are able to connect geologic processes with tangible evidence are more likely to understand the complexities of the concepts when they are presented later in middle school (AAAS 1993, 2001; CSE 2005; NSES 1995; OSPI 2002, 2005). A long-term study to follow several individuals over extended periods of time is beyond the scope of this paper. I resolve this dilemma, however, in two ways. First, I focus my investigation on perceptions of upper elementary students with video interviews both before and after exposure to tangible geological evidence in the School Overnight Program at IslandWood Environmental Learning center (IW ELC). Second, I examine teacher, curriculum designer, and research specialist's perceptions of earth science curricula at both elementary and middle school levels with a questionnaire. The results of the video interviews, teacher's questionnaire, and curricula designers questionnaire provide an effective means to evaluate student, teacher, and curricula designer perceptions, respectively.

Thus, this thesis is significant for three reasons. First, it identifies a need for inquiry-based earth science education at the fourth grade level and posits a logistical way to fulfill this need. Second, it enriches existing curricula and suggests that teachers make use of local, tangible examples to become better equipped to teach geology in the classroom. Finally, it solicits student, teacher, and curricular designers perceptions to better identify and implement effective teaching of earth sciences in upper elementary classrooms.

Background and Rationale

In August of 2003 I was one of twelve new IslandWood Education for Environment and Community Graduate Students following the site founder around the campus. Deep in the woods, disoriented, and overwhelmed, we came around an unexpected corner to find an array of orange construction fencing. The temporary barrier marked a large excavation site and harbored an exposed earthquake fault. At the bottom of the trench we encountered Brian Sherrod, a United States Geological Society Paleoseismologist, who explained what we had before us — a strand of the Seattle fault, and evidence of a shallow megathrust earthquake 1,100 years before present (Atwater and Andrew 1992; Blakely et al 2002; Blakely 2003; Sherrod 2003a; Weaver et al 1999).

This unexpected find at a fortuitous moment precipitated excitement among the graduate students, and we drafted a proposal to keep the trench open and to become a teaching resource. On a later date, we talked further with Brian Sherrod (2003b) to determine how best to preserve the site, and what kind of information would be most accessible to IslandWood's intended fourth through sixth grade audience (Atwater and Andrew 1992; Blakely et al 2002; Blakely 2003; Weaver et al 1999). We submitted our proposal to Debbi Brainerd. The trench remained open for the year, and remains open with generous grants from the USGS and Aspect Consulting, Inc.[1]

Over the following year I devoted classroom assignments and field experiences to the development of lessons that teach geology at IW ELC. The lessons provide a background to understand the recent geologic history of the PNW (i.e. glaciers 20,000 years before present), the predominant observable earth movements (i.e. earthquakes and their impact), and an emphasis on how people have been affected and will continue to be affected by as an integrating the use of stewardship, consistent with IslandWood's overarching questions and goals. More information, based on several questions of inquiry can be found at the following website: (http://resources.islandwood.org-/geology/questions.htm) (Brewer 2003a, 2003b, 2004b, 2004c, 2004d, 2004e, 2004f, 2004g, 2004h, 2004i, 2004j, 2004k).

About IslandWood Environmental Learning Center (ELC) [2]

IslandWood is a non-profit 501(c)(3) organization that strives to educate and teach community environmental stewardship by linking the arts, science, and technology through hands-on learning in a natural setting. The innovative outdoor learning facility is located on Bainbridge Island, Washington and began in 1998 with the purchase of 255 acres of second-growth timber near the site of the former Port Blakely Mill. The land contains six distinct ecosystems: a forest, cattail marsh, bog, stream, four-acre pond, and access to a marine estuary on adjacent public property, as well as a preserved earthquake fault (discovered in 2003). Following nearly two years of research, community meetings, and focus groups with children, teachers, scientists, artists, and historians, and

[1] IslandWood continues to develop a plan for the site. It is my continued hope that an accessible alternative will be made available to the public for a number of reasons. A sample of the lessons
[2] The following section is adapted from Brewer (2004a) and IslandWood ELC (2001, 2003), and based on my experiences as an EEC Graduate Student 2003-2004.

fundraising, design and construction began on the campus buildings, trail system, and outdoor field structures. IslandWood piloted education programs in Spring 2002 and began the first year of operation in September 2002.

The programs are unique in that they integrate scientific inquiry, technology and the arts while using cultural and natural environments as the context for hands-on learning. Operating from sustainably designed facilities, IslandWood also serves as a model for energy conservation and community stewardship.

School Overnight Program (SOP)

During the school year, the primary focus is to provide a 4-day residential learning experience for 4th, 5th, and 6th grade students in the Puget Sound region — the School Overnight Program (SOP). Each week of the school year, approximately 100 students and their teachers live on campus for four days and three nights. Each year IslandWood hosts approximately 2,400 children and 250 teachers from Seattle and Kitsap County in the SOP. More than half of the children that attend the SOP come from schools with a high percentage of students on free and reduced lunch. IslandWood provides scholarship assistance to as many students as possible. In 2003 IslandWood provided tuition assistance to over 60% of the students from participating schools.

Each instructor teaches a total of seventeen weeks with a group of 8-10 children and one adult chaperone. Each week teachers use a curriculum that integrates scientific inquiry, technology and the arts while using cultural and natural environments as the context for hands-on learning.

At various weeks throughout the academic year schools have the opportunity to participate in the Artist In Residence (AIR) and the Scientist In Residence (SIR) programs to complement the SOP. These individuals, often leading researchers, designers, and innovators in the their respective fields, work closely with the students in their SOP to integrate the expertise of their knowledge consistent with the IslandWood mission of integrating the arts, science and technology. They work with two groups each full field day, and conduct an evening presentation one night during the SOP. Example participants include (but not limited to) Art Kruckenberg, Emeritus UW Botanist and Puget Sound Natural Historian, Brian Sherrod, USGS Paleoseismologist, Jah Breeze, Congolese drummer, Melinda West, Traditional Suquamish basket weaver.

Graduate Program in Education for Environment and Community (EEC)

In partnership with the University of Washington, IslandWood offers on-site graduate study in educational theory and methods emphasizing teaching and learning about community, environment and stewardship granting a Certificate in Education for Environment and Community. Each month students in alternate cohorts spend two weeks teaching in the SOP and two weeks focusing on academics and school partnerships. The purpose for the Graduate Program is to train current and future educators to create learning environments that offer every child the opportunity to gain a deeper understanding and appreciation of both human and natural communities.

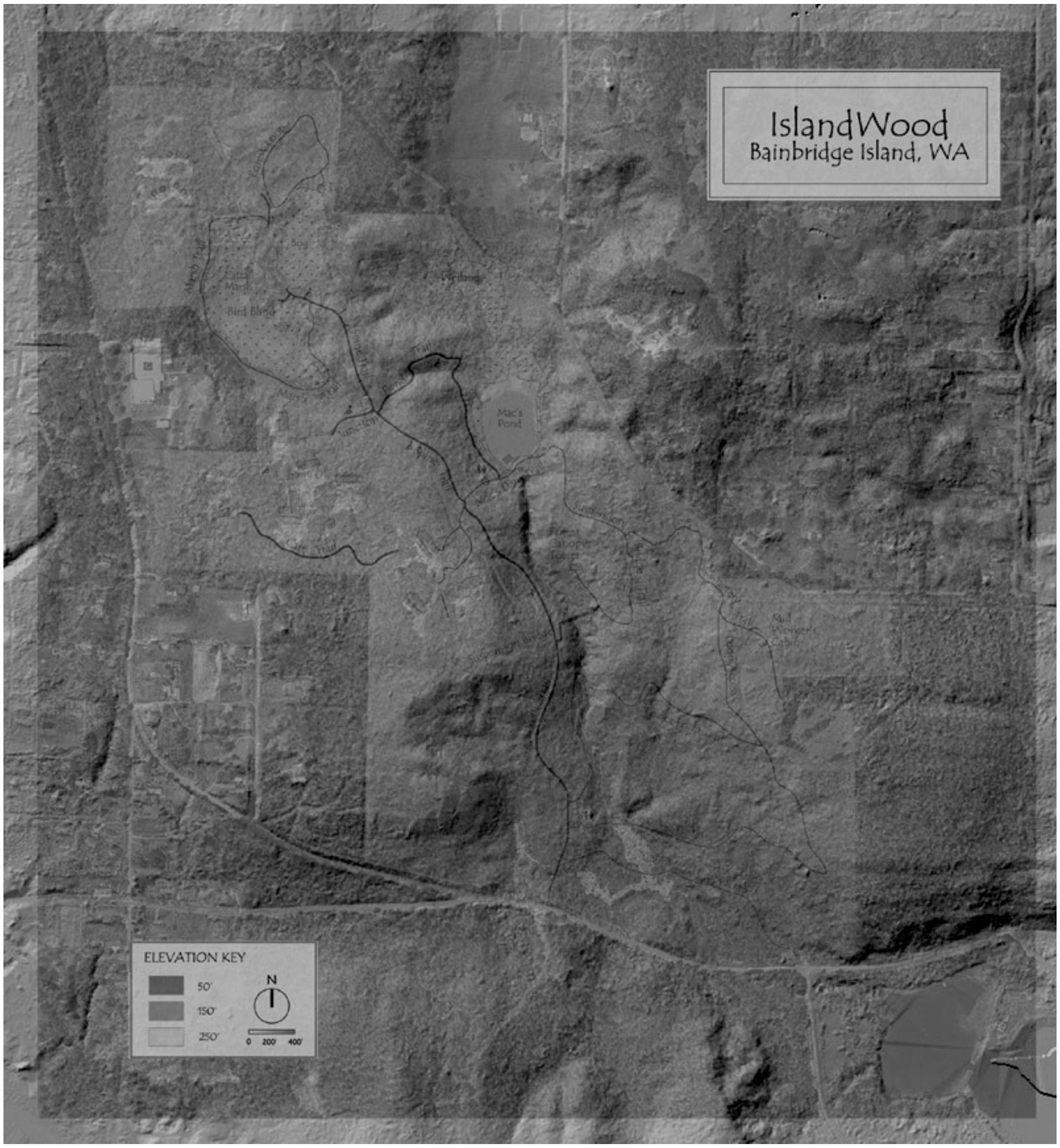

Figure 1: IslandWood Campus Superimposed on LIDAR and Aerial Photo (Brewer 2003b).

Preliminary Literature Review, Analysis of Education Standards, and Needs Assessment

A preliminary literature review of existing K-8 Earth Science curricula that teach earthquakes, volcanoes, plate tectonics, and tsunami linked with national and state standards revealed four paramount themes (AAAS 1993, 2001; CSE 2005; NSES 1995; OSPI 2002, 2005). First, environmental education feasibility studies; second, consistent definitions of geoscience language used with fourth through sixth graders understanding; third, analysis of national and state education standards; and fourth, analysis of existing elementary and middle school earth science curricula. Further, limited studies have been done that correlate national and state standard expectations with inquiry-based curricula in upper elementary grades, especially in Washington State.

Environmental Education Feasibility Studies

Following state mandate of the integration of Environmental Education in 1999 (OSPI 2000), two significant Environmental Education Feasibility Studies have informed this study: a 1999 study conducted by IslandWood (2001, 2003) and the "Report Card on the Status of Environmental Education in Washington State" (OSPI 2004). Additional studies have been done but do not provide evidence specific to Washington State (Kearney 1999; Lieberman and Hoody 1998a).

In 1999 IslandWood conducted a feasibility study that found:

- The Washington State Legislature mandated environmental education for all students in 1999. However, no direct state funding has been allocated by the Legislature (McWayne and Ellis 2003; OSPI 2000).
- Half of the children in the Seattle Public Schools had never participated in a residential environmental education program due to lack of funding.
- The largest barrier to residential environmental education experiences is the long distance of the facilities from Seattle and the resulting high cost of transportation.

- Students in low-income areas receive the least exposure to outdoor-based programs but have the greatest need for experiences beyond their communities.

IslandWood's commitment to excellence in education of the land by the land provides an unprecedented opportunity to educate the greater Puget Sound Region about earthquake mechanisms, regional earthquake hazards and mitigation, and better prepare and inform public awareness of earthquake potential. This thesis, therefore, is part of a continued effort to further develop and integrate earth sciences into the IslandWood curriculum, and in the process benefit the greater Puget Sound Region; development of the IW ELC curriculum is beyond the scope of this thesis (Brewer 2004a, IslandWood ELC 2001, 2003).[3]

Additionally, in 2004, at the bequest of the Washington State Legislature, the state OSPI published the "Report Card on the Status of Environmental Education in Washington State" which provided the following Summary of subjects and grades and overall recommendation:

- Summary of subjects and grades (OSPI 2004:3)
    - Effectiveness of environmental education in improving Students' standardized test scores (**A**) (WA DNR 2004).
    - Legal and academic foundations of environmental education (**A**)
    - Independent, innovative approaches to environmental education (**A**)
    - General awareness of environmental education (**C**)
    - State support of environmental education (**D**)
- Overall recommendation: To sustain the high grades and remedy the low marks in this report, the legislature should direct the state education, natural resource, and environmental health agencies to participate in a statewide Strategic Plan for Environmental Education. The plan will ensure uniform quality, quantity, and delivery of Environmental Education. Broadening the

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[3] A preliminary plan of such a curriculum may be viewed in Appendix.III.4.

delivery of quality EE will further enhance student test scores and increase public awareness of EE and its substantial benefits (OSPI 2004:3).

Further, the Study urges everyone to become involved by suggesting that parents, students, teachers, and school administrators, business people and community leaders, elected officials, and everyone do the following (2004:24-25):

- Parents and Students Can:
    - Tell the school board, Parent-teacher association, and elected officials about the benefits of EE.
    - Urge community leaders to support and expand Environmental education locally.
    - Volunteer with a local EE Program and recruit others to participate.
- Teachers and School Administrators can:
    - Integrate EE into the curriculum across subjects and grade levels.
    - Seek in-service training to learn about outstanding EE programs and methods.
    - Help local EE providers to meet student needs by aligning activities and curriculum with local, State, and national learning Standards.
- Business people and community leaders can:
    - Partner with local school districts and EE providers to enhance student learning.
    - Contribute time, products, and services to EE programs in your community.
    - Support schools and non-profit partnerships providing EE in your community.
- Elected officials can:
    - Establish a lead organization or agency to coordinate and promote EE in Washington.
    - Appropriate funds for statewide EE strategic planning and grant

programs.

- Using national and state guidelines, create standards and programs to provide pre-training and in-service training to EE teachers.

- Everyone can:
  - Join the Environmental Education Association of Washington.
  - Participate in the development of a comprehensive strategic plan for EE in Washington.
  - Support the local EE network, which can be found at www.eeaw.org

Significantly, McWayne and Ellis found that 77 percent of teachers knew of the state mandate and 23 percent of teachers did not know of the mandate (2003:11).[4] Further, 73 percent of respondents claimed to be Aware of EE Use for Improving Student Learning and WASL Scores, while 27 percent claimed not to be; 87 percent of respondents Would Like More EE Info Regarding Improving Student Learning, and 13 percent did not want additional recourses (2003:13). Data from across the state, however, showed a lack of "Adequate Environmental Education Resources to Provide Integrated Education in the Classroom" (2003:33). Overall, about 39 percent claimed to have enough resources, while 61 percent claimed to not have enough resources. Examination of the responses by Educational Service District (Figure 2) reveals that areas surrounding urban areas have the most resources allocated.

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[4] This figure comes from responses of 26 percent of 2,651 schools reporting in Washington State (McWayne and Ellis (2003:6).

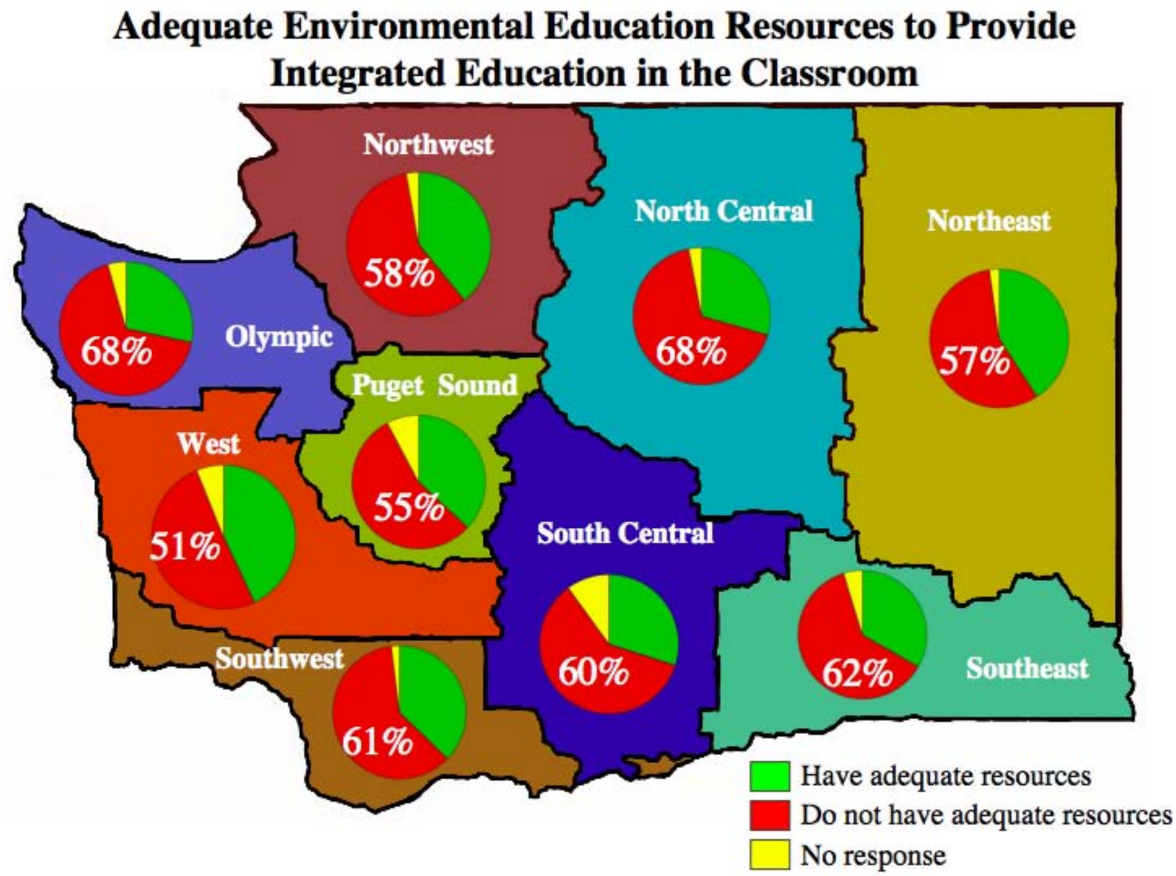


Figure 2: Adequate Environmental Education Resources to Provide Integrated Education in the Classroom (McWayne and Ellis 2003:33).

Definitions

Washington State Science EALR and GLE make an important distinction in the language between the fifth grade and eighth grade benchmark understanding of earth sciences: at the fifth grade level students should *know* and *describe* that geological processes occur and can be slow and gradual (such as weathering and erosion, glaciers, etc.) or sudden and catastrophic (such as earthquakes, tsunami, etc.), whereas at the eighth grade level students should *identify* and *explain* such geological processes (OSPI 2005:32-33). This is perhaps the single most important distinction between the benchmarks, and necessitates careful definitions of student perceptions of processes and interactions in the earth system.

Wiggins and McTighe (1998) advocate a backwards design rooted in six facets of understanding: explanation, interpretation, application, perspective, empathy, and self-knowledge. A backwards design stages three questions to effective curricula design: (1) what is worthy and requiring of understanding? (2) What is evidence of understanding? And (3) what learning experiences and teaching promote understanding, interest, and excellence? Placed into a matrix backwards design provides a comprehensive model that not only aligns with standards, incorporates student understanding, but accounts for student interest and provides continual reevaluation for efficacy (1998:18). Beginning with the language of state and national standards, definitions of *know*, *describe*, *identify*, *explain*, *processes and interactions in the earth system*, and *perception* advocate only part of the backwards design and comprise selected components of the six facets of understanding.

The use of *perception* in this thesis refers to acuity, insights, and observations used to rationale cognitive attitudes. Use of the term includes multiple definitions, such as the process of using the senses to acquire information about the surrounding environment or situation; an attitude or understanding based on what is observed or thought; the ability to notice or discern things that escape the notice of most people; and any of the neurological processes of acquiring and mentally interpreting information from the senses (Microsoft Corporation 1999). Methods to measure perceptions students may acquire, hold, or otherwise exhibit will be explained below.

Conversely, science is riddled with alternative conceptions that both students and teachers may hold. It is imperative that analysis of students' perceptions be cognizant of these alternative conceptions. Such conceptions that teachers may hold are also relevant but beyond the scope of this thesis (Dahl et al 2004; Field et al 2003; Harkin and Ross 2003; Herman and Lewis 2004; Gosselin and Mackelan-Hurst 2002).

National and State Standards

While completing lessons at IslandWood (Brewer 2004b), I endeavored to align my lessons with Washington State Essential Academic Learning Requirements (EALRs), Grade Level Expectations (GLEs) (OSPI 2002, 2005), National Science Education Standards (NSES 1995), and America Academy for the Advancement of Sciences (AAAS) Project 2061 Science Benchmarks (AAAS 1993, 2001).

Additionally, some curricula, such as the Tremor Troops (K-6) and Seismic Sleuths (7-12) Federal Emergency Management Agency (FEMA), provide a logical place to integrate understanding with earthquake mitigation (FEMA 1993, 1995, 1997a, 1997b, 1999, 2005). Other curricula, on the other hand, advocate hands-on inquiry but do not provide local tangible examples, which requires teachers to supplement the curriculum. Moreover, augmentation of the curricula requires both an in-depth analysis of the standards framework as well as knowledge of specific local, tangible examples of geological events, such as on the IW ELC campus, throughout the region. Curricula that provide a strong framework that can be simultaneously based within a local region are highlighted below.

In the following analysis I have focused my attention to benchmarks that relate specifically to processes of the earth, changes to the earth's surface, and plate tectonics. In so doing I am placing emphasis on deep understanding of earthquake processes and mechanisms at both the fifth and eighth grade benchmarks. The perceptions that students may have of this understanding can then be linked directly to the appropriate national and state standards.

<u>Washington State Standards — Essential Academic Learning Requirements (EALRs) and Grade Level Expectations (GLEs)</u>

The Washington State EALRs and GLEs use language to make an important distinction between the fifth and eighth grade benchmark understanding of earth sciences.

These expectations are further explained and illuminated by examining the following GLEs aligned with Science EALR 1.1.5, 1.2.1, 1.2.4, and 1.3.4 (OSPI 2002, 2005). In each of the following entries, the number that follows each bullet in parentheses refers to the grade of expected learning mastery.

The GLE provides these curricula expectations for Earth and Space Systems in Nature and Properties of Earth Materials, at the 3-8 grade level, defined by Science EALR 1.1.5 (OSPI 2005:20,21):

- Understand physical properties of earth materials including rocks, soil, water, air.
    - (3) Describe and sort rocks based on physical properties (e.g., color, shape, size, texture).
    - (3) Describe and sort soils based on physical properties (e.g. color, particle size, ability to retain or drain water, texture, smell, support plant growth, source of mineral nutrients [not food] for plants).
    - (4) Describe the states of water on Earth (i.e., clouds, fog, dew, rain, hail, snow, ice) as solid, liquid, or gas.
- Understand how to classify rocks, soils, air, and water into groups based on their chemical and physical properties.
    - (7) Describe properties of minerals and rocks that give evidence of how they were formed (e.g., crystal size and arrangement, texture, luster, cleavage, hardness, layering, reaction to acid).
    - (7) Describe properties of soils that give evidence of how the soils were formed (e.g., chemical composition such as acidic, types of particles, particle size, organic materials, layering).
    - (7) Describe how Earth's water (i.e., oceans, fresh waters, glaciers, ground water) can have different properties (e.g., salinity, density).

The GLE provides these curricula expectations for Structure of Physical Earth/Space and Living Systems, at the 3-8 grade level, defined by Science EALR 1.2.1 (OSPI 2005:22,23):

- Analyze how the parts of a system go together and how these parts depend on each other.
    - (3) Identify the parts of a system (e.g., a device, natural or living thing) and how the parts go together.
    - (3) Describe the function of a part of a system (e.g., a device, natural or living thing).
    - (4) Describe a simple system that can perform a task and illustrate how the parts depend on each using common classroom materials.
    - (4) Explain how one part of a system depends upon other parts of the same system.
    - (5) Predict and explain how a system would work if one of its parts was missing or broken.
    - (5) Describe what goes into (input) and out of (output) a system (e.g., what keeps a system running)
    - (5) Describe the effect on a system when an input in the system is changed.
- Analyze how the parts of a system interconnect and influence each other.
    - (6) Explain how the parts of a system interconnect and influence each other.
    - (7) Describe the flow of matter and energy through a system (i.e., energy and matter inputs, outputs, transfers, transformations).
    - (8) Describe interactions & influences between two or more simple systems

The GLE provides these curricula expectations for Components and Patterns of Earth Systems, at the 3-8 grade level, defined by Science EALR 1.2.4 (OSPI 2005:26,27):

- Understand that Earth's system includes a mostly solid interior, landforms, bodies of water, and an atmosphere.
    - (3) Identify land masses, bodies of water, and landforms on a globe or a map (e.g., continents, oceans, rivers, mountains).

  - (5) Describe how one part of Earth's system depends on or connects to another part of Earth's system (e.g., Puget Sound water affects the air over Seattle).
  - (5) Identify and describe various landmasses, bodies of water, and landforms (e.g., illustrate continents, oceans, seas, rivers, mountains, plains from a globe and a map).
  - (5) Construct a model that demonstrates understanding of Earth's structure as a system made of parts (e.g., solid surface, water, atmosphere)
- Understand the components and interconnections of Earth's systems.
  - (7) Describe the components of the Earth's systems (i.e., the core, the mantle, oceanic and crustal plates, landforms, the hydrosphere and atmosphere).
  - (7) Describe the interactions among the components of Earth's systems (i.e., the core, the mantle, oceanic and crustal plates, landforms, the hydrosphere and atmosphere).
  - (7) Describe magma (i.e., magma comes from Earth's mantle and cools to form rocks)

The GLE provides these curricula expectations for Processes and Interactions in the Earth System, at the 3-8 grade level, defined by Science EALR 1.3.4 (OSPI 2005:32,33):

- Know processes that change the surface of Earth.
  - (5) Describe how weathering and erosion change the surface of the Earth.
  - (5) Describe how earthquakes, landslides, and volcanic eruptions change Earth's surface
- Understand the processes that continually change the surface of the Earth.
  - (7) Describe the processes by which soils are formed (e.g., erosion and deposition in river systems).
  - (7) Describe how heat (thermal) energy flow and movement (convection currents) beneath Earth's crust cause earthquakes and volcanoes.

- (7) Describe how constructive processes change landforms (e.g., crustal deformation, volcanic eruption, deposition of sediment).
- (7) Describe how destructive processes change landforms (e.g., rivers erode landforms).
- (7) Describe the processes involved in the rock cycle (e.g., magma cools into igneous rocks; rocks are eroded and deposited as sediments; sediments solidify into sedimentary rocks; rocks can be changed by heat and pressure to form metamorphic rocks)

American Academy for the Advancement of Science (AAAS) Standards — Project 2061

The AAAS Project 2061 (AAAS 1993, 2001) templates and benchmarks for Processes that Shape the earth emphasize the importance of learning "what causes earthquakes, volcanoes, and floods and how those events shape the surface of the earth… Students may find it harder to take seriously the less-obvious, less-dramatic, long-term effects of erosion by wind and water, annual deposits of sediment, the creep of continents, and the rise of mountains" (1993:71). The AAAS Atlas of Science Literacy presents a strand based on change in the Changes that Shape the Earth (CS) map (2001: 51), which overlaps with the Plate Tectonics (PT) map (2001:53).

Several items are curious about the AAAS templates above. The Plate Tectonics map (2001:53) contains no entries for K-2 and 3-5, and, instead, begins understanding at a sixth and seventh grade level. AAAS addresses this omission, and explains that, "some of the benchmarks here are built on earlier benchmarks in the CHANGES IN THE EARTH'S SURFACES map. The intent of not repeating them here is to emphasize that learning about plates and their movement should wait until after students have developed ideas about change and the earth's landforms in the elementary grades" (2001:52). The Plate Tectonics map (2001:53) contains no mention of the rates of change, which would link further back to K-2 and 3-5 grade understanding, and develop the understanding delineated. The Changes in the Earth's Surfaces map (2001:51) contains no mention of earthquakes or volcanoes at the K-2 and 3-5 grade level, when the K-2 benchmark, "some changes are so slow or so fast that they are hard to see," clearly provides for differentiation of what causes gradual or abrupt changes.

Moreover, the Science Benchmarks highlight this discrepancy further. In the introduction to the 3-5 benchmarks for Processes the Shape the Earth, the authors suggest, "students can build devices for demonstrating how wind and water shape the land and how forces on materials can make *wrinkles*, *folds*, and *faults*. Films of *volcanic* magma and ash ejection dramatize another source of buildup" (1993:72, my emphasis). The discrepancy continues at the 6-8 grade level: "it is especially important that students come to understand how sedimentary rock is formed periodically, embedding plant and animal remains and leaving a record of the sequence in which the plants and animals appeared and disappeared" (1993:73). Compare this to one of the 3-5 grade benchmarks: "rock is composed of different combinations of minerals. Smaller rocks come from the breakage and weathering of bedrock and larger rocks. Soil is made partly from weathered rock, partly from plant remains-and also contains many living organisms" (1993:72, 2001:51). Understanding of these interweaving concepts provides concrete depth and breadth. Yet, the absence of these items at the national standards level, and the presence at the Washington State level, clearly indicate that comprehensive earth science curricula are still needed for upper elementary students.

National Science Education Standards (NSES)

The National Science Education Standards Content Standard D, with reference to earth and space sciences, suggests that at K-4 grade level students know the following skills to understand changes in the earth and sky (NSES 1995):

- The surface of the earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.
- Weather changes from day to day and over the seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation.

The National Science Education Standards Content Standard D, with reference to earth and space sciences, suggest that at 5-8 grade level students know the following skills to understand changes in the earth and sky (NSES 1995):

- The solid earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core.
- Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major

geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions.

- Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.
- Some changes in the solid earth can be described as the "rock cycle." Old rocks at the earth's surface weather, forming sediments that are buried, then compacted, heated, and often recrystallized into new rock. Eventually, those new rocks may be brought to the surface by the forces that drive plate motions, and the rock cycle continues.
- Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks.

Analysis of State and National Standards

From the foregoing analysis of the standards defined by the AAAS, NSES, and EALRs many similarities and discrepancies arise. Beginning at third grade all three sets of standards suggest that students grasp how sedimentary processes shape the earth gradually, and the importance of recognizing different rock types (minerals, igneous, metamorphic, and sedimentary). Both the EALR and the NSES agree that students at a fourth grade level recognize that change happens both gradually and abruptly, while the AAAS strangely places understanding abrupt changes at a sixth grade level with more complex understanding of plate tectonics.

Using this framework to teach about a specific earthquake event on the IslandWood ELC campus raises the important question of which standard should be adopted. Even though the AAAS and NSES standards may not be as detailed as the Washington State EALR and GLE, residence and locality in Washington State would necessitate the use of EALR and GLE standards. Heretofore all mention of standards should be thought as in alignment with the EALRs and GLEs.

Although mastery of the five geologic principles (crosscutting relationships, superposition, original horizontality, original lateral continuity, and intrusions) is not required until the 10th grade benchmark, developing a solid foundation of these ideas is an essential learning requirement (OSPI 2002, 2005). Understanding these geologic principles are the essence of understanding *processes and interactions in the earth system* (Hippensteel 2004).

If some of the concepts that relate to understanding earthquakes and geologic processes are targeted at sixth to eighth grade levels, should the material be re-aligned for fourth and fifth grade students? Instead of realign the lesson focus perhaps providing depth and breadth of material as it is presented, when it arises, will pique student interest and prevent later alternative conceptions (Libarkin, et al 2005). I have heard fourth and fifth grade students articulate geologic principles, such as superposition and crosscutting (faulting) after instruction with tangible evidence of an earthquake.[5] The greatest obstacle at the fourth grade level is the concept of deep time; I did not emphasize this concept but instead focused on tangible, visible evidence — an exposed earthquake fault (Libarkin, et al 2005).

[5] Reference is made here to my teaching experience in the IslandWood SOP program during the 2003-2004 academic year, and to the emphasis placed on teaching the lessons created and presented in the Independent Study Project (Brewer 2004b).

Existing Curricula in Earth Sciences for Elementary and Middle School

The following table, adapted from Center for Science Education (CSE 2005), *CSE K-12 Curriculum Dissemination Center: Curriculum Profiles*, displays curricula aimed at specific grade levels. Each entry provides a general overview, identifies the publisher, developer, and the year the curriculum was published. This list is not exhaustive, but representative of earth science curricula aimed at elementary and middle school students. I have excluded curricula that tend to focus on astronomy, physics, and life sciences, to highlight curricula that emphasize earth sciences and processes that shape the earth. I also admit that my exclusion or inclusion is based on a short synopsis provided CSE and not based on first-hand or classroom experience. Questionnaires, described at length below, will provide an opportunity to rate teacher familiarity, efficacy, and student perceptions from teacher's and curricula designers' point of view.

Table 1: Overview of Existing Curricula for Elementary and Middle School.

Grade Level	**Curriculum**
K–6	Developmental Approaches in Science, Health and Technology (DASH) (CSE 2005:3-4).
	DASH comprises 10 clusters, all of which are visited within each of the seven grade levels: Learning; Health and Safety; Time, Weather, and Sky; Way finding and Transportation; Animals; Energy and Communication; Plants; Food and Nutrition; Conservation, Recycling, and Decomposition; and Matter, Space, and Construction. The problem-solving activities are organized into 10 clusters at each grade level. DASH is designed as a sequential, multi-grade, spiral curriculum that enables students to construct their understanding of the basic concepts and skills of science, health, and technology Publisher: Curriculum Research and Development Group, University of Hawaii Year Published: 2000 Developer: Curriculum Research and Development Group, University of Hawaii
K–6	Full Option Science System (FOSS) (CSE 2005:5-7).
	Full Option Science System (FOSS) is a modular science program comprised of 27 modules. The modules are organized under four strands: Life Science, Physical Science, Earth Science, and Scientific Reasoning and Technology. There are five modules at the kindergarten level (Trees; Animals Two by Two; Wood; Paper; and Fabric), six for grades 1 and 2 (New Plants; Insects; Solids and Liquids; Balance and Motion; Air and Weather; and Pebbles), eight for grades 3 and 4 (Human Body; Structures of Life; Ideas and Inventions; Magnetism and Electricity; Physics of Sound; Measurement; Water; Earth Materials), and eight for grades 5 and 6 (Food and Nutrition; Environments; Landforms; Levers and Pulleys; Mixtures and Solutions; Models and Designs; Solar Energy; and Variables). The modular structure of the FOSS program is intended to give teachers the opportunity to adapt and implement the materials according to their own programs Publisher: Delta Education Year Published: 2000 Developer: Lawrence Hall of Science, University of California, Berkeley

Table 1: Overview of Existing Curricula for Elementary and Middle School.

K–6	Insights: An Elementary Hands-On Inquiry Science Curriculum (CSE 2005:8-12).
	The Insights curriculum consists of 17 modules that represent a balance of life, earth, and physical science. The modules also highlight six major science themes: systems, change, structure and function, diversity, cause and effect, and energy. Each module is designed for use at grades K–1, 2–3, 4–5, or 6 and is intended to last six to eight weeks. Each module is made up of a carefully sequenced, age-appropriate set of hands-on experiences designed to be directly relevant to the child. The modules are designed for use in self-contained elementary classrooms, and can be used as a core curriculum to be expanded as necessary, or individually in conjunction with existing programs. Publisher: Kendall/Hunt Publishing Company Year Published: 2nd edition: 2003; 1st edition: 1997 Developer: Education Development Center, Inc.
K-6	Federal Emergency Management Agency (FEMA) Tremor Troops (FEMA 1999:5).
	FEMA and the National Science Teachers Association (NSTA) teamed to create this Teacher's Package with five units: Each of the first four units is divided into three levels: Level 1, for grades K-2; Level 2, for grades 3-4; and Level 3, for grades 5-6. The last unit has four parts with activities for students in all grades, K-6. Unit I, Defining an Earthquake, builds on what students already know about earthquakes to establish a working definition of the phenomenon. Legends from near and far encourage children to create their own fanciful explanations, paving the way for the scientific explanations they will begin to learn in this unit. Unit II, Why and Where Earthquakes Occur, presents the modern scientific understanding of the Earth's structure and composition, and relates this to the cause of earthquakes. Unit III, Physical Results of Earthquakes, provides greater understanding of the processes that shape our active Earth. Earthquakes are put in the context of the large- and small-scale changes that are constantly at work on the continents as well as the ocean floor. Unit IV, Measuring Earthquakes, explains earthquakes in terms of wave movement and introduces students to the far-ranging effects of earthquakes. Unit V, Earthquake Safety and Survival, focuses on what to expect during an earthquake; how to cope safely; how to identify earthquake hazards; and how to reduce, eliminate, or avoid them. Units I through V are intended to be used in the order presented. When students ask questions about earthquake safety, the introduction in Unit V will help you answer their questions. You may want to take time then to do a few activities to enable students to develop quake-safe skills. Publisher: FEMA and NSTA Year Published: 1999, revised Developer: NSTA and FEMA
1–6	Science and Technology for Children (STC) (CSE 2005:13-15).
	Science and Technology for Children (STC) is a modular program comprised of 24 units. There is four units for each grade level, one each in the following strands: a life science, earth science, physical science, and technology. Each STC unit generally has 16 lessons with hands-on investigations. Teachers can use the four modules to comprise the science curriculum for the entire school year or use one or two individual units as supplements to other curriculum pieces. Publisher: Carolina Biological Supply Company Year Published: 1997 Developer: National Science Resources Center (NSRC)
5–8	Investigating Earth Systems (IES) (CSE 2005:21-22).
	Investigating Earth Systems is a modular Earth science curriculum component for middle school. It includes nine activity-based modules designed for grades 5–8. Modules are grouped into three grade levels: grades 5–6, 6–7, and 7–8. Modules introduce concepts through series of Investigations (six to seven per unit), which are presented within a standard format that includes both the skills and the content students are expected to learn. Every investigation follows a learning cycle including: a problem or a question, a series of activities that lead students through finding possible answers to the challenge, content notes for students' background information, and a review and reflect section that encourages students to reflect on what they have done and summarize what they have learned in their journals. A section on thinking about scientific inquiry guides students on a process for thinking back on the use of the inquiry processes. Publisher: It's About Time Year Published: Fall 2000 Developer: American Geological Institute

Table 1: Overview of Existing Curricula for Elementary and Middle School.

Grades	Curriculum
6–8	Foundations and Challenges to Encourage Technology-Based Science (FACETS) (CSE 2005:35-37).
	Foundations and Challenges to Encourage Technology-Based Science (FACETS), is a set of 24 stand-alone, interdisciplinary investigation guides. Each guide presents science, mathematics, and other curricular topics on what is called a "need to know" basis. The nature of the modules suggests that teachers work with other content area teachers in the school to design cross-curricular experiences for the students. Topics present inquiry, technology, and science in a personal and social perspective. Units focus on a set of problem-solving skills that reflect the processes and strategies used by scientists in investigative research: defining a problem, finding information, testing explanations, using models and simulations, designing and making, collecting data, analyzing and checking data, drawing conclusions, communicating findings, and reflecting and connecting. Modules typically begin with an introduction to the topic followed by an average of six activities, taking 2–4 weeks to complete. Distributor: American Chemical Society (Washington, D.C.) Year Published: 1996 Developer: American Chemical Society
6-8	Constructing Understanding of Earth Systems (CUES) (CUES 2005).
	CUES will consist of five units: systems in space, the geosphere, the hydrosphere, the atmosphere, and the biosphere, Each unit in CUES will have six to eight major learning outcomes ("Unit Understandings") that will drive the development of assessments, activities, text, and video for the program. Subject matter outcomes for each CUES unit will be derived directly from National Science Education Standards Structure of the Earth System, Earth's History, Earth in the Solar System, and Science in Personal and Social Perspectives. Outcomes for science inquiry and nature of science will be infused throughout the course. Content in life science and physical science will be addressed when appropriate. More information can be found at http://www.agiweb.org/education/cues/teachers/cuesintro.html. Publisher and Developer: AGI, NSF Year Published: expected 2006 Developed by: AGI and AGU
7–8	Full Option Science System (FOSS) for Middle School (CSE 2005:55-58).
	FOSS/MS is a 9-course middle school science curriculum for grades 6, 7, and 8. The courses are grouped into three strands: Life Science, Physical Science and Technology, and Earth and Space Science. Each strand includes three courses. The Middle School program complements the FOSS K–6 program, also developed by the Lawrence Hall of Science, University of California at Berkeley. The program is published and distributed by Delta Education. Publisher: Delta Education Year Published: 2000–2003 Developer: Lawrence Hall of Science
6-12	Delta Education (Delta Education 2005).
	In addition to the FOSS program, Delta Education offers K-6 curricula such as SCIS 3+, an activity-centered program based on a strong conceptual framework and a well-defined teaching strategy. The Delta Science Modules (DSM) enhance existing science curriculum with complete modular classroom kits. With 57 individual subject modules, DSM provides classroom flexibility allowing teachers to reinforce science content or build curriculum to meet state or local frameworks. Publisher: Delta Education Year Published: ongoing Developer: Delta Education, Educators Publishing Service (EPS), and Orton-Gillingham and Slingerland
7-12	Federal Emergency Management Agency (FEMA) Seismic Sleuths (FEMA 1995:vi).
	FEMA and the American Geophysical Union (AGU) teamed to create the units in this package, which follow a pattern of zooming in and out, beginning with concerns closest to home, moving to general principles and global perspectives, then homing in again to engage students in evaluating their personal preparedness and that of their families, schools, neighborhoods, and communities. Look for the magnifying glass symbols opposite the text, which indicate essential vocabulary and helpful hints (Teaching Clues and Cues). Units 1 and 6 deal most specifically with the personal and local, but every unit contains a mixture of general

Table 1: Overview of Existing Curricula for Elementary and Middle School.

	information and specific, local applications. A healthy respect for the power of earthquakes requires both kinds of understanding. Units 4 and 5 feature interactive lessons in architecture and engineering, topics seldom dealt with in grade 7-12 curriculum materials. Publisher: AGU and FEMA Year Published: 1995 Developer: AGU
9–12	EarthComm: Earth System Science in the Community (CSE 2005:103).
	EarthComm is a high school science curriculum that emphasizes the relevance of Earth science to students' own lives and environments. It includes five modules that can be taught in any order. Each module contains three chapters that constitute units. Each chapter begins with a community-based problem or issue as a Chapter Challenge, which provides an opportunity for students to recall what they might already know about the subject. The Chapter Challenge problem then forms the focus of the chapter activities and content as well as the final assessment. Each chapter contains about six activities or explorations that primarily involve hands-on manipulation, interpretation and construction of maps, or the directed use of designated web sites. The activities and content presentations throughout each chapter are followed by related questions, problems, and exercises. The final Chapter Challenge assessment asks students to tie together all that they have learned throughout the activities. Professional Development support is available through AGI (see www.agiweb.org/earthcomm for further information.) Publisher: It's About Time, Inc. Year Published: 1999–2002 Developer: Dr. Michael Smith, Director of Education at the American Geological Institute (AGI)

Notable Curriculum in Earth Sciences for Grades 4-8

I have evaluated many earth science curricula (cf. Table on preceding pages), and have concluded that the following four are the most effective to engage student interest with tangible evidence, accurate modeling, and self-evaluative assessments to best prepare them for continued learning. The four curricula are *Investigation Earth Systems (IES)*, *Project Earth Science: Geology (PES)*, *Constructing Understanding in Earth Sciences (CUES)*, and *Great Explorations in Math and Science (GEMS)*. Additionally, as with any curriculum addressing geology, glaciology, and other earth sciences, each of these curricula require adaptation for Pacific Northwest place based-education (see Appendix.III.1 for example resources).

Investigation Earth Systems (IES)

Investigating Earth Systems is a modular Earth science curriculum component for middle school. It includes nine activity-based modules designed for grades 5–8. Modules are grouped into three grade levels: grades 5–6, 6–7, and 7–8. Modules introduce concepts through series of Investigations (six to seven per unit), which are presented within a standard format that includes both the skills and the content students are expected to learn. Every investigation follows a learning cycle including: a problem or a question, a series of activities that lead students through finding possible answers to the challenge, content notes for students' background information, and a review and reflect section that encourages students to reflect on what they have done and summarize what they have learned in their journals. A section on thinking about scientific inquiry guides students on a process for thinking back on the use of the inquiry processes (Smith, Southard, Mably 2001, 2002).

Each of the investigations detailed below (Table 2) are available online, and additionally provide many links to supporting materials. For example, Investigation 1 of the Dynamic Planet Chapter includes three relevant links: Paper Models and Animations, Mathematics of Cartography, A Model of Three Faults.

The latter links offsite to USGS Learning Web, and instructs students to construct a colored model (Figure 4) to illustrate a normal fault, thrust (reverse) fault, and a strike-slip fault along the perforated line. To model a normal fault students locate points A and B on the model; students move point B so that it is next to Point A. Observing the model from the side (its cross-section), students draw the normal fault as represented by the model they have just constructed.

To model a thrust fault students locate points C and D on the model; students move Point C next to point D. Observing the cross-section of the model, students draw the thrust fault as represented by the model they have just constructed.

To model the strike-slip fault locate points F and G on the model; students move the pieces of the model so that point F is next to point G. Students draw an overhead view of the surface as it looks after movement along the fault.

In each case students are asked to evaluate the following questions: Which way did the first point (i.e. A) move relative to the second point (i.e. B)? What happened to rock layers X, Y and Z? Are the rock layers still continuous? What likely happened to the river? the road? the railroad tracks? Is this type of fault caused by tension, compression or shearing?

Such a model is effective because it illustrates many geologic principles in one lesson and provides visual, auditory, and kinesthetic learning methods. The next logical step is to visit a tangible example of each of the three faults in the field.

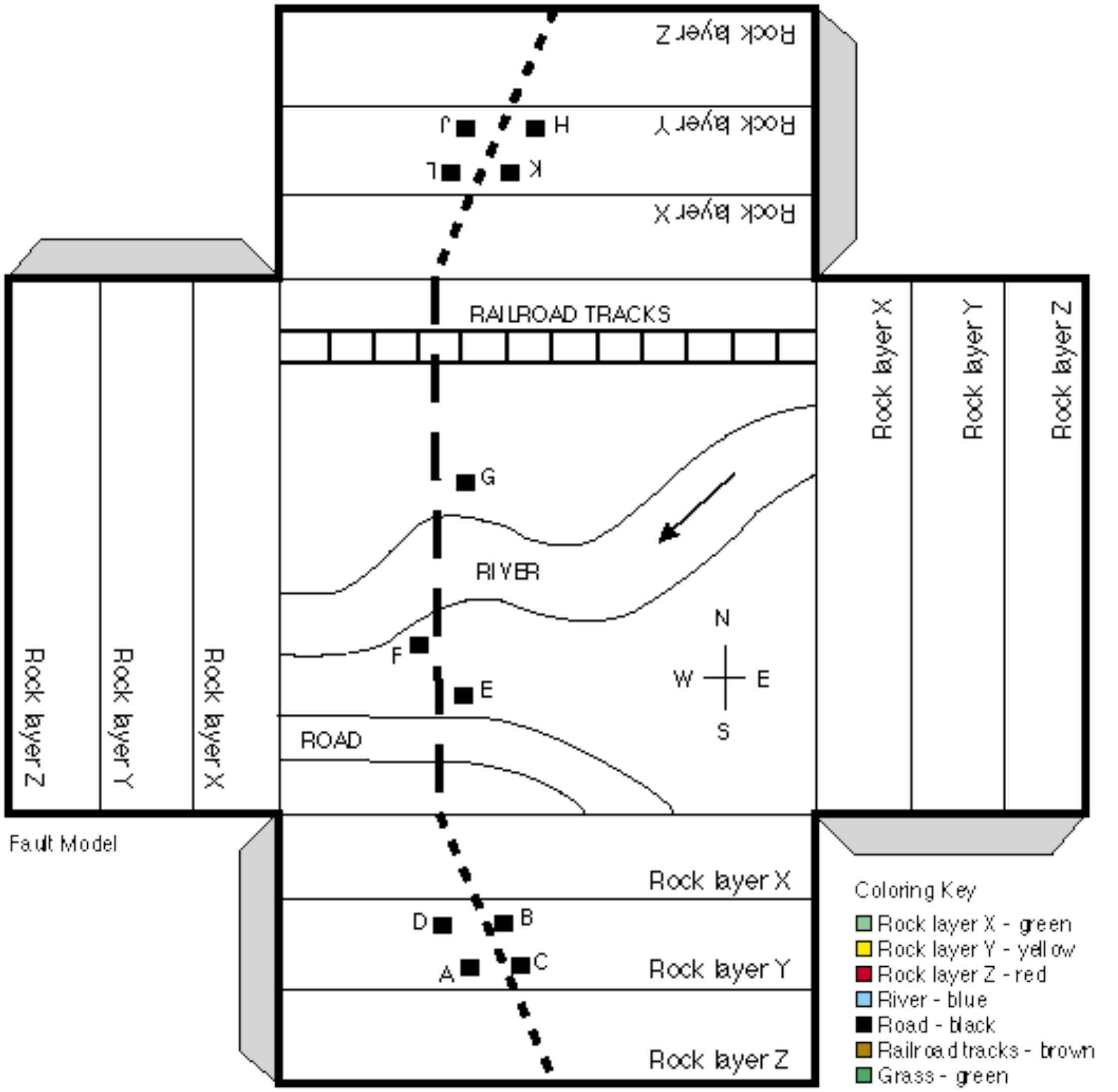


Figure 3: A Model of Three Faults (USGS 2002b).

Module Titles	Grade Level	Investigation Titles
Investigating Soil	**5–6**	**1. Beginning to Investigate Soil 2. Separating Soil 3. Examining Soil Samples 4. Water and Other Chemicals in Soil 5. The Weathering of Materials 6. Rock Abrasion 7. Using Soil Data to Plant a Garden**
Investigating Oceans	**5–6**	
Investigating Materials and Minerals	**5–6**	**1. Materials and Time 2. Properties of Materials 3. Mixing Materials 4. Minerals and Rocks 5. Mineral Exploration 6. Extracting Minerals 7. Tracing a Mineral to Its Source**
Investigating Water as a Resource	**6–7**	**1. Fresh Water as a Resource 2. Tracing Your Local Water Supply 3. Sources of Water 4. Water Movement on the Planet 5. The Special Properties of Water 6. Maintaining Water Resources 7. Water Quality Partnership Plan**
Investigating Climate and Weather	**6–7**	
Investigating Rocks and Landforms	**6–7**	**1. Different Types Of Rock 2. Rocks And Landforms In Your Region 3. Rocks And Weathering 4. Erosional Landforms 5. Deltas And Floodplains 6. Glaciers, Erosion, And Deposition 7. Rocks, Landforms, And Human Activity**
Investigating Our Dynamic Planet	**7/8**	**1. Gathering Evidence and Modeling 2. The Interior of the Earth 3. Forces that Cause Earth Movements 4. The Movement of the Earth's Lithospheric Plates 5. Earthquakes, Volcanoes, and Mountains 6. Earth's Moving Continents 7. Natural Hazards and Earth Dynamics**
Investigating Energy Resources	**7/8**	
Investigating Fossils	**7/8**	**1. The Properties of Fossils 2. Sediment Size and Fossil Formation 3. Fossil Forming Conditions 4. Fossils and Geologic Time 5. Comparing Fossils Over Time 6. Being a Paleontologist**

Table 2: IES' Module And Investigation Titles At Each Grade Level (CSE 2005:21-22).

Project Earth Science: Geology (PES)

Project Earth Science: Geology introduces students to plate tectonics and teaches them what causes volcanoes and earthquakes. Lead explorations of these and other larger-than-the-classroom geological phenomena with the teacher-tested, *Standards*-based activities. Earth's physical evolution and dynamic processes are carefully explained in language accessible to students and teachers. Supplemental readings provide educators with the background information to answer student questions and concerns (Ford 2001).

The lessons in PES are hands-on and student-centered; they require students to develop cognitive models that can then be extrapolated into working models. An iteration of the lesson "All Cracked Up" — to understand the inner structure of the earth and corrects ratios thereof — can be viewed in the film "Tectonic Modeling" on the companion DVD.

Module	Grade Level	Activity/Reading
Project Earth Science: Geology — Activities	**5-8**	**Activity 1: GeoPatterns** **Activity 2: All Cracked Up[1]** **Activity 3: Edible Tectonics** **Activity 4: A Voyage Through Time** **Activity 5: Solid or Liquid?** **Activity 6: Convection** **Activity 7: A Drop in the Bucket** **Activity 8: Seafloor Spreading** **Activity 9: Volcanoes and Plates** **Activity 10: Volcanoes and Magma** **Activity 11: Volcanoes and Hot Spots** **Activity 12: Shake It Up** **Activity 13: Rock Around the Clock** **Activity 14: Study Your Sandwich, & Eat It Too!** **Activity 15: Rocks Tell a Story**
Project Earth Science: Geology — Reading	**5-8**	**Reading 1: Plate Tectonics** **Reading 2: Volcanoes** **Reading 3: Earthquakes** **Reading 4: Rocks and Minerals**

[1] This lesson can be viewed in action by watching the film, "Tectonic Modeling," that I created November 2005 on the companion DVD.

Table 3: PES' Activity and Reading Titles (Ford 2001).

Constructing Understanding in Earth Sciences (CUES)

Inquiry and the interrelation of Earth's systems form the backbone of CUES. Too often taught as a linear sequence of events called "the scientific method," inquiry underlies all scientific processes and can take many different forms. It is very important that students develop an understanding of inquiry processes as they use them. Students naturally use inquiry processes when they solve problems. Like scientists, students usually form a question to investigate after first looking at what is observable or known. They predict the most likely answer to a question. They base this prediction on what they already know to be true. Unlike professional scientists, students may not devote much thought to these processes. In order to take a scientific approach to questions, students must formally recognize these processes as they do them. To make sure that the way they test ideas is fair, scientists think very carefully about the design of their investigations. This is a skill students practice throughout each unit of CUES. Table 3 details the unit and chapter titles (CUES 2004a, 2005).

Unit Title	Grade Level	Chapter Title
Unit 1: The Geosphere and Nature of Science	**6-8**	**Chapter 1 Nature of Science** **Chapter 2 Large-Scale Forces that Change the Geosphere** **Chapter 3 Surface Processes that Change the Geosphere**
Unit 2: The Hydrosphere	**6-8**	**Chapter 4 The Hydrologic Cycle** **Chapter 5 Storage Systems in the Hydrosphere** **Chapter 6 Humans and Water Management**
Unit 3: The Atmosphere	**6-8**	**Chapter 7 Weather** **Chapter 8 Atmospheric Circulation, Weather Systems, and Climate** **Chapter 9 Human Influences on the Atmosphere**
Unit 4: The Biosphere	**6-8**	**Chapter 10 How has the Biosphere Changed over time?** **Chapter 11 The Biosphere Today** **Chapter 12 The Biosphere in the Future**

Table 4: CUES' Unit and Chapter Titles (CUES 2005).

Much like IES, above, CUES complements printed materials with extensive website links to external sites to display relevant and pertinent research endeavors. Further, assessment in these modules requires multiple facets of Understanding (Wiggins and McTighe 1998); the three sample questions taken from the student journal of Chapter

3, “Surface Processes that Change the Geosphere” requires students to think from differing perspectives, explain, apply, interpret, empathize, and examine their own self-knowledge.

1. What are the key characteristics of each rock: Sedimentary, Igneous, and metamorphic?

2. Start with one of the tree types of rocks groups. Write a story from the rock’s point of view to describe its journey through the rock cycle through time. Note the processes that act to change the rock at each stage of its journey. Your must become each rock type during your journey. BONUS: Include plate tectonics in your story.

3. Volcanoes erupt lava and ash to form extrusive igneous rocks. Your friend says that eruptions add new matter to the Earth system. Do you agree with this? Explain why or why not. (CUES 2004b:3)

In another example, students are provided a before, prediction, and after template (Figure 6), and asked to answer some questions about each station of the stream table: Draw a sketch of the landforms in your stream table for later comparison; Describe how the sand eroded and moved, and how the size and shape of the channel change with time (2004b:18).

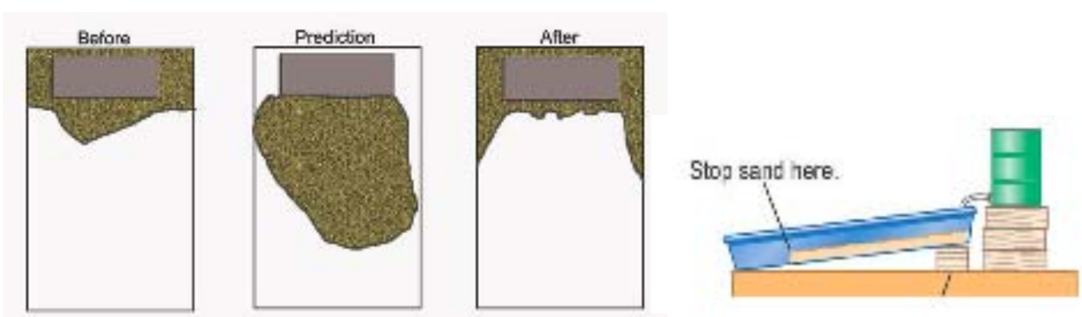


Figure 4: Stream Table Station Drawings (by author) and Construction (CUES 2004b).

Great Explorations in Math and Science (GEMS)

GEMS is a leading resource for innovative science and mathematics education. Developed at the Lawrence Hall of Science, the public science education center at the University of California at Berkeley, and tested in thousands of classrooms nationwide, over 70 GEMS Teacher's Guides and Handbooks offer a wide range of supplementary learning experiences for preschool through 8th grade.

GEMS' activities engage students in direct experience and experimentation to introduce essential, standards-based principles and concepts. Clear step-by-step instructions enable all teachers to be successful presenting the activities. GEMS units offer effective, practical, economical, and schedule-friendly ways to provide high-quality science and math learning to all students (Cuff et. al 1995, 2002).

I obtained two curricula that pertained to teaching earth science: *Plate Tectonics* (Cuff et. al 2002) and *Stories in Stone* (1995). The latter is an earth-science unit that deepens understanding of the processes that lead to the formation of igneous, sedimentary, and metamorphic rocks. This is not a field guide (although it recommends some); *Stories in Stone* helps students demystify the dramatic, inexorable *processes* that cycle through the visible and hidden geology of our planet.

In *Plate Tectonics* students conduct simulated research at key geological sites around the world, such as Hawaii, California, Iceland, Japan and Nepal. Investigations range from the bottom of the ocean to the top of Mount Everest. Classroom models of erupting volcanoes, strike-slip faults, rock layers, and sea-floor spreading help reveal the dynamic nature of the Earth's crust. Students record observations, calculations, and conclusions in a geological field notebook

Module	Grade Level	Chapter/Session
Plate Tectonics	**6-8**	**Session 1: Geologic Time and Processes that Form the Earth's Crust** **Session 2: Field Work in California** **Session 3: Investigating Viscosity and Volcanic Rock** **Session 4: Field Work in Hawaii** **Session 5: Field Work in Japan** **Session 6: Field Work in Nepal** **Session 7: Field Work in Iceland** **Session 8: Evaluating the Theory of Plate Tectonics**
Stories in Stone	**4-8**	**Session 1: Properties of Rocks and Minerals** **Session 2: Distinguishing Rocks from Minerals** **Session 3: The Shapes of Mineral Crystals** **Session 4: Formation of Igneous Rocks** **Session 5: Formation of Sedimentary Rocks** **Session 6: Formation of Metamorphic Rocks** **Session 7: Recycling Earth's Crust** **Session 8: Classifying Rocks and Minerals**

Table 5: GEMS' Module and Session Titles (Cuff et. al 1995, 2002).

Methods, Design, and Timeline

What perceptions does an inquiry-based, experiential learning experience provide upper elementary students? Will tangible evidence of earth processes enhance student understanding? In order to answer these questions, four methods were used in this study: interviews, questionnaires (copies of each are included as an appendix), a comprehensive literature review of existing upper elementary and middle school curricula, and participation in the Scientist in Residence program at IslandWood ELC.

Interviews with selected students

Interviews included two groups of selected students (approximately 16) who have attended and experienced an IslandWood School Overnight Program (SOP). Interviews consisted of questions about what each student knew about earth science concepts both before and after visiting IW.

The first group of 8-10 4th grade students, centered on their 2005 SOP experience at IW ELC, included two group video interviews of 30 minutes each in a pre-IW ELC visit, and the same students in a post-IW ELC interview. Questions focused on three themes: how explanations of earthquakes, glaciers, and superposition may be attributed to exposure of an earthquake fault at IslandWood ELC; how conceptions about plate tectonics may arise (adapted from a study posed to College Students about plate tectonics [Libarkin et al 2005]); and how often students' perceptions of teacher efficacy enhances their learning by making concepts too complicated, inviting outside speakers, or going on field trips.

The second group of 8-10 5th grade students reflected on their 2004 SOP experience in a group video, and took no longer than 45 minutes. The interview had three parts: first, I asked students to explain what they remember from IW; second, they were shown a video of them at IW, and given a chance to correct and amend previous answers. Questions focused on three themes: how explanations of earthquakes, glaciers, and superposition may be attributed to exposure to an earthquake fault at IslandWood ELC; how conceptions about plate tectonics may arise (adapted from a study posed to College Students about plate tectonics [Libarkin et al 2005]); and how often students' perceptions of teacher efficacy enhances their learning by making concepts too complicated, inviting outside speaker, or going on field trips.

Questionnaires for peer educators and curriculum designers

Questionnaires were sent to 10 peer educators and approximately 10 curricula designers about earth science curricula efficacy, variety, and student accessibility. The questionnaire for teachers will be slightly different than the questionnaire for curriculum designers. I anticipated two shortfalls related to questionnaires: the results may be unexpected, and a timely or incomplete return. Candidates were advised to spend no more than one hour to complete the questionnaire thoroughly and candidly. The answers, analyzed below, were gathered to determine efficacy, depth and breadth, as well as student engagement of existing earth science curricula.

Questions in the curricula designer's questionnaire focused on organization and design consideration, amount of feedback received from teachers in the field, recommendations for hands-on, inquiry based activities, and a chance to rate the efficacy of other existing curricula.

Questions in the teacher's questionnaire focused on likes and dislikes of curricula used, how often the curricula must be adapted to meet student needs, how often hands-on, inquiry based activities are recommended (and obstacles that may arise), and a chance to rate the efficacy and familiarity of existing curricula. The questionnaire was sent to candidates at EarthComm, CUES, Exploratorium, IES, LASER, Winston Rinehart and Holt, Delta Education, and GEMS.

Comprehensive literature search of existing curricula

A comprehensive literature search of existing curricula targeting fourth through seventh grade earth sciences, outlined above, shaped how I presented information in the Scientist in Residence program at IslandWood ELC. Analysis of the curricula above must assess the difference between portending to be a hands-on, inquiry based curricula and the reality that teachers and students are able to access tangible evidence in the field.

Cross-referencing the following three perspectives accomplishes this task: perceptions from students point of view will be evidenced in the results of the interviews; perceptions from teachers point of view will be evidenced in the results of the questionnaire; and perceptions from curricula designers point of view will be evidenced in the results of the questionnaire.

Participation in the Scientist in Residence (SIR) program at IslandWood ELC

Participation in the Scientist In Residence at IslandWood (May 23-26) was in pre-assigned groups, and part of an existing School Overnight Program experience working with pre-assigned schools. I worked with three groups each full field day, for a total of six groups of eight to ten students over the week. For this opportunity, I worked with Brian Sherrod, USGS Paleoseismologist, to create an earth science curriculum consistent with the educational mission of IslandWood and based on four geologic concepts: time, change, cycles, and earth at home (stewardship and mitigation). These concepts may be easily amended to different sites. All concepts incorporated deep understanding, inquiry, hands-on experiences, arts, sciences, and technology in a natural setting, and earthquake mitigation.

Completion of a thorough curriculum for IslandWood ELC is beyond the scope of the paper, but its beginning is an essential part of measuring students' perceptions through hands-on, inquiry based lessons centered on tangible geological evidence.

An abbreviated plan of what I accomplished during the SIR is presented below and a full plan appears in Appendix.II.H:

- Group gathers and discusses types of sedimentary rocks, layering;
- Group hikes to the trench to visit the fault; what is an earthquake, what is superposition, how do we know that an earthquake has occurred here, was there anyone living here then, where did they go, why is this important?

- Create a group mural[6] of what is superposition, or what happened with the earthquake fault to share at the campfire
- Group reflection and closure — who will present at the campfire, importance

Decoding and Assistance

During the decoding process, members of the Education Team at IslandWood ELC will be asked to observe recorded video segments. Their continued expertise, input, and constructive criticism will provide additional relevant insights. Further, because of the nature of the material, with an emphasis on inquiry-based, hands-on learning in a natural setting, their observations will provide important checks for accuracy.

[6] The group murals are included in Appendix II.A.

Qualitative and Quantitative Data Presentation from Video Interviews, Questionnaires, and IW SIR

Questionnaires and interviews contain both quantitative and qualitative data. In this section, data is presented through qualitative deep, thick descriptions as well as tabular quantitative formats. A table of each question type follows with notes about where each question is reported and why some are not reported:

Types of Questions: Qualitative or Quantitative?			
Source/?#[1]	**Qualitative**	**Quantitative**	**Reported[2]**
I/1	**X**		**Appendix.II.G.1**
I/2	**X**		**Appendix.II.G.1**
I/3	**X**		**Appendix.II.G.1**
I/4		**X**	**QDS**
I/5		**X**	**QDS**
I/6		**X**	**QDS**
I/7			**N/A[3]**
QPE/1	**X**		**Appendix.II.G.2**
QPE/2	**X[4]**		**Appendix.II.G.2**
QPE/3	**X**		**N/A[5]**
QPE/4		**X**	**QDS**
QPE/5		**X**	**QDS**
QPE/6		**X**	**QDS**
QPE/7		**X**	**QDS**
QPE/8	**X**		**Appendix.II.G.2**
QPE/9	**X**		**Appendix.II.G.2**
QPE/10	**X**		**Appendix.II.G.2**
QPE/11		**X**	**QDS**
QPE/12		**X**	**QDS**
QPE/13		**X**	**QDS**
QPE/14		**X**	**QDS**
QPE/15		**X**	**QDS**
QCD/1	**X**		**N/A**
QCD/2	**X**		**N/A[6]**
QCD/3	**X**		**Appendix.II.G.2**
QCD/4		**X**	**QDS**
QCD/5		**X**	**QDS**
QCD/6	**X**		**Appendix.II.G.2**
QCD/7		**X**	**QDS**
QCD/8	**X**		**Appendix.II.G.2**
QCD/9	**X**		**Appendix.II.G.2**
QCD/10	**X**		**Appendix.II.G.2**
QCD/11		**X**	**QDS**
QCD/12		**X**	**QDS**
QCD/13		**X**	**QDS**
QCD/14	**X**		**N/A[7]**
QCD/15		**X**	**QDS**

[1] Source codes: "I" — Interview; "QPE" — Questionnaire for Peer Educators; "QCD" Questionnaire for Curriculum Designers; "QDS" — Quantitative Data Section, below.
[2] Location where the data is reported herein.
[3] This question is not relevant because it asked if students had any questions of me, and all question content followed the format "What is IslandWood like…"
[4] Questions #1 and #2 have been combined into one question; each part is separated by "______".
[5] This question did not elicit much response from respondents and can not be reported accurately.
[6] Questions #1 and #2 pertain to the mission/vision of curricula but not enough data to report accurately.
[7] Question #14 queries the ease of teaching geosciences. There is not enough data to report accurately.

Table 6: Types of Questions: Qualitative or Quantitative?

Qualitative Data

Full texts of the Interviews questions and Questionnaires appear in the appendix Appendix.I.A and Appendix.I.B, respectively. Full transcripts of video interviews are available in Appendix.II.E and full texts of written responses to interviews and questionnaires appear in appendix Appendix.II.G.

Questionnaires

As anticipated above, Questionnaires sent to peer educators and curricula designers did not yield a significant return. Of the ten (10) questionnaires of each type sent, I received two (3) from peer educators and three (3) from curriculum designers. This presents a dilemma for data presentation: the sample does not provide adequate data to cross reference and meet the expectations anticipated in the beginning of this study. Despite the dearth of data, some of the data will prove to be relevant and will be analyzed below in further detail and in subsequent sections: qualitative data and quantitative data differentiated for each questionnaire (peer educators and curriculum designers).

I have subjectively chosen to limit analysis of the questionnaires to the following questions because they are the most relevant to the overarching question of this thesis and elucidate responses that inspire further thought about the overarching questions of this thesis. Moreover, because the sample size is small, the margin of error for many of the questions is too great to report a measurable difference.

For each questionnaire, I have detailed reported responses as well as what I was looking for within the response. The data is analyzed in the following sections (Data Analysis and Conclusion).

Questionnaire for Peer Educators

I have chosen four qualitative questions from the questionnaire for peer educators: #1, #2, #8, and #9. These asked which curricula were effective for teaching earthquakes and plate tectonics, what is the best use of tangible evidence in teaching, and where would be the most effective field trip location to teach with tangible evidence, respectively.

Responses to Question #1 and #2

My hope with these questions was that responses would help develop a framework of effective curricula and what worked or did not work with these curricula that were being used in the classroom. Further, my hope was that these questions coupled with the quantitative question #7 would inform which curricula are the most effective to teach with tangible evidence. Responses did not meet this expectation because candidates did not answer the second part of each question, "why do you like or dislike these curricula."

Respondents of the Peer Educators Questionnaire indicated few curricula that they used to teach earthquakes and plate tectonics. Curricula mentioned by name included FOSS, STC, and Insights (see the table above for an overview). All responses indicated that the choice of these curricula was a focus on investigations and the research-based approach. Responses to these questions did not inform question #7.

Responses to Question #8

My hope with this question was that, in addition to sites beyond the Seattle metropolitan area. I expected outlying locations such Mt. Rainer, Mt. St. Helens, Olympic National Park, etc. I also expected candidates to mention sites with the Seattle Metropolitan area, such as the exposed bluffs in Discovery Park, exposed bedrock at Alki Point, the Seattle Space Needle webcam (to view Puget Sound glaciation), one of the State Ferry rides (i.e. Seattle-Bainbridge Island or Seattle-Bremerton), or the seismology lab at the University of Washington. In short, I hoped that candidates would think locally and realize that geology is present even in an urban environment.

Respondents of the Peer Educators Questionnaire indicated several common places that would be ideal field trip locations: Mt. St. Helens, Olympic National Park, and/or North Cascades National Park. No one mentioned a location with fifty to seventy-five miles of the Seattle metropolitan area.

Responses to Question #9

My hope with this question was that candidates would indicate a mélange of the possibilities. Even though the question was worded as a quantifiable answer, because the possibilities are easily combined in an educational setting, I anticipated that responses would focus on the most effective way to engage students in geosciences and not focus on the suggested prompts.

Respondents of the Peer Educators Questionnaire indicated a few necessities of most effective way to engage students with tangible evidence, visitations by professional scientists, field trips, and/or use of another educational facility. One respondent suggested using "Tangible evidence [and a] professional scientist." A second response suggested combining "Hands-on activities in class and outside on field trip." A third response focused on student engagement, positing "We engage all students at their conceptions." None of the responses suggested combining all four approaches, such as visiting an exposed earthquake on another educational facility with a professional scientist.

Questionnaire for Curriculum Designers

I have chosen four questions from the questionnaire for curriculum designers: #3, #6, #9, and #10. These asked how the curricula integrated technology, science, and the arts; how the curricula would respond to a struggling teacher of the program; what would be the most effective way to engage students; and what resources are most important to geoscience curricula and are missing from existing curricula, respectively.

Responses to Question #3

My hope by asking this question was that the targeted curricula would link integration of technology, science, and the arts with tangible evidence. Further, I anticipated some mention of the arts as a bridge and unifier between kinesthetic and spatial domains.

Respondents spoke primarily of science and technology but integrating the arts. When asked why such integration is important, candidates answered: **"**Learning is greatly enhanced by such integration and by making multiple links so students can see/apply how concepts bridge different disciplines" ; "Science is a vehicle/catalyst for catching in meaningful way" ; and "The geoscience community is moving more toward a systems approach to studying the planet, so we have designed CUES to reflect this integrated approach. We also want students to use technology and to communicate their findings to one another, as these are important aspects of science."

Responses to Question #6

My hope in asking curricula designers how they would respond to teachers struggling to implement their curriculum was to ascertain a knowledge level necessary to teach the curricula. Further, I anticipated candidates to provide several resources that would be especially helpful to complement their curricula and better inform both student and teacher.

Respondents suggested that such a teacher should “adapt [the material] for their students, without sacrificing essential content or scientific accuracy” ; “getting professional development offered by district or publisher and/or take geology classes, field trips at local college or university” ; and use “a set of literacy strategies that many of our teachers find very useful.” None of the candidates provided additional resources beyond their own curricula materials. None of the candidates mentioned a target level of expertise or what types of classes would be especially helpful (beyond “taking geology classes”).

Responses to Question #9

My hope by asking what would be the most effective way to engage students was that candidates would indicate a mélange of the possibilities. Even though the question was worded as a quantifiable answer, because the possibilities are easily combined in an educational setting, I anticipated that responses would focus on the most effective way to engage students in geosciences and not focus on the suggested prompts.

Respondents focused on hands-on, inquiry approaches that integrate tangible evidence. Only one candidate combined several approaches, commenting, “We have found that the most effective way off engaging students is having them do investigations related to issues in their local communities. They then present their findings to those officials in the community responsible for dealing with the issues.” None of the responses suggested combining all four approaches, such as visiting an exposed earthquake on another educational facility with a professional scientist.

One response in particular, suggesting field trips to the Grand Canyon before and after the unit (see Response #2 in Appendix.II.G.2) presents a challenge to instruction. This particular curriculum, FOSS and FOSS/MS, is centered on the study of Grand Canyon, both from a geologist perspective and from the perspective of the Powell

Expedition. While such an integrated approach is thorough and informative about geologic processes from varying perspectives, expecting students to be able to visit the Grand Canyon before and after study of the unit presents an immediate challenge to successfully implement the curriculum. Where this is not possible (for the majority of schools that adopt the curriculum, such as Seattle Public Schools) there is no alternative field trip location suggested in the Teacher Resource Guide (FOSS/MS 2001).

Responses to Question #10

My hope through asking what curricula designers think are missing from existing curricula was to highlight both the niche occupied by the publisher as well as suggestions for further development. Further, I anticipated responses to highlight difficulties of spatial-temporal understanding in geosciences. I was not looking for the publisher to suggest professional development as a missing component, rather content materials that would make the curricula more effective and better engage students.

One Respondent suggested "professional development" was missing from existing curricula. The other two respondents illuminated important points: **"**the biggest missing element is finding effective ways to convey and deeply implant a sense in students of the holistic/global systems science/nature — the interconnectedness of Earth." ; "It is very important to have students engage with the technologies that geoscientists use to study the planet" such as webs sites, GIS, GPS or other geospatial technologies. None of the candidates addressed the importance of spatial-temporal understanding overtly. None of the responses provided enough data to pinpoint the niche of each curriculum.

Interviews

All Interviews contained the same qualitative questions, and are reported under the corresponding heading. Students were provided written interview questions in advance of each video interview, which provides a mechanism to cross reference their process throughout, as well as amend responses previously written or articulated during the interview. Additionally, each student had a poster do write, draw, or otherwise record their answers during each interview (Appendix.II.B) and the group was shown a PowerPoint (Appendix.II.C).

For each interview, I have detailed was looking for within the interview and students answered for each question. The data is analyzed in the following sections (Data Analysis and Conclusion).

Interview 2004

Since the geology instruction that these students received while in my field group at IslandWood (as fourth graders) was their first exposure to geology, My overall hope was that each of the students in this interview would remember much of what they had learned at IslandWood the year before. I anticipated that their answers would be vague at first, but after showing a video of the fault, superposition, and pictures of several learnings that they would recall with greater acuity. I was not looking to provide instruction through the interview process, or correct alternative conceptions. Further, I was looking for concise definitions of each term.

In question #1, one respondent grasped the temporal concept of a glacier by commenting, “In Washington, like long time age there was a big Glacier.” Another respondent graphically depicted an alpine glacier.

Figure 5: Student Drawing of an Alpine Glacier

A third respondent defined a glacier as "a mass of snow that flows down slowly through or on mountains, valley and also is sometimes covers land areas [and]… is formed into snow and it causes by when it comes to winter snowfalls exceed to summer for many melting years." The final respondent commented that a glacier is "A great mass of ice moving really slow. " None of the candidates commented that a glacier is a river, even though they duly noted the slow rate of travel.

Three of the four students responded to question #2. Responses included mention of shaking, motions of the earth, and breaking of rocks within the earth. Only one student mentioned rupture along a fault; "an earthquake is [caused] by how a sudden of rocks that is breaking along a fault." None of the responses included a component of energy release and accompanying waves emanating from an epicenter.

Responses to question #3 in Part I of the interview (before showing of the PowerPoint and the Superposition Video) were vague and not relevant to a consistent definition of superposition. After viewing the PowerPoint and Superposition Video that revisited some of the things that the student had learned at IslandWood, students revised their responses. When I asked one student what he had said at the beginning of the video, three others responded in unison "the older rock is on the top and the younger rock is on the bottom." I commented, "that's what happened after the earthquake. Before the earthquake, how was it?" One student answered, "the younger is on the top and the older rock is on the bottom," and another added, "so it's like switched." Then I asked, "why is that important that it switched? It tells us that something has happened… like what? "and a student responded with “an earthquake.” Then we revisited PowerPoint slide #2 again and determined that the orange pins represent, in the words of a student, “where the earth, the earthquake” occurred.

Interview 2005 Pre

Students selected for this group interview had not previously studied geology, and my anticipation was that they would exhibit many alternative conceptions throughout the interview without much conceptual knowledge of these geologic terms. Further, by introducing them to some of the concepts they would experience first-hand at IslandWood and through instruction via the Scientist in Residence, later I would be able to anticipate knowledge acquisition and comprehension.

In question #1, only two of the seven students commented that a glacier is a big [or large] mass of ice and snow that moves very slowly down a mountain or across.” None of the students had knowledge of glacier formation.

Student responses to question #2 all mentioned shaking of the earth. Three of the seven students associated earthquakes with volcanoes. Two of the seven students associated earthquakes with shifting and/or crashing movements of the earth and/or lands. None of the students mentioned energy and seismic waves.

In question #3, students were asked to define superposition. None of the students provided a consistent geological definition, and instead answered variations of “I don’t know.” One student defined the essence of superposition, stating “One above the other,” but was unable to express that relationship to horizontal strata.

Interview 2005 Post

After an initial interview, exposure to tangible evidence, and geology instruction through the Scientist in Residence at IslandWood, my hope was that students would articulate an increased understanding these three terms, especially superposition. Further, that they would have a better spatial understanding of the spatial-temporal scale of geology.

Four of five student[7] responses to question #1 defined a glacier as “A big hunk of ice that rolls very slowly and picks up things like pieces of land.” None of the students were able to articulate glacial formation.

Student responses to question #2 all mentioned shaking of the earth. None of the students associated earthquakes with volcanoes. One of the five students associated earthquakes with “Earth shake or (crashes) contarys [sic] crash. ______________________________[8] 2 plates pushing and one wins.” None of the students mentioned energy and seismic waves.

In question #3, students were overwhelmingly able to articulate superposition. Four of the five students defined superposition as the “Young rock on top, old rock on bottom.” The remaining student defined this concept as, “Old rock is on the top and the new is on the bottom,” but incorporated understanding of superposition and an earthquake’s effect into a drawing.

[7] Two students (of the original seven) were absent from this interview, and I have tried to maintain the same order to match student corresponding student responses; inevitably there is some error.

[8] Separates responses between part 1 and part 2 of the answer.

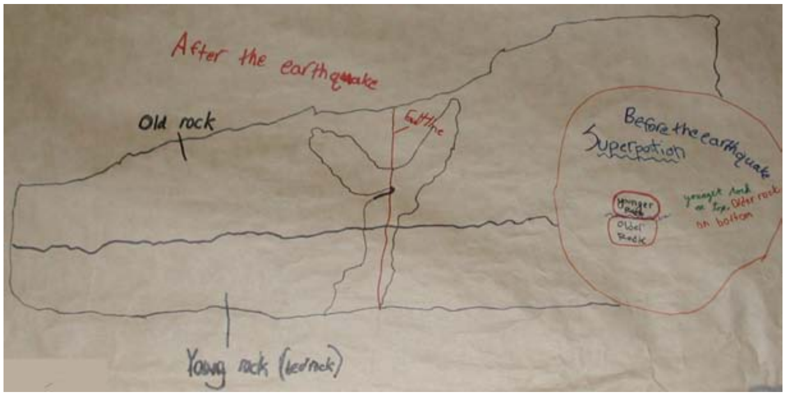


Figure 6: Student Drawings of Superposition

All five students associated the importance of an earthquake with superposition, which is consistent with the definition given during instruction: superposition is the when the older rock is always on the bottom and the younger rock is always on top, unless… unless an earthquake occurs to change that position.

Quantitative Data

Quantitative data consisted mainly of a continuum of answer choices. Even though many of the questions intended to measure much of the same data, it is significant to report all the variations from each data source to illuminate differing perspectives.

The data, however, does not equate to a reliable sample because of low responses to the questionnaires. Nevertheless, that data is reported herein and will subsequently be analyzed in the following section.

Interviews

Each interview contained three measures of quantifiable data. First, students were presented with the Figure 4 below and asked to determine which drawing (A, B, C, or D) best represented the relationship between the Earth's surface and Tectonic Plates. This figure is adapted from a questionnaire given to introductory geology students at the college level (Libarkin et. al 2005). The results of this question are presented in Table 7.

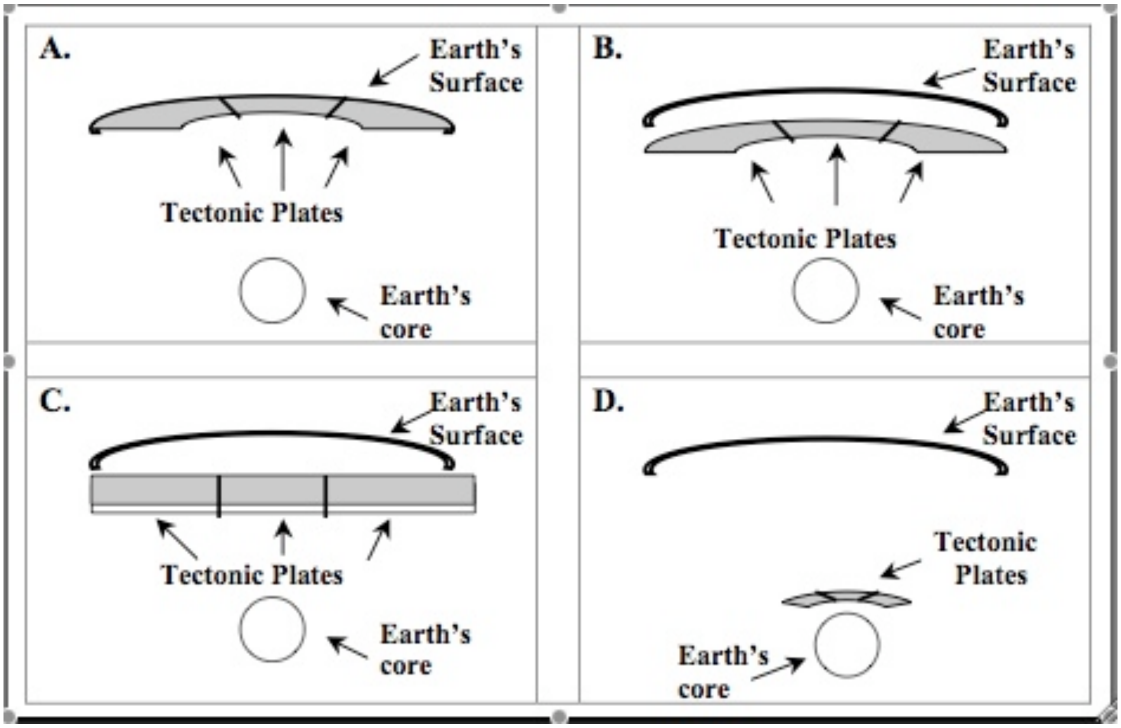


Figure 7: Tectonic Models (Libarkin et. al 2005).

Student Responses to Tectonic Models					
	A[1]	***B***	***C***	***D***	***Total***
2004	1	2	0	1	4
Pre 2005	1	6	0	0	7
Post 2005	0	6	0	0	6
Total	2	14	0	1	17
Percentage	***12***	***82***	***0***	***6***	***100***

[1] The correct answer of these four models is "A." This represents the Lithosphere, which represents 1-2% of the radius of the earth (100 kilometers of 6,378 kilometers [USGS 19991]).

Table 7: Student Responses to Tectonic Models

Second, in each interview, students were asked some general questions about science, how often they found the subject difficult, and how often teachers made the material difficult. My underlying reason for the latter component was to glean data about how much teachers were having to adapt ineffective curricula to engage students. The results of these questions are presented in Table 8.

Three of the four students in Interview 2004 responded to questions 5a and 5b as "rarely" (75%) and "occasionally" (25%). All four students (100%) responded "occasionally" to question 6.

In response to Interview Pre 2005 question 5a one of the seven students (14%) indicated "all of the time"; four of the seven students (57%) indicated "most of the time"; and two of seven students (29%) responded as "rarely". In response to question 5b two of seven students (29%) indicated "most of the time"; one of seven students (14%) indicated "occasionally"; and four of seven students (57%) indicated "rarely". In response to question 6 six of seven students (86%) indicated "occasionally" and one of seven (14%) indicated "rarely".

In response to Interview Post 2005 question 5a one of the five students (20%) indicated "all of the time"; two of the five students (40%) indicated "most of the time"; and one of the five students (20%) responded "occasionally". In response to question 5b two of five students (40%) indicated "most of the time"; two of five students (40%) indicated "occasionally"; and one of five students (20%) indicated "rarely". In response to question 6 four of five students (80%) indicated "occasionally" and one of five (20%) indicated "rarely".

General Science Questions from Part III of Interviews						
		All of the Time	Most of the Time	Occasionally	Rarely	Total[†]
2004	**5a**[1]	**0**	**0**	**1**	**3**	**4**
% Response[Δ]				***25***	***75***	
	5b[2]	**0**	**0**	**1**	**3**	**4**
% Response[Δ]				***25***	***75***	
	6[3]	**0**	**0**	**4**	**0**	**4**
% Response[Δ]				***100***		
Pre 2005	**5a**[1]	**1**	**4**	**0**	**2**	**7**
% Response[Δ]		***14***	***57***		***29***	
	5b[2]	**0**	**2**	**1**	**4**	**7**
% Response[Δ]			**29**	***14***	***57***	
	6[3]	**0**	**0**	**6**	**1**	**7**
% Response[Δ]				***86***	***14***	
Post 2005	**5a**[1]	**1**	**2**	**1**	**0**	**5**[¥]
% Response[Δ]		***20***	***40***	***20***		
	5b[2]	**0**	**2**	**2**	**1**	**5**
% Response[Δ]			***40***	***40***	***20***	
	6[3]	**0**	**0**	**4**	**1**	**5**
% Response[Δ]				***80***	***20***	
Total		**2**	**12**	**20**	**15**	**48**
Percentage		***5***	***25***	***40***	***30***	***100***

† This value represents the number of students present at each interview.

Δ This percentage is calculated from the value statement divided by the students total for each question that students responded.

1 "How often do you think learning about earthquakes, glaciers, and the earth is too complicated (i.e. all the time, most of the time, occasionally, or rarely)?"

2 "Does your teacher make it too complicated (i.e. all the time, most of the time, occasionally, or rarely)?"

3 "How often do you take a field trip in science (i.e. as often as possible, occasionally, not at all)?"

¥ Two students were unable to make the second interview; one student did not respond to this question.

Table 8: General Science Questions from Part III of Interviews

Third, because one my goals of the interview was to show an increase in understanding before and after exposure to tangible evidence, it is imperative to present this data in tabular form. Most significantly, is understanding of the geologic principle of superposition. Data from the interview is presented in Table 9.

Understandings of What is Superposition?				
	Pre 2005	Post 2005[1]	2004 Begin	2004 End[2]
"I don't know"	**6**	**0**	**4**	**0**
"one above the other"[3]	**1**	**5**	**0**	**4**
Total	**7**	**5**[4]	**4**	**4**
Percent Increase	**-**	***100%***	**-**	***100%***

[1] The data for the 2005 interview compare written responses provided prior to each interview and written student responses during the interview (Appendix II.F.2 and Appendix II.F.3).

[2] The data for the 2004 interview compares between written responses provided prior to the interview and written student responses during the interview (Appendix.II.E.1 and Appendix II.F.1).

[3] Understanding of superposition must show relation between "one above the other", horizontal strata, and a dimension of time. The student response in the Pre 2005 Interview does not exhibit this understanding.

[4] Two students were absent from the second interview; one of them was the student that described superposition inconsistently in the Pre2005 interview.

Table 9: Understandings of What is Superposition?

Questionnaires

The quantitative questions reported below focus on three themes: how often adaptation of curricula is needed for understanding, how often the curricula suggests a field trip, and how often a teacher or curricula would integrate tangible evidence (such as an exposed earthquake fault). Despite the small sample size, that data highlights teacher efficacy and curricula strength.

Questionnaire for Peer Educators

Results from the questionnaire for peer educators appears in Table 10 (questions 4-7) and Table 11 (questions 11-13). Questions 4-7 focus on adaptations needed to engage students and level of difficulty for student understanding as well teacher delivery. The sample size is small, but highlights a clear distinction between teaching efficacy and confidence; adaptations are needed every time or needed occasionally to rarely.

Peer Educator Responses to Questions 4-7.					
Question/ Value Statement[1]	Every Time	Weekly	Occasionally	Rarely	N/A
4[2]	**1**	**0**	**0**	**1**	**1**
% Response[Δ]	***33***	***0***	***0***	***33***	***33***
5[3]	**1**	**0**	**1**	**1**	
% Response[Δ]	***33***	***0***	***33***	***33***	***0***
6[4]	**1**	**0**	**0**	**2**	
% Response[Δ]	***33***	***0***	***0***	***66***	***0***
7[5]	**1**	**0**	**0**	**1**	**1**
% Response[Δ]	***33***	***0***	***0***	***33***	***33***

[1] Responses to these questions ranged from every time (as often as possible), weekly, occasionally, rarely, and Not Applicable (or no answer given).
[Δ] This percentage is calculated from the value statement divided by the respondent total for each question.
[2] Question #4: How often do you find a need to adapt these curricula to further engage your students (i.e. every time you teach, weekly, occasionally, or rarely)?
[3] Question #5: How often do you find the curricula you use in Earth Sciences to be too complicated for your students (i.e. every time you teach, weekly, occasionally, or rarely)?
[4] Question #6: How often do you find the curricula you use in Earth Sciences to be too complicated for you as a teacher (i.e. every time you teach, weekly, occasionally, or rarely)?
[5] Question #7: How often do your curricula suggest that you take a field trip to local geologic features (i.e. as often as possible, occasionally, or rarely)?

Table 10: Peer Educator Responses to Questions 4-7.

Before questions 11-13 I provided the statement "IslandWood Environmental Learning Center, Bainbridge Island, Washington, currently has an exposed earthquake fault, the staff to teach about local geology, and a curriculum supported by Washington State Essential Academic Learning Requirements." Questions then asked about the importance of access to tangible evidence and how often candidates would attempt to visit the site.

Questions 11-13 ask similar questions in different ways and can be tabulated together. Candidates indicated that tangible evidence and field trips should be integrated into the curricula either once per week (44%) or once per unit (44%), and only one candidate indicated desire to integrate tangible evidence as often as possible (11%).

Peer Educator Responses to Questions 11-13.				
Question/ Value Statement[1]	As Often as Possible	Once per Week	Once per Year/Unit	Never
11[2]	**0**	**1**	**2**	**0**
12[3]	**0**	**2**	**1**	**0**
13[4]	**1**	**1**	**1**	**0**
Total	**1**	**4**	**4**	**0**
Response %[5]	***11***	***44***	***44***	***0***

[1] Responses to these questions ranged from as often as possible, once per week, once per year and/or per unit, and never.
[2] Question #11: If there were an exposed earthquake fault visible and accessible to you and your students, how often would you seek access?
[3] Question #12: If there were knowledgeable staff willing to teach you and your students about that exposed earthquake fault, how often would you seek access?
[4] Question #13: If there were a comprehensive local geology curriculum, aligned with state standards and centered on an exposed earthquake fault, how often would you seek access?
[5] The response % is calculated from the total number of all responses in questions 11-13 — 9.

Table 11: Peer Educator Responses to Questions 11-13.

Questionnaire for Curriculum Designers

Results from the questionnaire for curriculum designers appears in Table 12 (questions 4-5) and Table 13 (questions 11-13). Questions 4-5 focus on adaptations needed to engage students and level of difficulty for student understanding as well teacher delivery. The sample size is small, but highlights a clear distinction between teaching efficacy and confidence; adaptations are needed every time or needed occasionally to rarely.

Questions 4 and 5 ponder the amount of feedback received from teachers about adaptability and student complications. From a response total of 6 (calculated from the total number of all response in questions 4 and 5), 50% of responses indicated often/continual feedback, 33% indicated receiving feedback occasionally, and 17% indicated never receiving feedback.

Curriculum Designers Responses to Questions 4-5				
Question/ Value Statement[1]	Often/ Continually	Once per Week	Occasionally	Never
4[2]	**2**	**0**	**1**	**0**
5[3]	**1**	**0**	**1**	**1**
Total	**3**	**0**	**2**	**1**
Response %[4]	***50***	***0***	***33***	***17***

[1] Responses to these questions ranged from often/continually, weekly, occasionally, or rarely/never.
[2] Question #4: How often do you receive feedback about your curricula that teachers need to adapt these curricula to further engage their students (i.e. often, weekly, occasionally, or rarely)?
[3] Question #5: How often do you receive feedback about your curricula that teachers find your Earth Sciences curricula to be too complicated for their students (i.e. often, weekly, occasionally, or rarely)?
[4] The response % is calculated from the total number of all responses in questions 4 & 5 — 6.

Table 12: Curriculum Designers Responses to Questions 4-5.

Before questions 11-13 I provided the statement "IslandWood Environmental Learning Center, Bainbridge Island, Washington, currently has an exposed earthquake fault, the staff to teach about local geology, and a curriculum supported by Washington State Essential Academic Learning Requirements." Questions then asked about the importance of access to tangible evidence and how often candidates would attempt to visit the site through the use of each curriculum.

Questions 11-13 ask similar questions in different ways and can be tabulated together but the data is not conclusive. Candidates indicated that tangible evidence and field trips should be integrated into the curricula either once per unit (89%) or as often as possible (11%).

Curriculum Designers Responses to Questions 11-13				
Question/ Value Statement[1]	As Often as Possible	Monthly	Once per Month/Unit	Rarely/ Not at all
11[2]	**1**	**0**	**2**	**0**
12[3]	**0**	**0**	**3**	**0**
13[4]	**0**	**0**	**3**	**0**
Total	**1**	**0**	**8**	**0**
Response %[5]	***11***	***0***	***89***	***0***

[1] The response values for these questions are as often as possible, monthly, once per month/unit, and rarely/not at all.
[2] Question #11: If there were an exposed earthquake fault visible and accessible to be used with your curricula, how often would you seek access?
[3] Question #12: If there were knowledgeable staff willing to teach your curricula using that exposed earthquake fault, how often would you seek access?
[4] Question #13: If there were a comprehensive local geology curriculum, aligned with state standards and centered on an exposed earthquake fault, how often would you seek access?
[5] The response % is calculated from the total number of all responses in questions 11-13 — 9.

Table 13: Curriculum Designers Responses to Questions 11-13.

Combined Data from Both Questionnaires

Question 15 in each questionnaire presented candidates with the same table (cf. Table 1 and the table following question #15 in each questionnaire, Appendix.I.B) and asked them to rate the curricula (CSE 2005) on a scale between 1 and 5 as defined below. the combined data is presented in Table 14.

The questionnaire peer educators used the following scale to rate the following curricula, especially those used, where:

1. engages student interest with no effort and requires minimal adaptations;
2. engages student interest with no effort and occasional adaptations;
3. engages student interest with continual effort and occasional adaptations;
4. requires regular adaptations to engage students; and
5. requires considerable effort to complete lessons and students often do not understand lesson objectives

The questionnaire curriculum designers used the following scale to rate the following curricula that shaped your curriculum development, or are effective at promoting earth science where:

1. is very effective, engages student interest, with no adaptations;
2. is somewhat effective, engages student interest, and requires occasional adaptations;
3. is somewhat effective, often engages student interest, and requires occasional adaptations;
4. is somewhat ineffective, and requires regular adaptations to engage students; and
5. is mostly ineffective, requires considerable effort to complete lessons and students often do not understand lesson objectives

Even though the scales differ slightly in how the candidates were asked to rate the curricula, the focus remains comparable. Candidates were asked to rate the effectiveness of the curriculum (either as teachers or designers) and consider how often adaptations were needed to complete the lesson plans. Therefore, given the focus on adaptations, the combined data is presented in Table 14.

In addition to the above rating, if a candidate could not complete the rating, each candidate was asked to indicate familiarity with the curriculum by placing a check adjacent to the name. the purpose for this request was to attempt to quantify which curricula are the best known and the most widespread and pervasive in classrooms. Several items were left blank, and one candidate did not complete the table (five of six completed).

From the Table and candidates responses, the most well known curricula are FOSS, FOSS/MS (rated by four of the five responses). The next most well know was STC (rated by three of the five candidates), then Insights, FEMA (Tremor Troops and Seismic Troops), and IES (rated by two of the five candidates); a few others that were known by a single candidate (DASH, EarthComm, Exploratorium, and GEMS).

Rating Curriculum Efficacy, Student Interest, and Adaptations											
Curriculum/Score	1	2	3	4	5	F[1]	Total			%	Comments
Developmental Approaches in Science, Health and Technology (DASH)						[1][1]	0	0	0	0	
Full Option Science System (FOSS)	[1]	[2]	(1)[2]			(1)	3	1	4	16	length is an issue; otherwise excellent
Insights: An Elementary Hands-On Inquiry Science Curriculum			[1] (1)			[1]	1	1	2	8	
Federal Emergency Management Agency (FEMA) Tremor Troops			[1]	(1)			1	1	2	8	
Science and Technology for Children (STC)		[2]	1				2	1	3	13	
Investigating Earth Systems (IES)	[1]	[1]					2	0	2	8	dynamic planet is excellent
Foundations and Challenges to Encourage Technology-Based Science (FACETS)		[1]					1	0	1	5	
Full Option Science System (FOSS) for Middle School	[1]	[2] (1)				(1)	3	1	4	16	
Constructing Understanding of Earth Systems (CUES)							0	0	0	0	
Delta Education		(1)	[1]			(1)	1	1	2	8	
Federal Emergency Management Agency (FEMA) Seismic Sleuths			[1]	(1)			1	1	2	8	
EarthComm: Earth System Science in the Community						[1]	0	0	0	0	
Exploratorium — Life Along the Fault Line (on-line resource)		(1)				(1)	0	1	1	5	
Great Explorations in Math and Science (GEMS)		[1]					1	0	1	5	
Total [Curriculum Designer]	3	9	4	0	0	4	15				
Total (Peer Educator)	0	3	3	2	0	6	8				
Total	3	12	7	2	0	10	24				
Percent (%) of Scale Response	*13*	*50*	*29*	*8*	*0*	-				*100*	

1 Familiarity with the Curriculum indicated on the questionnaire.

2 Responses in "[..]" indicate responses from the Curriculum Designer questionnaire. Incl. 3 candidates.

3 Responses in "(..)" indicate responses from the Peer Educator questionnaire. Incl. 2 candidates.

4 Totals include three entries, from bottom left clockwise, [..], (..), and combo; not including familiarity.

5 Percentages are calculated from the combined total of [..] and (..) responses.

Table 14: Rating Curriculum Efficacy, Student Interest, and Adaptations

Data from IslandWood Scientist in Residence

The Scientist in Residence at IslandWood May 23-26, 2005 provided an opportunity to record instruction at the exposed earthquake fault as well as a testament of my teaching efficacy (measured in the post-interview responses). Geology instruction during the SIR experience was based on four generic concepts, *time*, *change*, *cycles*, and *earth at home* (stewardship and mitigation). The plan presented above and in the Appendix.II.H illustrated different aspects of these overall themes, and taught specifically about how the IslandWood campus could be used the to teach basic geological principles, processes, and understandings (Brewer 2004k).

Data from this experience is presented in a few key ways: video footage of instruction, transcripts (Appendix.II.E), and adaptations from lessons originally created as part of my 2004 IslandWood Independent Study Project. These lessons may be viewed at the following website: http://resources.islandwood.org/geology/questions.htm.

The videos — “Introduction to the Fault,” and “Teaching at the Fault,” — may be viewed on the accompanying DVD. Additionally, I have created a few videos — “Tectonic Models,” “Historical Visualization,” “What is Superposition,” and “Pacific Northwest Glaciation” — that complement the material presented herein to teach with tangible evidence and examine the complexities of geosciences.

“Tectonic Models” examines effective modeling in the geosciences, focusing on plate tectonics, and attempting to explain three-dimensional phenomena that are beyond human scale and spatial-temporal understanding with two-dimensional representations.

“Historical Visualization” provides a visual overview history of the last 40 million years of the Puget Sound Region; it focuses on sedimentary deposition (bedrock and glaciers) and most recent recorded earthquake event on the Seattle fault (900 CE).

“What is Superposition” is a compilation of students that I taught while at IslandWood explaining superposition and the events of the IslandWood fault. It provided a central framework for my research before recording instruction at the fault during the Scientist in Residence.

I adapted “Pacific Northwest Glaciation” from Haguerud (2003) to include visualizations of the depth of the ice over the Seattle area. It also includes the shaking event along the Seattle fault (900 CE, 1,100 years before present).

Data Analysis and Results

I anticipated that with further emphasis on inquiry based curricula, increased hands-on experiences, and student accessibility to tangible evidence that students would be able to articulate geologic principles and show greater comprehension of geologic processes because they have been provided a cognitive mental model. The data presented in the previous section illustrates many of these important themes. Some of the most pertinent data is analyzed in subsequent sections.

Interviews

Results from interviews with students fell into three general themes. First, students with exposure to tangible geological evidence showed increased understanding of processes that shape the earth and changes to the earth surface. Table 9 shows a 100 percent increase in knowledge from prior experience to post experience. The fourth grade students had not had previous instruction in geology and showed a one-hundred percent increase in understand of the geologic principle of superposition. The fifth grade students also showed a 100 percent increase in understanding throughout the interview, which begs the question: why did they not remember immediately. As soon as they were shown the video of them at IslandWood, shown a picture of the fault, and the asked again what is superposition, then they were able to articulate the definition. Like the fourth grades students, these students had also not had previous instruction in earth sciences until the fifth grade. Therefore, when these students were at IslandWood the instruction during our field experience was their first exposure to earth sciences, and it is doubtful that any detailed instruction about geologic principles (especially superposition) occurred in their fifth grade instruction. Nonetheless, it is safe to say that these students (both the fourth and fifth graders) have benefited from instruction with tangible evidence; they are to articulate geologic principles at a level that is beyond the expectation of the state standards. I surmise, however, that they have been provided a level of specificity and a cognitive mental model that will stick with them throughout their life. At the same time, verification of the latter statement is beyond the scope of this paper, and will require further study.

Second, interviews with students highlighted alternative conceptions that arise in upper elementary programs when new instruction was given (i.e. earthquakes, glaciers, and superposition). The most significant alternative conception that arose were the findings based on Figure 9 and presented in Table 7. The movie "Tectonic Models" provides a detailed analysis of the need for effective modeling and why a complex question such as Figure 9 is so difficult to comprehend. Gobert (2005:444) comments, "Geology is a complex, semantically rich domain involving the interpretation of geological maps as external visualizations. Geological maps are complex in particular because 3-dimensional features must be inferred from 2-dimensional representations depicted by differing line types and weights." In other words how do you model a concept, such as Plate Tectonics, that is 3-dimensional, beyond human scale, and too slow to physically observe? Again, Gobert (2005:446ff.) comments, there are "three types of knowledge [required[: *spatial knowledge*, i.e. the spatial structure of a geological object, in the case of Plate Tectonics, the inside structure of the earth; *causal knowledge*, i.e., causal mechanisms underlying Plate Tectonic phenomena, e.g. convection currents; and *temporal knowledge,* i.e. knowledge about the time scale of different geological phenomena (continental drift versus volcanic eruption)"

Another significant alternative conception was student understandings of how a glacier formed. On the one hand, since the fourth graders had not had any previous instruction in geology (and teaching glaciology was not in my agenda, except to emphasize glacier history of the Puget Sound), they can hardly be blamed for not understanding how a glacier forms; is it enough for them to know that a glacier consists of ice. On the other hand, the fifth graders, who had recently had instruction in glaciology (evident in their responses and drawings), could accurately describe a glacier as a river of ice (compare with Figure 7 above).

Lastly, interviews provide insights and perceptions of how students view earth science curricula in general (Table 8). In response to questions 5a, 5b, and 6 most students indicated that earth sciences were only complicated “occasionally” or that teachers who taught earth sciences made the material too complicated “occasionally” or “rarely”. Because of the small sample no firm conclusions can be made from this data; nevertheless, in response to question 6 it is possible to suggest that with exposure to tangible evidence students find earth sciences or teachers presenting the material less complicated.

Questionnaires

The small sample from both, however, does permit conclusive data except for the following limited trends. Questionnaires from teachers and curricula designers provide alternate views than the students, and highlight expectations and frustrations with student understanding. Furthermore, questionnaires effectively evaluate existing curricula for efficacy, student accessibility, and the extent to which they are perceived to be hands-on, inquiry based.

Peer Educator indicated that their curricula generally suggested inclusion of field trips once per unit but they wanted to integrate field trips more often; Curriculum Designers, who receive feedback regularly, suggest that field trips be at least once per unit to complement the lesson package and did not show the excitement of an exposed earthquake fault that I had anticipated.

Additional Data Analysis

From the limited results of the combined data a surprising trend emerges: the most well-known curricula (FOSS, FOSS/MS, and STC) seem to be the most problematic in the promotion of local tangible evidence to supplement geoscience instruction. FOSS, especially, centers the earth science unit on the study of the Grand Canyon. Students examine both from a geologists perspective to learn relative dating and through the eyes of John Wesley Powell (and other expedition members). What if a class is not able to travel to the canyon (which the curricula suggest visiting, ideally, before and after the unit)? No alternatives are provided for the teacher. The students are left to ponder places that are beyond human scale and visually abstract. The curricula that I have highlighted above (CUES, GEMS, IES, and PES) all provide opportunities to easily adapt the lessons to local geologic phenomena.

As a Scientist In Residence at IslandWood May 23-26 I implemented a science curriculum that blended arts, sciences, and technology in a natural hands-on setting, into the four-day SOP experience. Upon completion students were able to articulate geologic principles, such as superposition, crosscutting (faulting), without being bogged down by the concept of deep time. Further, students have an embedded tangible, visual image of an exposed earthquake fault to reinforce continued knowledge. Further, using stewardship as an integrating theme, consistent with IslandWood's curriculum overarching questions and goals, the lessons integrated the force of earthquakes, their impact on people, and how understanding can better prepare actions in the future.

The IslandWood Scientist in Residence provided an opportunity test my ideas of tangible teaching by observing student responses before, during and after teaching. Further, working with Brian Sherrod provided an opportunity to check my instructional knowledge for understanding and determine the most effective use of vocabulary to make the material as clear as possible. Most importantly, while developing instruction materials for this experience I did not adhere a single model, rather chose freely from existing curricula and adapted each that I thought would best deliver the intended result. In the process I came to the revolutionary conclusion of this thesis: no one should use one curriculum exclusively, but must actively and willingly adapt material to integrate tangible evidence that permeates our environment.

Conclusion

Careful attention to students' perceptions and cognitive mental maps of an inquiry-based, experiential learning with tangible evidence of processes and interactions in the earth system provides upper elementary students with an opportunity to grasp complex earth science concepts.

While it is essential that existing curricula be aligned to State (OSPI 2002, 2005) and National Standards (AAAS 1993, 2001; NSES 1995), it is equally imperative that curricula integrate correlations between glaciers, earthquakes, and cultural movements with tangible evidence; earthquake mitigation using visible building design; and emphasize the value and importance of educating others about geologic forces and their catastrophic potential.

Existing K-8 Earth Science curricula that teach earthquakes, volcanoes, plate tectonics, and tsunami, which often require a middle school level understanding, to a fourth grade level. Fourth grade students are able to grasp complex earth science concepts with tangible evidence. Students, at all levels but especially elementary students, must be able to connect geologic processes with tangible evidence so that mental cognitive maps ensure deep understanding when presented with the concepts later in middle school.

Teaching geosciences must not only mirror the language distinction between fifth grade students' ability to *know* and *describe* and eighth grade students' ability to *identify* and *explain* geological processes, but must also be enhanced with tangible evidence. Only then will it become increasingly clear that changes on the earth's surface can be slow and gradual (such as weathering and erosion, glaciers, etc.) or sudden and catastrophic (such as earthquakes, tsunami, etc.). It is imperative that curricula units be designed to develop interest in subjects that many students do not have access to and/or receive on a regular basis with real-life evidence. Emphasis on inquiry based curricula, increased hands-on experiences, and student accessibility to tangible evidence coupled with science standards that reflect such an emphasis make teaching and learning more accessible to a greater audience.

Above all, teachers of geosciences must continually amend, adapt, and integrate tangible examples into instruction. I offer four paramount ways to this below (see Recommendations). Teaching with tangible evidence, however, is not enough; a curricular framework must be developed that encourages adaptation of curriculum to increase learning outcomes. Development of a sense of place and wonder through queries and investigations is not the only way to learn; however, coupled with integration of visible examples that students can use to develop cognitive mental maps enables deep understanding that educators and curricula designers strive for.

Further Considerations and Curricular Extensions

This thesis is significant for three reasons. First, it identifies a need for inquiry-based earth science education at the fourth grade level and posits a logistical way to fulfill this need. Second, it enriches existing curricula and suggests that teachers make use of local, tangible examples to become better equipped to teach geology in the classroom. Finally, it solicits student, teacher, and curricular designers perceptions to better identify and implement effective teaching of earth sciences in upper elementary classrooms.

Completion of a thorough curriculum for IslandWood that integrates tangible evidence is beyond the scope of the paper, but its beginning is an essential part of measuring students' perceptions through hands-on, inquiry based lessons centered on tangible geological evidence. the curriculum is based on four geologic concepts: time, change, cycles, and earth at home (stewardship and mitigation). These concepts may be easily amended to different sites. All concepts will incorporates deep understanding, inquiry, hands-on experiences, arts, sciences, and technology in a natural setting, and earthquake mitigation. A tentative plan of what such a curriculum would entail is presented in Appendix.III.4.

Recommendations

> "The American Association for the Advancement of Science urges teachers to take science *out of the textbook and into reality* and to help students *do science* rather than learn about it" (OSPI 2004:24, emphasis in original).

From the results of this study I recommend the following five actions to integrate tangible evidence into earth science curricula and challenge students to grapple with complex geoscience modeling. The first two recommendations are for teachers and administrators to recognize the importance teaching with tangible evidence and recognition that curricula must be modified and are never stand alone units. The latter three are suggestions that may be some of the most effective ways to assess as well as provide opportunities to for students to demonstrate knowledge in the geosciences.

First, teachers must seek tangible examples and/or outcrops in the surrounding environment (including the urban environment). Further, teachers must advocate classroom excursions to such locations on a regular basis to supplement classroom learning; school administrators must provide such opportunities and recognize the importance of tangible evidence in the classroom (and should be encouraged to provide additional classroom help on a regular basis). For example, when teaching sedimentary deposition and glaciers, and teacher should map glacial erratics on the school campus or visit an exposed outcrop within walking distance of the classroom (i.e. a local city park). The United States Geologic Survey (2005) has recently created new website, "Schoolyard Geology" that provides "activities and examples of what to look for to turn your schoolyard into a rich geologic experience." See Appendix.III.3 for more details.

Second, teachers must adapt curricula as needed to increase student understanding, especially as it pertains to local understanding of the immediate environment. Students learn through multiple intelligences, and a single curriculum cannot provide the stimulus needed to engage all minds. Student learning, therefore, must be allowed thrive through as many lenses as possible.

Third, collaborated field trips between differing classroom teachers provide myriad opportunities to combine learning targets. For example, suppose that a social studies class has planned a visit to the local museum exhibit; on the way to the museum, those same students in the science class, stop to examine an exposed landscape feature that illustrates something they have seen. Further, many locations allow one to return via different route, which permits an opportunity to combine to excursions in one. Additionally, many books exist that detail local outcrops and should be used to supplement and complement existing curricula. Some examples for the Pacific Northwest include: *Roadside Geology or Washington* (Alt and Hyndman 1984) and *Fire, Faults, & Floods: A Road & Trail Guide Exploring the Origins of the Columbia River Basin* (Mueller and Mueller 1997). For a more comprehensive list please see Appendix.III.1.

Fourth, in the absence of immediate exposure to outcrops, two actions may be considered. On many school campuses an artificial outcrop may be created from existing rocks in situ and/or external sources to create opportunities for students to explore the examples of the surrounding landscape where it is difficult to view local sources because they must travel large distances (Benison 2005). Alternatively, schools may elect to fabricate an artificial rock outcrop to teach several geologic principles as well as differing rock types where physical field trips to naturally occurring exposures are difficult to access and/or require large distances (Toten 2005).

Lastly, the integration of technology suggested by the Apple Education iLife Project (2005a, 2005b) provides myriad opportunities of student assessment as well as their own creativity to exceed expectations. The iLife project encourages students to integrate the software of iPhoto, iTunes, iMovie, Garage Band, and iDVD to create multi-media presentations that can be shared with classmates, the community, and science professionals. Topics should be something students are sure that they can explain, find relevant data, and meet the expectations. At the same time, they should be challenged to provide as much information as possible. Some sample topics generated from this project include but are not limited to the following questions.

- How did the rock in my yard (in front of the school, etc.) get to be there?

- Why are there so many hills between my house when I drive East-West but not when I drive North-South?
- Why did Mt. St. Helens erupt?
- Want happens when an earthquake breaks the surface of the earth?
- What is superposition (or any other geologic principles)?

For a lesson plan of the GeoME project, please see Appendix.III.2.

Appendixes

I. Documentation of Human Subjects

The following Appendixes detail questions asked in Interviews, Questionnaires.

A. Interviews

1. Interview 2004

Please answer the following questions as candidly, completely and openly as possible.

Date________________________________ School Name______________________________________

Number of students present____________ Number of students in field group_____________

This is going to be a group video. Please be respectful of each other, and try not to talk over each other. There is a microphone here between us. There are three parts — first several questions about things you might remember about IslandWood; second, a video of what you said at IslandWood with a chance to change you answers to part one after you watch it; and, third, questions about science in general.
This should take about 45 minutes to complete. Do you all agree to participate? Please say yes if you agree and understand the consent form.

PART I

1. **If you had to explain the word "glaciers" to a friend, what would you say? You may also draw your answer.**

    - **Please explain the event or events that you think might cause a glacier to occur. You may also draw your answer.**

2. **If you had to explain the word "earthquakes" to a friend, what would you say? You may also draw your answer.**

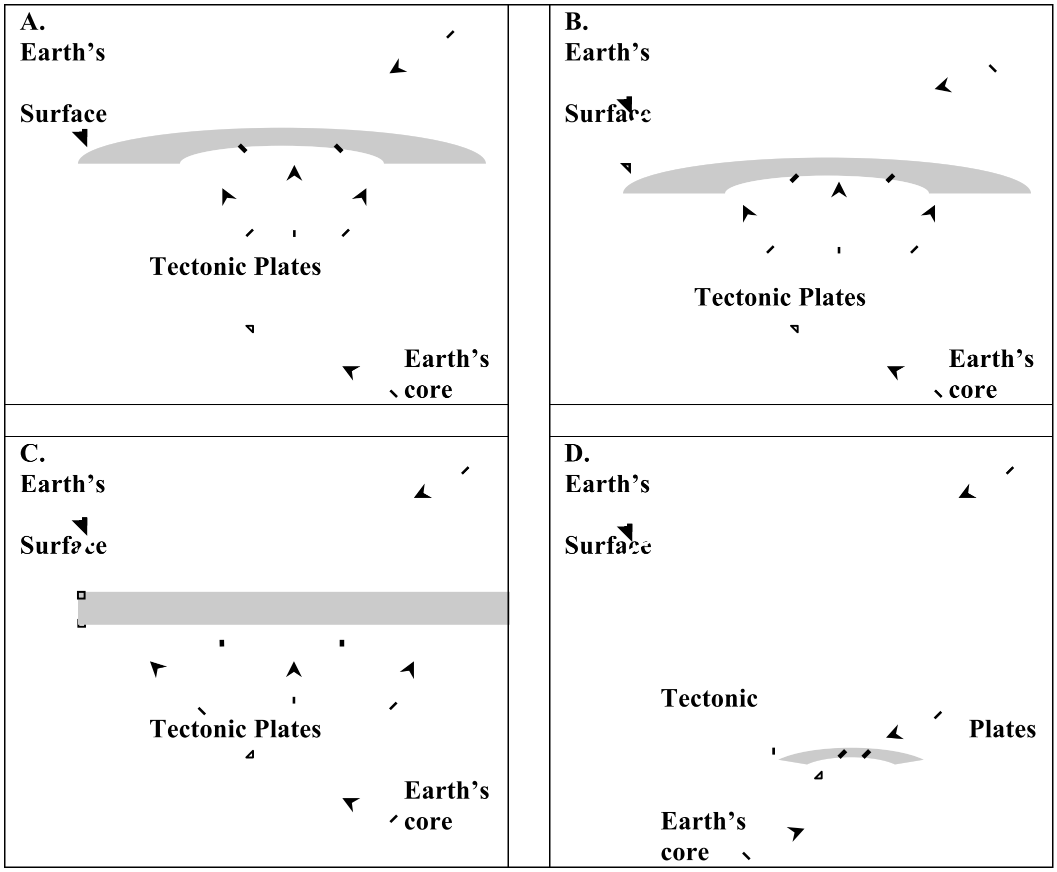
    - **Please explain the event or events that you think might cause an earthquake to occur. You may also draw your answer.**

3. **If you had to explain the word "superposition" to a friend, what would you say? You may also draw your answer.**
    - **Please explain the event or events that you think might cause superposition to occur. You may also draw your answer.**

4. **Which of the following drawings do you think best explains the earth's interior and tectonic plates (adapted from Libarkin et al. 2005)?**

    A tectonic plate is a section of the earth that moves slowly over time. Each plate boundary is a region of considerable geologic activity.

    If you don't know that is okay, just make a reasonable guess.



PART II

Now I am going to show you a video of our field group from IslandWood where you explain some of these things. After we watch it will you will have a chance to correct or change what you said if you change your mind. Please make your corrections in a different color pen.

PART III

Now I am going to ask some general questions about science. Please answer the following questions as candidly, completely and openly as possible.

5. **How often do you think learning about earthquakes, glaciers, and the earth is too complicated (i.e. all the time, most of the time, occasionally, or rarely)?**
   - **Does your teacher make it too complicated (i.e. all the time, most of the time, occasionally, or rarely)?**
6. **How often do you take a field trip in science (i.e. as often as possible, occasionally, not at all)?**
   - **Where do you usually go?**
   - **Do you enjoy going on field trips? Why or why not?**
7. **Thank you all very much. Do you have any questions for me?**

2. Interview 2005 (pre and post)

Please answer the following questions as candidly, completely and openly as possible.

Date________________________________ School Name______________________________________

Number of students present____________ Number of students in field group_____________

This is going to be a group video. Please be respectful of each other, and try not to talk over each other. There is a microphone here between us. There are three parts — first several questions about things you might learn/remember while you are/were at IslandWood; second, a video about some of the things that you might learn/remember wile you are/were at IslandWood; and third, questions about science in general.
This should take about 30 minutes to complete. Do you all agree to participate? Please say yes if you agree and understand the consent form.

PART I

1. **If you had to explain the word "glaciers" to a friend, what would you say? You may also draw your answer.**

    - **Please explain the event or events that you think might cause a glacier to occur. You may also draw your answer.**

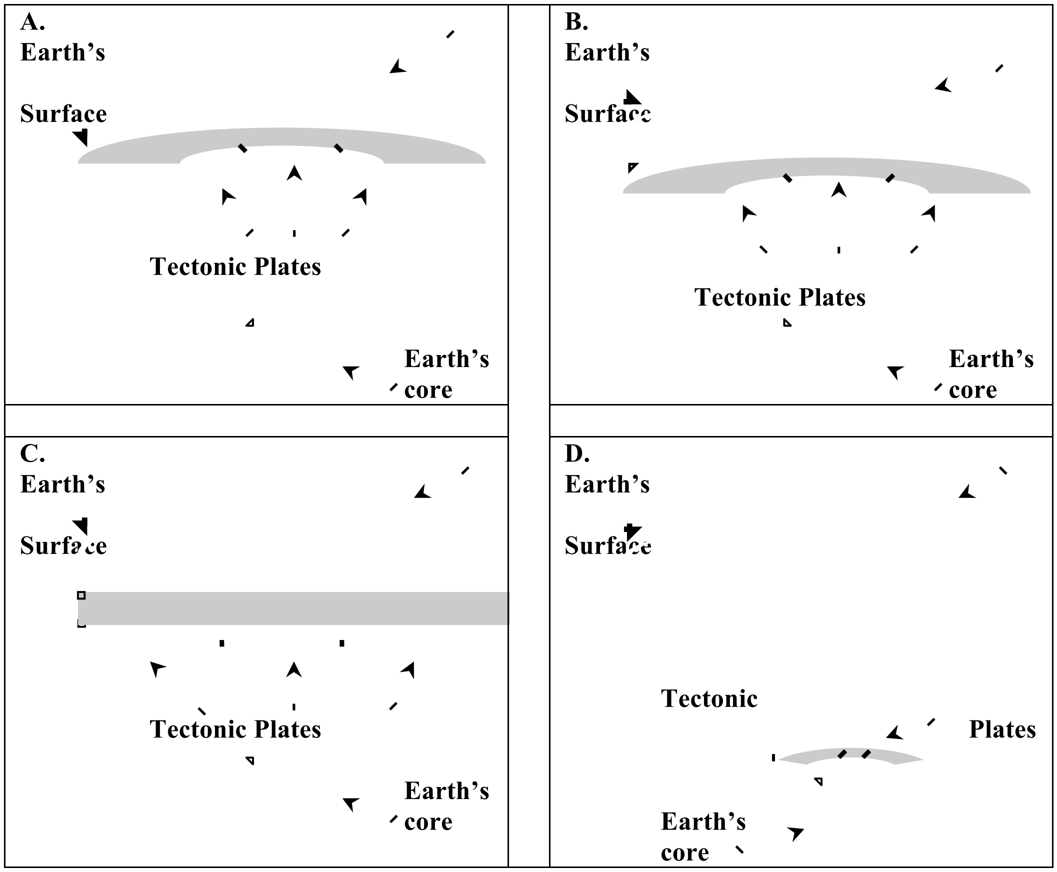
2. **If you had to explain the word "earthquakes" to a friend, what would you say? You may also draw your answer.**

    - **Please explain the event or events that you think might cause an earthquake to occur. You may also draw your answer.**

3. **If you had to explain the word "superposition" to a friend, what would you say? You may also draw your answer.**

    - **Please explain the event or events that you think might cause superposition to occur. You may also draw your answer.**

4. **Which of the following drawings do you think best explains the earth's interior and tectonic plates (adapted from Libarkin et al. 2005)?**
   A tectonic plate is a section of the earth that moves slowly over time. Each plate boundary is a region of considerable geologic activity.
   If you don't know that is okay, just make a reasonable guess.



<u>PART II</u>

Now I am going to show you a video of the 5th graders visit at IslandWood where they explained some of these things. After we watch it will you will have a chance to correct or change what you said if you change your mind. Please make your corrections in a different color pen.

<u>PART III</u>

Now I am going to ask some general questions about science. Please answer the following questions as candidly, completely and openly as possible.

5. **How often do you think learning about earthquakes, glaciers, and the earth is too complicated (i.e. all the time, most of the time, occasionally, or rarely)?**

   - **Does your teacher make it too complicated (i.e. all the time, most of the time, occasionally, or rarely)?**

6. **How often do you take a field trip in science (i.e. as often as possible, occasionally, not at all)?**

   - **Where do you usually go?**

   - **Do you enjoy going on field trips? Why or why not?**

7. Thank you all very much. Do you have any questions for me?

B. Questionnaires

1. Questionnaire for Teachers

Please answer the following questions as candidly, completely and openly as possible. Please spend no more than one hour completing all questions.

Please indicate the grade level(s) that you regularly teach________________________

Please indicate your School Name and Location________________________________

1. **What curricula do you use to teach Earth Sciences, such as Earthquakes?**
   - **Why do you like these curricula over others?**
2. **What curricula do you use to teach Earth Sciences, such as Plate Tectonics?**
   - **Why do you like these curricula over others?**
3. **What curricula do you use to integrate technology, science, and the arts in Earth Sciences?**
   - **Why do you like these curricula over others?**
4. **How often do you find a need to adapt these curricula to further engage your students (i.e. every time you teach, weekly, occasionally, or rarely)?**
5. **How often do you find the curricula you use in Earth Sciences to be too complicated for your students (i.e. every time you teach, weekly, occasionally, or rarely)?**
6. **How often do you find the curricula you use in Earth Sciences to be too complicated for you as a teacher (i.e. every time you teach, weekly, occasionally, or rarely)?**
7. **How often do your curricula suggest that you take a field trip to local geologic features (i.e. as often as possible, occasionally, not at all)?**
   - **How often are you able to take a field trip?**
     ___weekly ___monthly ___occasionally ___rarely ____not at all
   - **How much effort does it require to take a field trip?**
     ________no hassle _______occasional conflict ________considerable effort
8. **If you were to take a field trip where would you go?**
   - **How far are you willing to travel?**
   - **How much does transportation factors, district resistance, or financial resources shape your ability to take a field trip?**

9. What would be the most effective way to engage your students (i.e. tangible evidence, professional scientist, field trip, another educational facility)?

10. What resources would you most want to be included in Earth Science curricula that you feel are missing from those that you currently use?

IslandWood Environmental Learning Center, Bainbridge Island, Washington, currently has an exposed earthquake fault, the staff to teach about local geology, and a curriculum supported by Washington State Essential Academic Learning Requirements.

11. If there were an exposed earthquake fault visible and accessible to you and your students, how often would you seek access?

12. If there were knowledgeable staff willing to teach you and your students about that exposed earthquake fault, how often would you seek access?

13. If there were a comprehensive local geology curriculum, aligned with state standards and centered on an exposed earthquake fault, how often would you seek access?

14. Do you think that teaching Earth Sciences is a strength or a weakness? Why or why not?

- **How often do you defer your teaching to an expert?**
  weekly ___monthly ___occasionally ___rarely ____not at all

- **How does your district support you or not support you in your decision to use outside help?**

15. Please rate the following curricula, especially the ones that you use, where:
- **"1" engages student interest with no effort and requires minimal adaptations;**
- **"2" engages student interest with no effort and occasional adaptations;**
- **"3" engages student interest with continual effort and occasional adaptations;**
- **"4' requires regular adaptations to engage students; and**
- **"5" requires considerable effort to complete lessons and students often do not understand lesson objectives**

If you are not familiar with a curriculum, please indicate whether you have heard of this curriculum, by placing a check (✓) in the Grade Level box.

Descriptions of selected curricula below can be found at the Center for Science Education (CSE) Science Curriculum Dissemination Center:
(http://cse.edc.org/work/k12dissem/materials.asp)

Grade Level	**Curriculum**			
K–6	Developmental Approaches in Science, Health and Technology (DASH)			
1	**2**	**3**	**4**	**5**
K–6	Full Option Science System (FOSS)			
1	**2**	**3**	**4**	**5**
K–6	Insights: An Elementary Hands-On Inquiry Science Curriculum			
1	**2**	**3**	**4**	**5**
K-6	Federal Emergency Management Agency (FEMA) Tremor Troops			
1	**2**	**3**	**4**	**5**

1–6	Science and Technology for Children (STC)
1	**2 3 4 5**
5–8	Investigating Earth Systems (IES)
1	**2 3 4 5**
6–8	Foundations and Challenges to Encourage Technology-Based Science (FACETS)
1	**2 3 4 5**
7–8	Full Option Science System (FOSS) for Middle School
1	**2 3 4 5**
6-8	Constructing Understanding of Earth Systems (CUES)
1	**2 3 4 5**
6-12	Delta Education
1	**2 3 4 5**
7-12	Federal Emergency Management Agency (FEMA) Seismic Sleuths
1	**2 3 4 5**
9–12	EarthComm: Earth System Science in the Community
1	**2 3 4 5**
K-12	Exploratorium — Life Along the Fault Line (on-line resource)
1	**2 3 4 5**

Please indicate additional curricula that you use in your classroom (use additional pages if necessary)

2. Questionnaire for Curricula Designers

Please answer the following questions as candidly, completely and openly as possible. Please spend no more than one hour completing all questions.

Please indicate the grade level(s) that you target your curriculum_________________

Please indicate your Organization Name and Location__________________________

1. What is your organization mission statement?

- **What is the vision of your curriculum?**

2. From where do you draw your educational resources to develop Earth Science curricula?

- **How do you choose to focus your curriculum?**

3. How do you integrate technology, science, and the arts into your Earth Sciences curriculum?

- **Why do you think this is important?**

4. How often do you receive feedback about your curricula that teachers need to adapt these curricula to further engage their students (i.e. often, weekly, occasionally, or rarely)?

5. How often do you receive feedback about your curricula that teachers find your Earth Sciences curricula to be too complicated for their students (i.e. often, weekly, occasionally, or rarely)?

6. How would you respond to a teacher that found your Earth Sciences curricula too complicated for themselves and/or for their students?

7. How often do your curricula suggest that you take a field trip to local geologic features (i.e. as often as possible, occasionally, not at all)?

- **How often do you this is reasonable to take a field trip?**
  ___weekly __monthly __occasionally __rarely ____not at all

- **How much effort should it require to take a field trip?**
  _______no hassle _______occasional conflict ________considerable effort

8. Where would you recommend teachers to take a field trip?

- **How far is reasonable to travel?**

- **How much should transportation factors, district resistance, or financial resources shape a teacher's ability to take a field trip?**

9. What would be the most effective way to engage students (i.e. tangible evidence, professional scientist, field trip, another educational facility)?

10. What resources included in Earth Science curricula are the most important, and what do you think are missing from existing curricula?

IslandWood Environmental Learning Center, Bainbridge Island, Washington, currently has an exposed earthquake fault, the staff to teach about local geology, and a curriculum supported by Washington State Essential Academic Learning Requirements.

11. If there were an exposed earthquake fault visible and accessible to be used with your curricula, how often would you seek access?

12. If there were knowledgeable staff willing to teach your curricula using that exposed earthquake fault, how often would you seek access?

13. If there were a comprehensive local geology curriculum, aligned with state standards and centered on an exposed earthquake fault, how often would you seek access?

14. Do you think that teaching Earth Sciences should be easy for teachers? Why or why not?

- **How often should teachers defer their teaching to an expert?**
  weekly __monthly __occasionally __rarely ____not at all

- **How should a school district support a teacher or not support a teacher in their decision to use outside help?**

15. Please rate the following curricula that shaped your curriculum development, or are effective at promoting earth science where:
- **"1" is very effective, engages student interest, with no adaptations;**
- **"2" is somewhat effective, engages student interest, and requires occasional adaptations;**
- **"3" is somewhat effective, often engages student interest, and requires occasional adaptations;**

- **"4' is somewhat ineffective, and requires regular adaptations to engage students; and**
- **"5" is mostly ineffective, requires considerable effort to complete lessons and students often do not understand lesson objectives**

If you are not familiar with a curriculum, please indicate whether you have heard of this curriculum, by placing a check in the Grade Level box.

Descriptions of selected curricula below can be found at the Center for Science Education (CSE) Science Curriculum Dissemination Center: (http://cse.edc.org/work/k12dissem/materials.asp)

Grade Level	Curriculum			
K–6	Developmental Approaches in Science, Health and Technology (DASH)			
1	**2**	**3**	**4**	**5**
K–6	Full Option Science System (FOSS)			
1	**2**	**3**	**4**	**5**
K–6	Insights: An Elementary Hands-On Inquiry Science Curriculum			
1	**2**	**3**	**4**	**5**
K-6	Federal Emergency Management Agency (FEMA) Tremor Troops			
1	**2**	**3**	**4**	**5**
1–6	Science and Technology for Children (STC)			
1	**2**	**3**	**4**	**5**
5–8	Investigating Earth Systems (IES)			
1	**2**	**3**	**4**	**5**
6–8	Foundations and Challenges to Encourage Technology-Based Science (FACETS)			
1	**2**	**3**	**4**	**5**
7–8	Full Option Science System (FOSS) for Middle School			
1	**2**	**3**	**4**	**5**
6-8	Constructing Understanding of Earth Systems (CUES)			
1	**2**	**3**	**4**	**5**
6-12	Delta Education			
1	**2**	**3**	**4**	**5**
7-12	Federal Emergency Management Agency (FEMA) Seismic Sleuths			
1	**2**	**3**	**4**	**5**
9–12	EarthComm: Earth System Science in the Community			
1	**2**	**3**	**4**	**5**
K-12	Exploratorium — Life Along the Fault Line (on-line resource)			
1	**2**	**3**	**4**	**5**

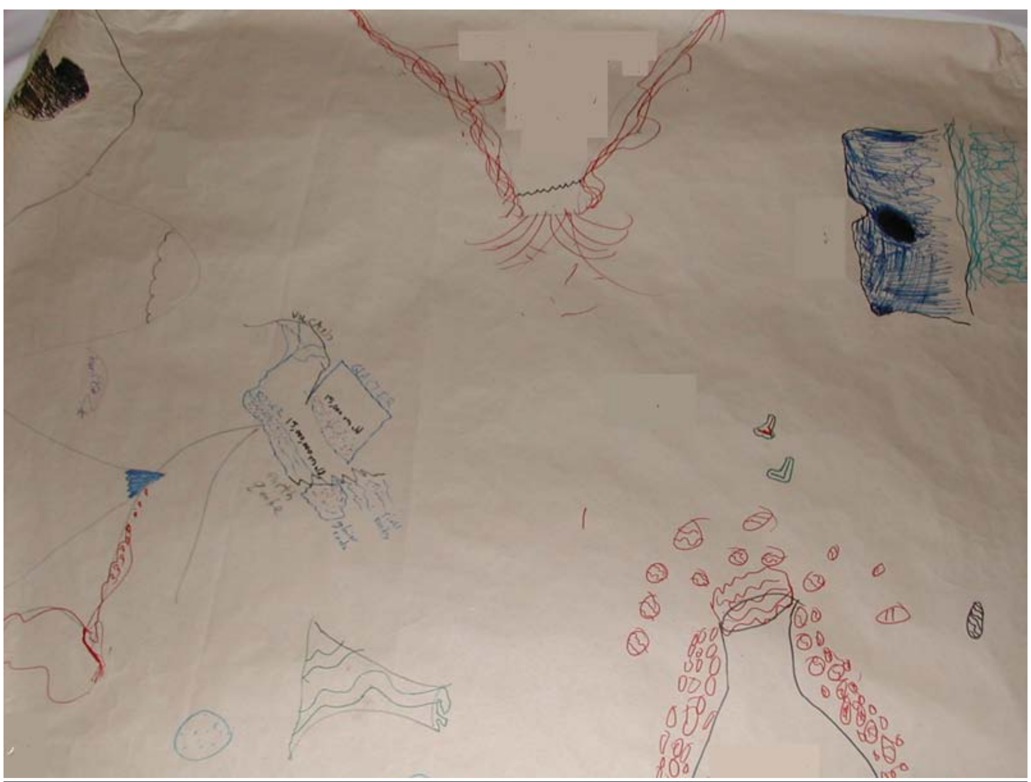
Please indicate additional curricula that you think a classroom teacher should use or consider (use additional pages if necessary)

II. Sample Data

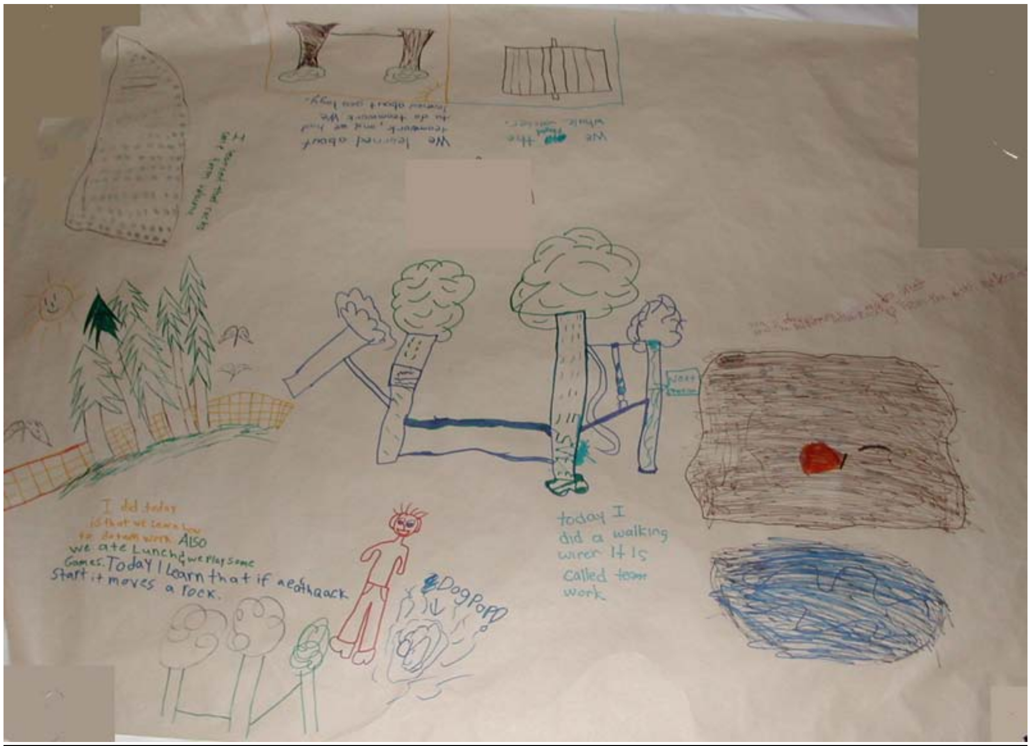
A. Group Murals from IW SIR

The following are photographed images of the murals that each group created at the end of their two-hour instruction during the Scientist in Residence at IslandWood May 23-25, 2005. Each group divided into two groups of four, for a total of twelve murals.

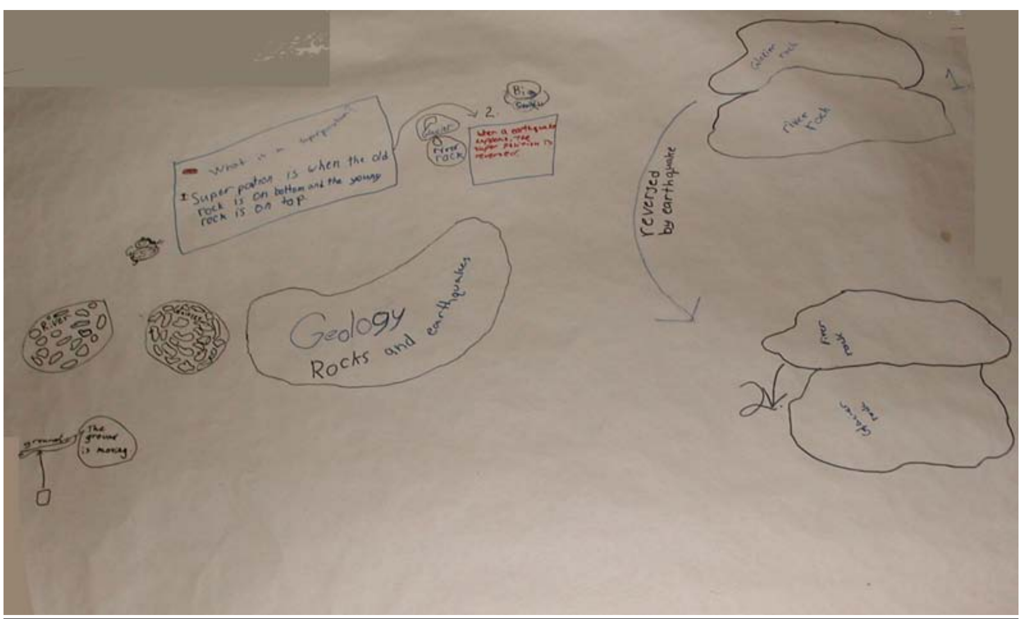
The direction for completion of the mural was to explain to the groups that could participate in the SIR everything that they knew about the earthquake fault that they had seen, recent geologic events that they had learned, and any other relevant information. The group presented their posters at the campfire. See Appendix.II.H for more detail about the SIR plan.



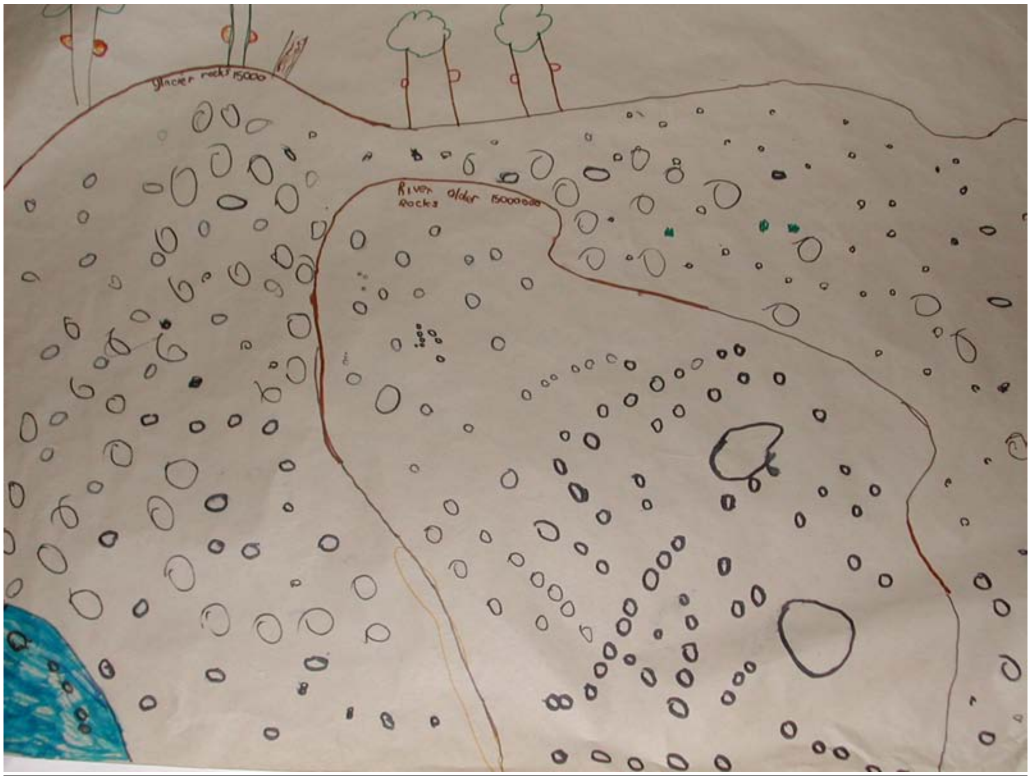
Group #1



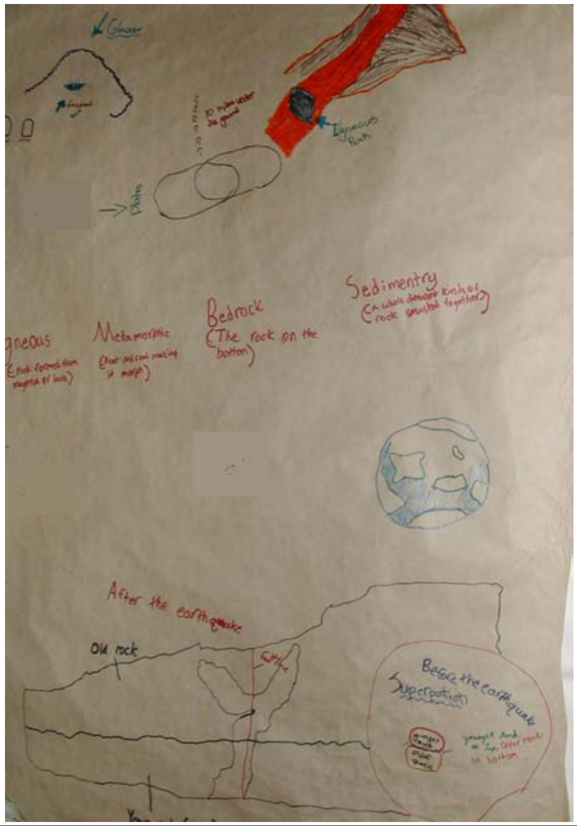
Group #2



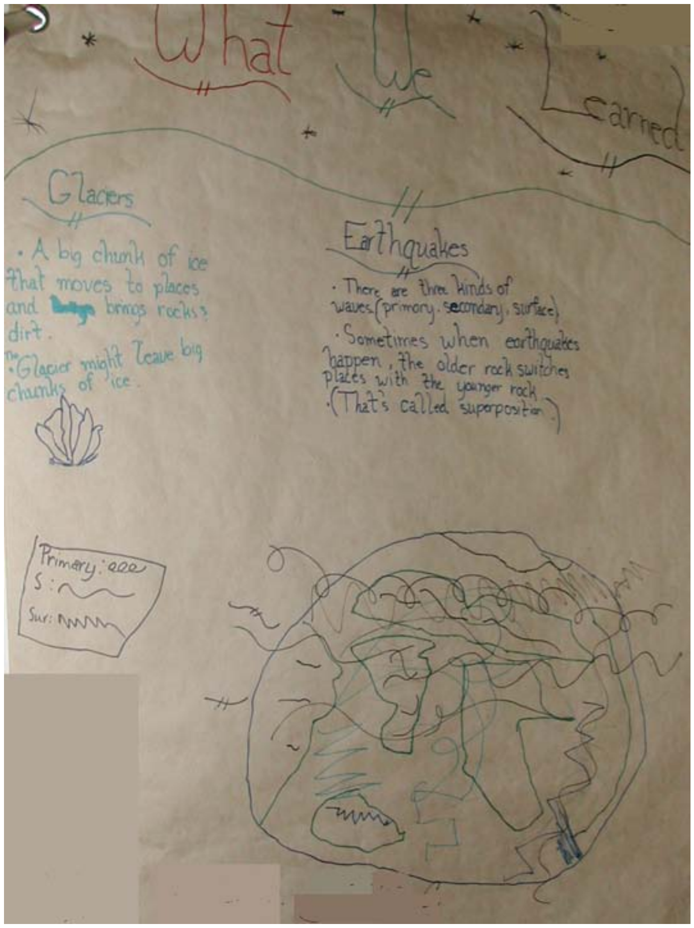
Group #3



Group #4

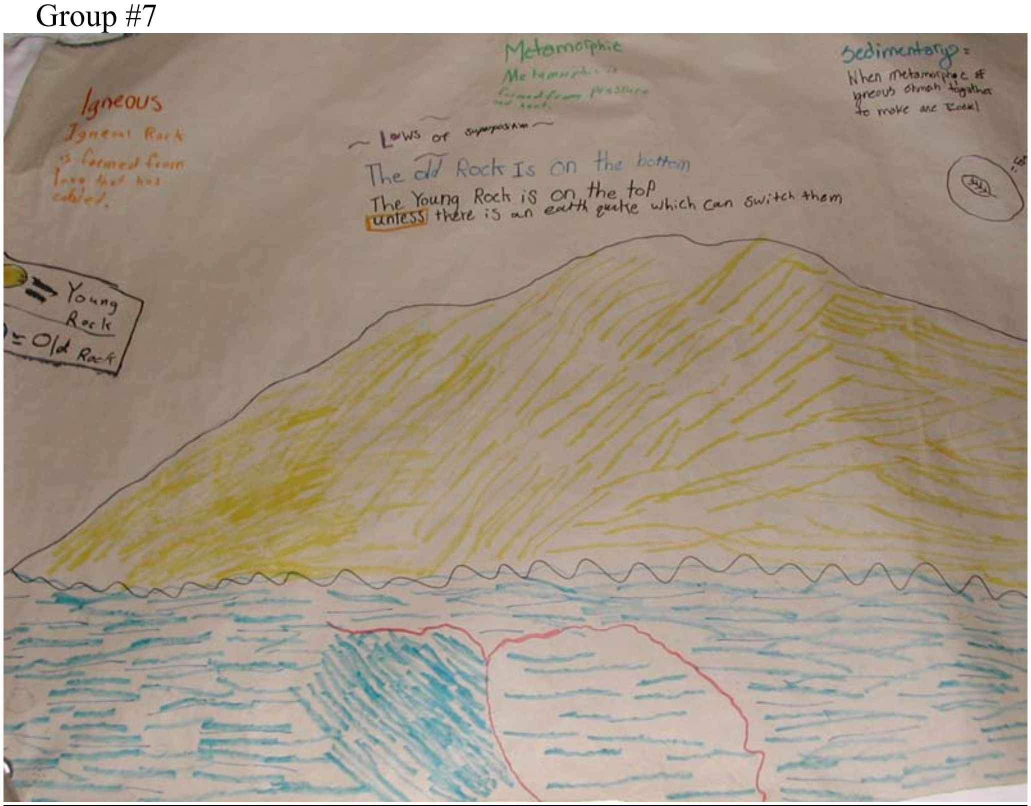

Plates
Sedimentry
Bedrock
(The rock on the botton)
Metamorphic
gneous
After the earthquake
Old rock
Before the earthquake
Superpotion

Group #5


What We Learned
Glaciers
· A big chunk of ice that moves to places and brings rocks & dirt.
·Glacier might leave big chunks of ice.
Earthquakes
· There are three kinds of waves (primary, secondary, surface)
· Sometimes when earthquakes happen, the older rock switches places with the younger rock.
·(That's called superposition.)
Primary:
S:
Sur:

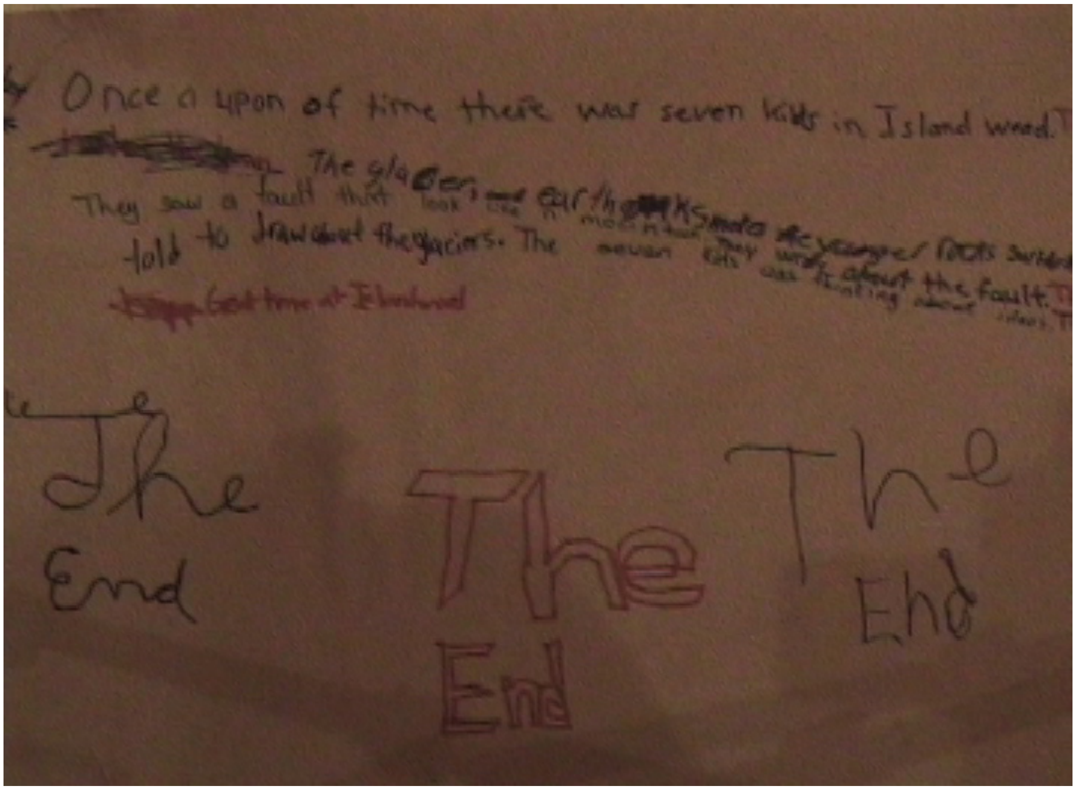
Group #6

Group #7

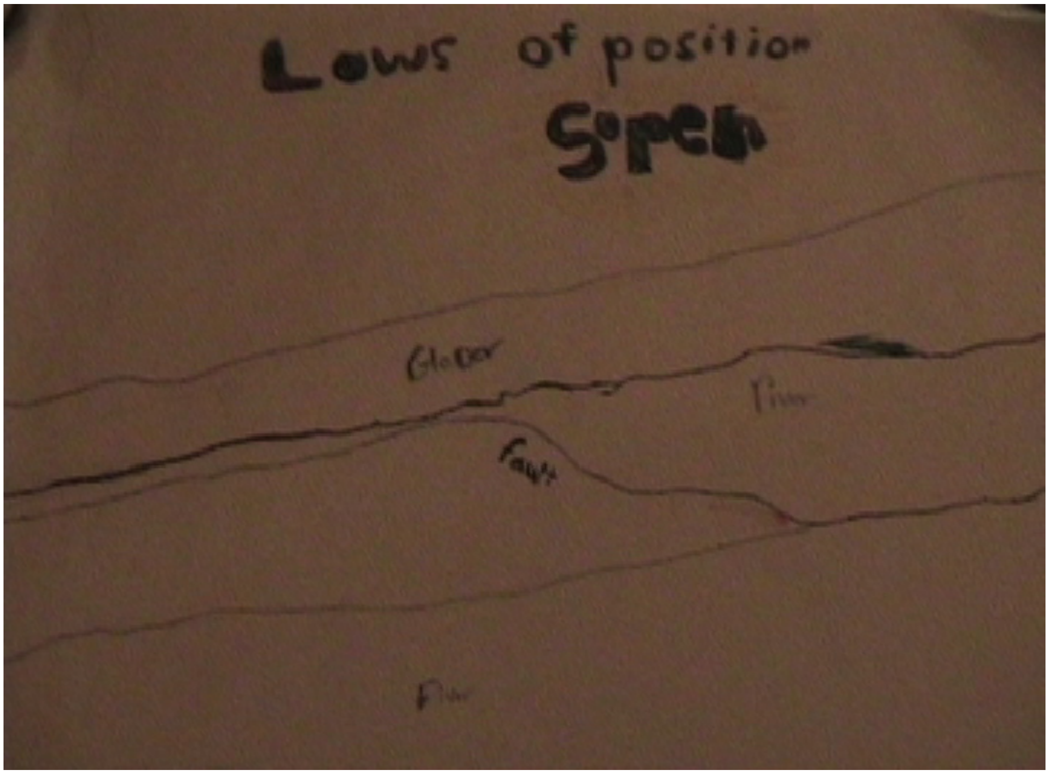


Group #8

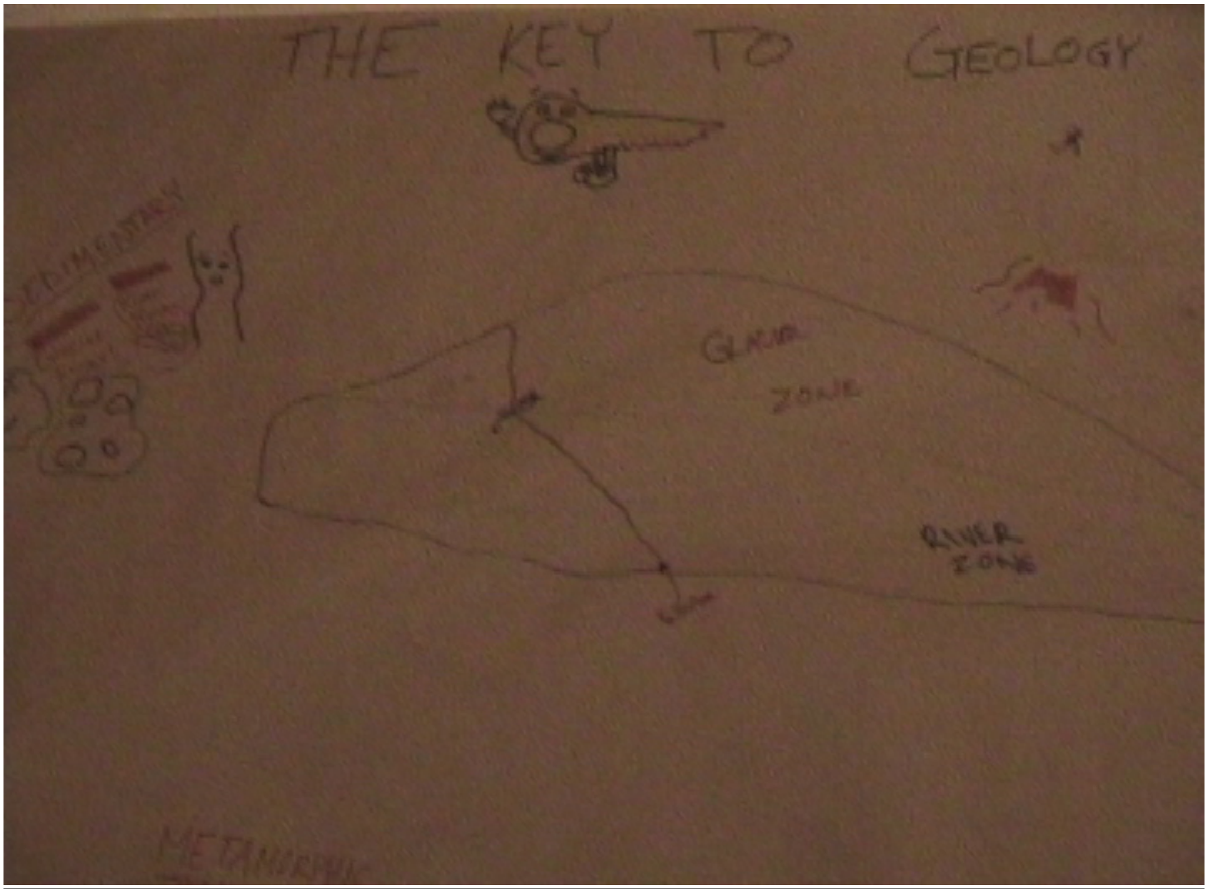
Group #9


Once a upon of time there was seven kids in Island wood.
The End
The End
The End

Group #10



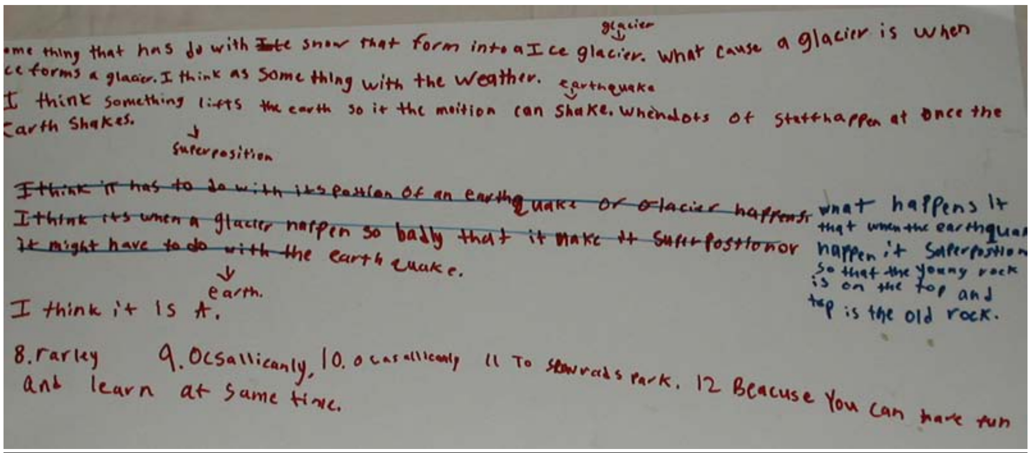
Group #11



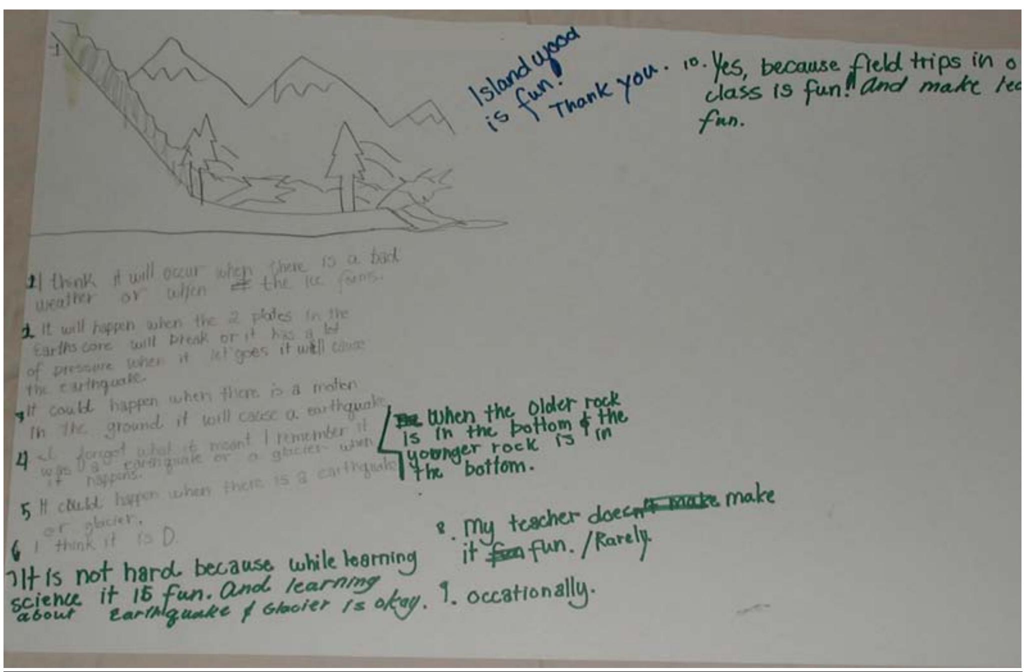
Group #12

B. Interview Poster Boards

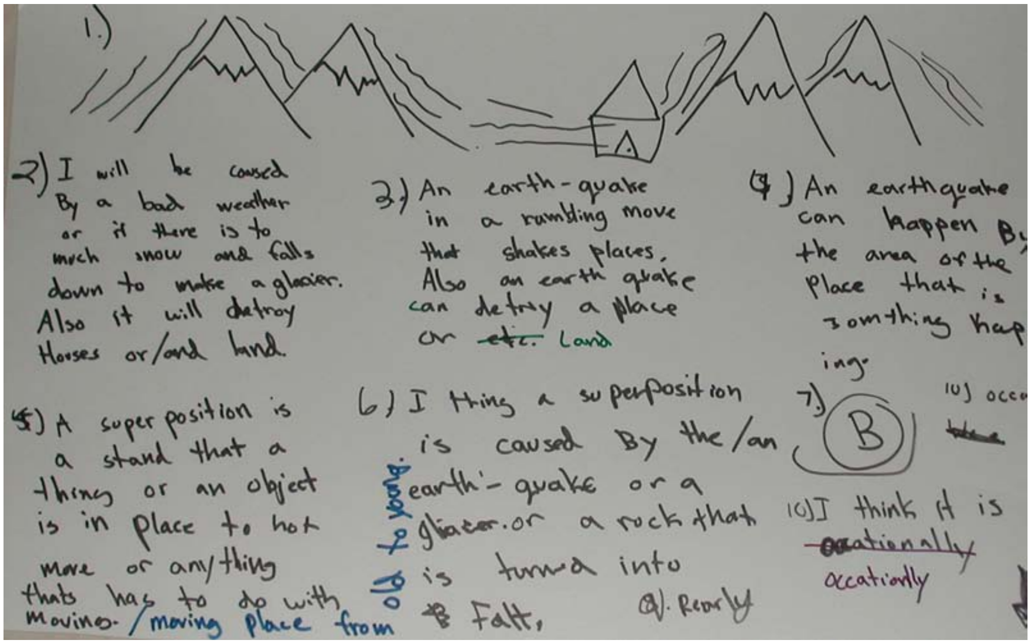
During Interviews, each student was provided a poster board (approximately 11 inches by 17 inches) to record their answers. Below are photographed images of each poster. Where applicable all student names have been erased. Post 2005 students received the same poster form their first interview and were allowed to correct in a different color pen and/or use the reverse.



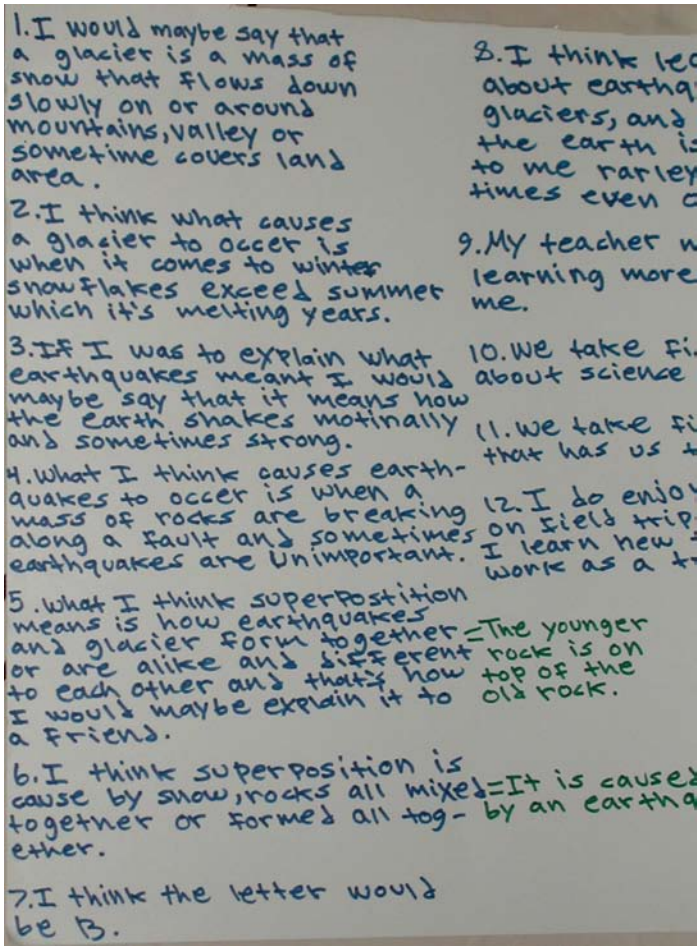
Interview 2004 #1



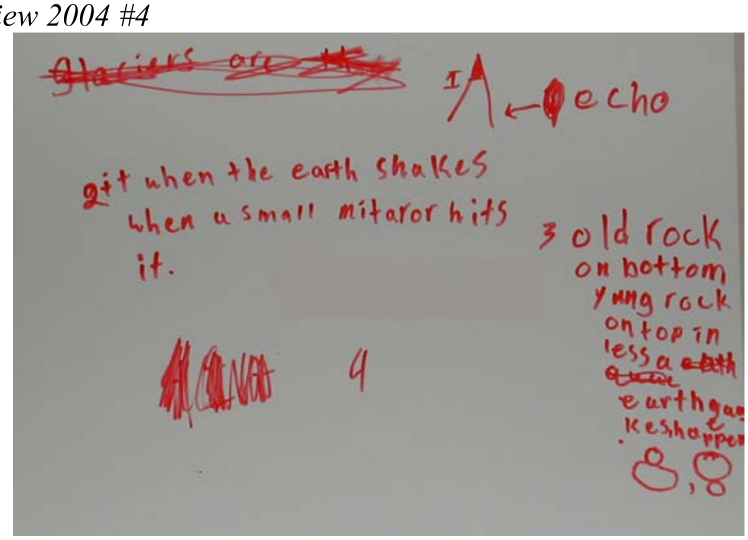
Interview 2004 #2



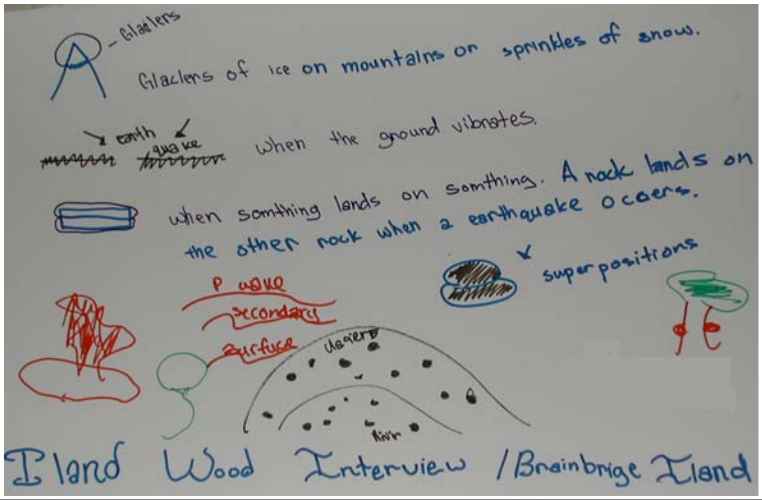
Interview 2004 #3



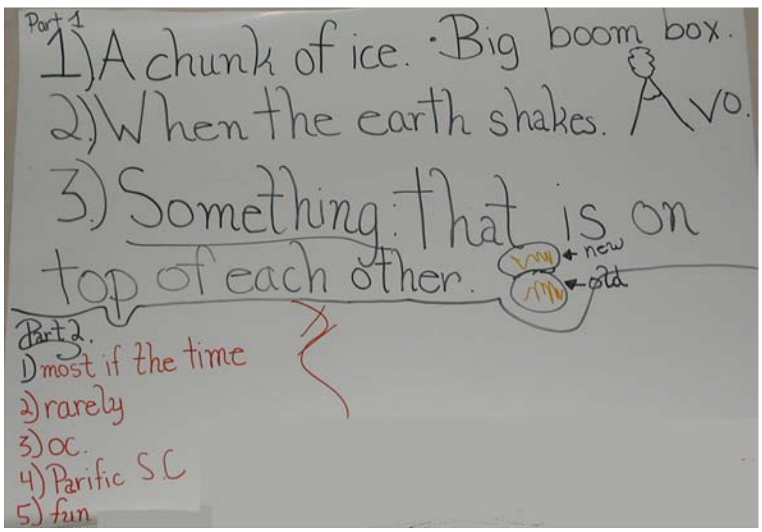
Interview 2004 #4



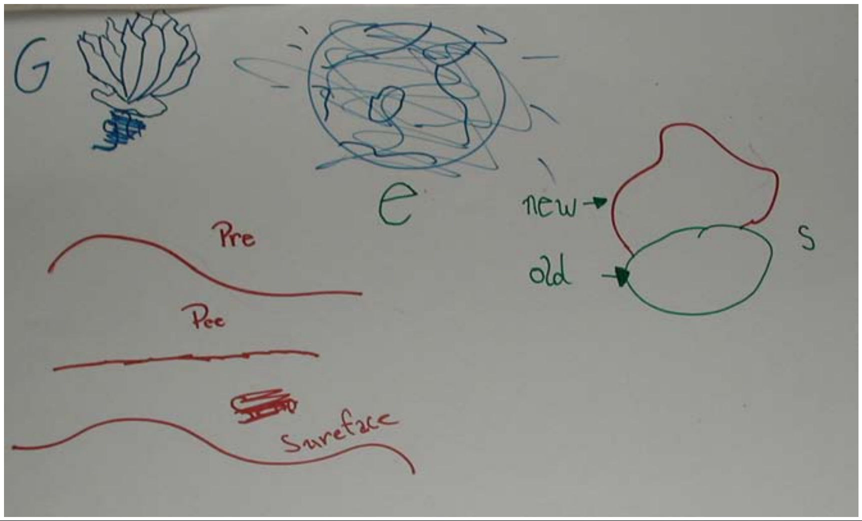
Interview 2005 #1



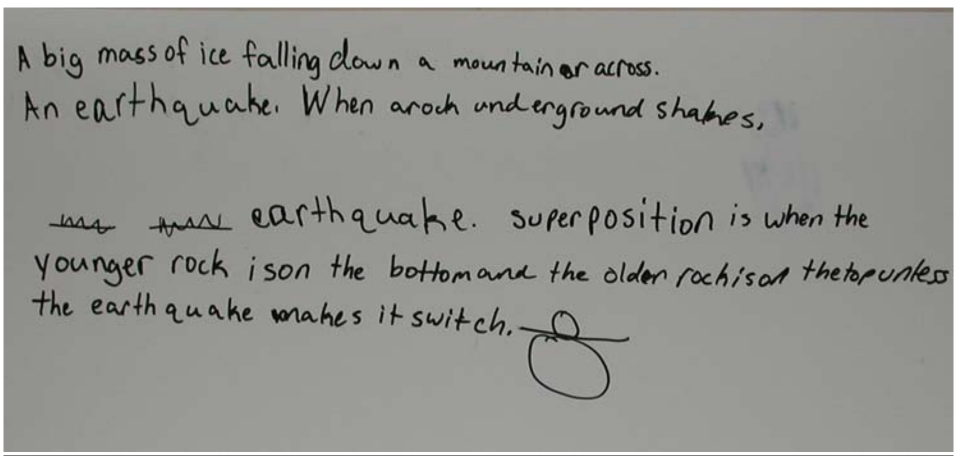
Interview 2005 #2



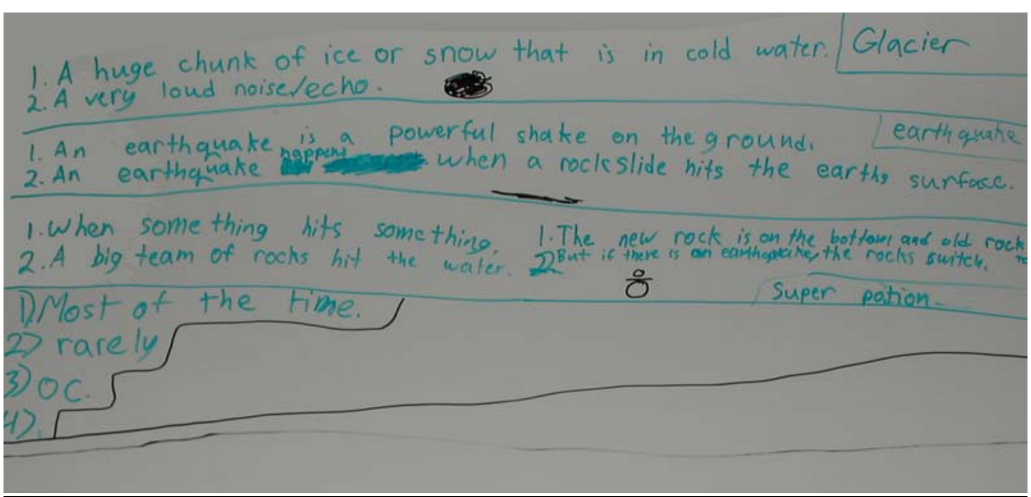
Interview 2005 #3



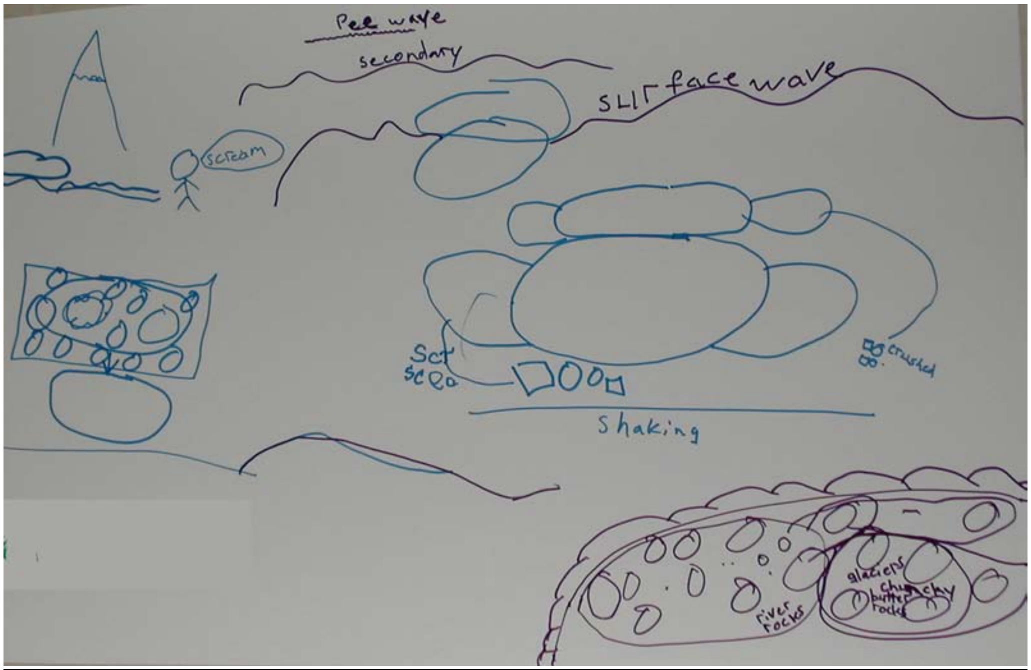
Interview 2005 #4



Interview 2005 #5



Interview 2005 #6



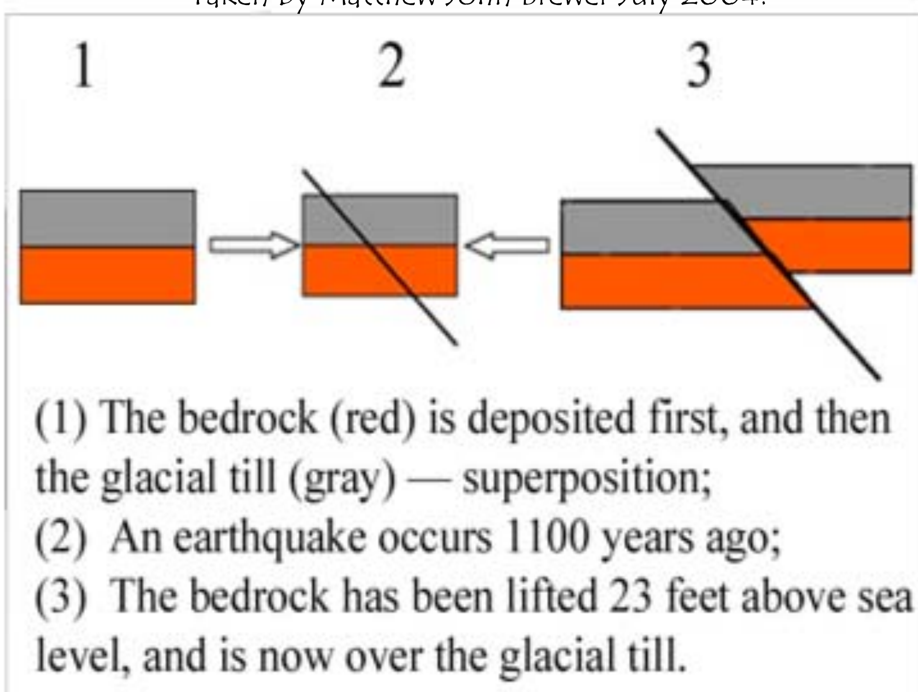
Interview 2005 #7

C. Interview PowerPoint

Slide #1: Superposition Movie, transcript Appendix.II.E.4.

Slide #2: Digital Photo of IslandWood Photo, courtesy of Brian Sherrod (2003c)

Slide #3: Glacial Erratics in front of IslandWood Dining Hall, Taken by Matthew John Brewer July 2004.

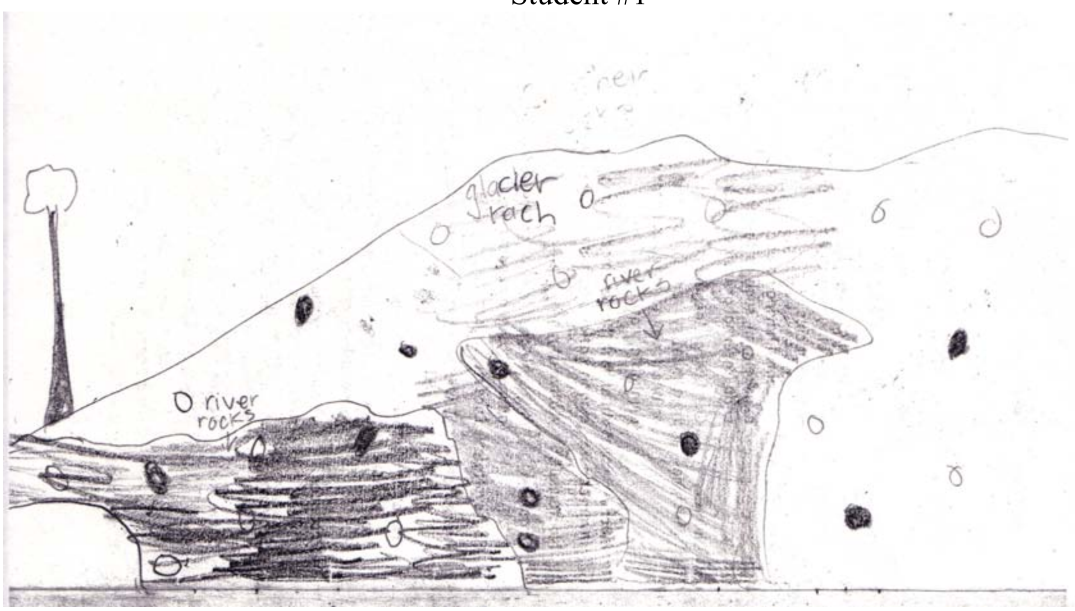


Slide #4: Fault Diagram and Superposition, of the IslandWood fault, Created by Matthew John Brewer June 2004

D. Drawings of IslandWood Fault

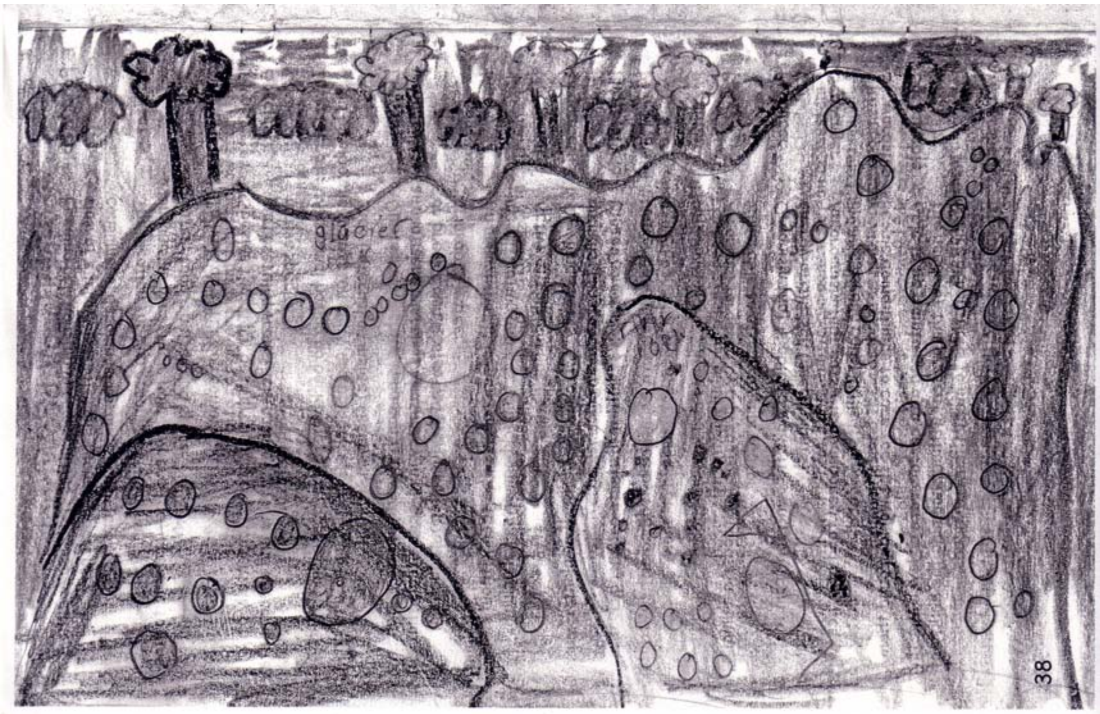
The following four drawings are samples from the IslandWood journal done by students at the fault during the Scientist in Residence instruction session. Following each drawing I provide a short analysis of what I see; students were not provided an opportunity to give a detailed analysis, except for their presentation in the poster and mural.

Student #1



Analysis of what I see — This student identifies the differing rock layers (bedrock darker in the lower left and lighter gray on the right; glacier on top), and grasps the different strata. There is no indication of the fault on the drawing. If the student were to label the white in the lower left corner, what would it be; in such a case then this drawing accurately portrays the fault wall.

Student #2

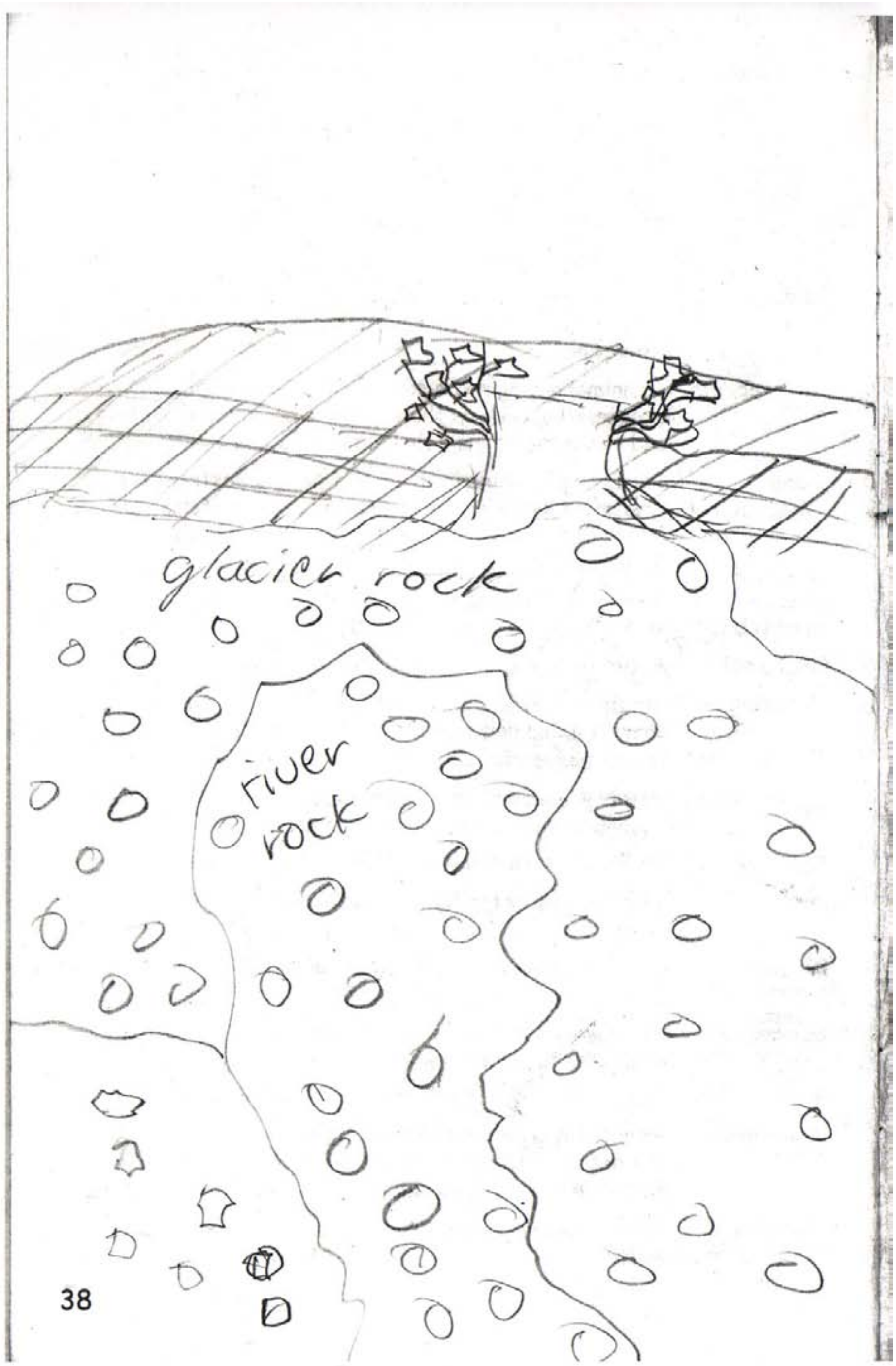


Analysis of what I see — The differing strata are labeled in this drawing; the glacier rock is in the middle, and the river rock is between the two enclosed regions. The drawing does not indicate where the fault is but may be inferred to be between the enclosed regions of the river rock.

Student #3

Analysis of what I see — This student indicated the river rock and the glacier rock on top of each other, and labeled each individual pebble color. The fault is not indicated; could it be the line that passes through the words "river rock" toward the lower left. Given the inclusion of the water in the lower left and the grass adjacent to that on the bottom, the line previously is in the location of the fault; however, the actual fault angles the opposite direction (because it is a reverse fault).

Student #4



Analysis of what I see — This student labeled the glacier and river rock without much distinction between the two. The fault is not indicated; given the location of the river rock below the stump on top of the exposed wall, the student may have the fault in the right location.

E. Transcripts

Transcripts of the three Video Interviews follow. All material herein was compiled, filmed, and edited by Matthew John Brewer between May and June, 2005, Seattle, Washington.

1. IW 2004

[*Four students -- #1, Latina girl with long black hair; #2, African American girl; #3, Latina/Asian girl with glasses; #4, African American boy.*
Location – Library – lots of background noise.
View -- #1 on left, #2 behind her, #3 in the middle, #4 on the right, and Matt on the far right. Each student has a blank sheet of paper in front of them and markers to draw.]

[*Begin Transcript 00:05:00*].
Matt: Okay. My name is Matt Brewer, again. Remember me from when we were at IslandWood? Then I'm going to ask you some questions from some of the things that we studied while we there, and you guys, that's what this permission slip was, talking about. So, do you all agree to participate in this interview?
All: Yes. [*#4 nods*].
Matt: Okay. So, you can, the paper that you have in front of you is to write or draw your answers, and they are the same ones that you had before this. So there's three parts. I'm going to ask you some questions, then I'm going to show you a video of you guys at IslandWood, with a few other kids, talking about some of the things that we learned, and then I'm going to ask you some other general questions about science. Okay? So as I ask you the question, you can, we'll share our answers, write down and share our answers. Okay?
#2: what if you don't know the answers?
Matt: if you don't know the answer that's okay, don't worry, we'll see, maybe by the end we'll have a chance to correct our answers or you might remember. So, the first question is if you had to explain the word "glacier" to a friend what would you say?
#1: do we write it down?
Matt: you write it down or draw your answer.
[*All students are writing silently…*]
#1: can I turn it over, color this.
Matt: yeah, or you can use the pen. Use both sides if you want.
So, please explain the event or events that you think might cause a glacier to occur. We can say it out loud if you want too. What causes a glacier to occur?
[*All students are writing silently…*]
#2: what was question two?
Matt: please explain the vent or events that you think cause a glacier to occur.
[*Lots of background noise, as class passes above that was singing in the last four minutes*].
[*All students are writing silently…*]

Are you ready for the next question? Okay, we'll wait for this class to pass.

Okay, next question is, if you had to explain the word "earthquake" to a friend what would you say?

[*All students are writing silently…*]

#1: what number was that?

Matt: we just did number three, that was number one and two.

#1: what was the question?

Matt: if you had to explain the word "earthquake" to a friend what would you say?

[*All students are writing silently…*]

The second part to that question is, please explain the events or event that you think causes an earthquake to occur.

#4: what was that?

Matt: please explain the event or events that you think causes an earthquake to occur.

[*All students are writing silently…*]

#1: can you say the question again?

Matt: please explain the events that you think cause an earthquake to occur.

[*All students are writing silently…*]

#3: what was the question?

Matt: please explain the events that you think cause an earthquake to occur.

[*All students are writing silently…*]

#1: after this question are we gonna watch the video?

Matt: yeah, one more question, well two more questions, then we'll watch the video. Ummm, so, the next question, let's wait just a moment for #3 to finish.

#1: I'm [*name Matt said for #3*].

Matt: sorry, [*corrects name*].

#2: [*inaudible comment, points to Matt's shirt*].

#1: I remember going to the bathroom outside, and there was like erosion and stuff, then the ocean and stuff, like the harbor.

#2: I remember when we went the bridge [*last words inaudible*].

#1: step on rocks… I wanna go back.

Matt: you can.

#1: I wanna live there.

#4: in the summer.

Matt: there are summer programs. There's some during the day, and there's some overnight.

#2: we had [*inaudible*]

Matt: okay, next question. If you had to explain the word "superposition" to a friend what would you say?

Remember you can draw or write.

#1: What word?

Matt: Superposition. You can draw if you want to. Draw or write, whatever is easier.
[*All students are writing silently…*]
The second part of that question is, please explain the event or events that you think cause superposition.
[*All students are writing silently…*]
Please explain the events that you think cause superposition to occur.
[*All students are writing silently…*]
Okay, next question. You all have to look at this drawing and tell me which one of these four drawings best describes where the plates are in the earth. The tectonic plates are the plates that are moving slowly near the earth's surface. Which one of these drawings describes where the earth's crust is and where the earth's core is? Where the plates are? So, just tell me, and I'll write it. You can write your answer down, but tell me, say it out loud so that I can write it down.
Sure, write the letter. So you think B [*to #1*]?
#1: Yes [*nods head*].
Matt: you think? [*to #3*].
#3: B [*or D hard to tell*]
Matt: and you? [*to #4*].
#4: A.
Matt: what do you think? [*to #2*].
#2: B.
Matt: Okay. Thank you. So, now I'm going to show you the video. If I put it up here, can everyone see it? Can everyone see it?
[*12:34:06 – begin Superposition.mov, for transcription refer to* Appendix.II.E.4] [*, end 14:21:09*]
#1: who's that? [*at the start of the second scene*]
Matt: there's a few other kids from different schools.
[*end 14:21:09*]
Sorry it wasn't very loud. Okay, can you all see that picture [*IW_trench_photo*]?
All; Yeah.
Matt: do you recognize that picture?
All: Yes.
Matt: Okay, explain what's going on this picture.
#2: there are rocks.
Matt: rocks, okay. I'll move it closer. [*holds computer in front of #1 and #2 and then #3 and #4*].
#1: there are orange pins and dirt.
Matt: Kay. What are the orange pins in this picture? You see the orange pins in this picture. What are the orange pins?
#1: ummm, the, where the… I think the wet dirt and the dry dirt, I don't know that good. [*looking at the computer*].
#4: ummm, the

Matt: Kay. Can you see it? [*holds the computer in front of #4*].
#1: I remember now.
Matt: what do you remember?
#1: I remember that I had to go to the bathroom badly.
#2: [*laughs*]. I remember that it was dry and half of the [*inaudible word*].
#1: and it was deep.
#2: and there was big chunks of rocks in it, and it was not layered.
Matt: it was not layered. So the rock that is along the bottom [*points with finger to the screen*], right here, is the glacier rock, right? Is that older or younger?
All: older.
#2: younger.
Matt: younger. It's more recent. So what is…
#1: how did you find this?
Matt: this is a picture that the geologist took when he excavated it.
#1: umm, the light went off.
Matt: [*touches the screen*]. Umm, so this is showing that the older rock is on top of the younger rock.
#1: so the older rock is on top and then?
Matt: right, so something happened that changed?
#1: the earthquake.
Matt: yeah, this is showing the earthquake. Did you guys see that picture when you were at IslandWood?
All: yeah.
Matt: Kay. So you remember it now? Okay one more slide. [*slide #3*] Do you know what those are?
#1: rocks.
Matt: Do you recognize where that is at IslandWood?
#3,#2,#1: [*all together*] yeah, by the cafeteria., the cafeteria, in front of the dining hall.
#4: the cafeteria.
Matt: yeah, so what's it a picture of?
#1: rocks.
#2: plants, dirt rocks,
Matt: do you remember the word for the rocks that came from a long way away?
#1: ummm, let me [*begins to look at her drawing*].
Matt: it started with an "E".
#4: ummm, [*inaudible comment*].
Matt: [*responds, but inaudible*].
#2: a rock from a long way?
Matt: it has to do with a rock that is out of place, it's another word for strange.
#4: erosion.
#3; I was about to say that.
Matt: close to erosion, but it's not erosion. Erosion is how the rock comes because it erodes off other rocks…. There's two "Rs" in it.

It starts with an "E" and the next two letters are "R".
#1: erection.
Matt: erratic. Erratic, remember that word?
All: yeah.
Matt: so these are examples of rocks that were brought by glaciers and they're called erratics. Okay, so do you want to change any of your answers from what you wrote before based on the movie, and based on the pictures? If you want to change it, use a different color pen please. Or just write it to the side, but use a different color pen.
#1: what was, what was the first question again?
Matt: the first questions was glaciers. The second question was earthquakes. The third question was superposition.
#2: do you want us to read it out loud to you?
Matt: sure.
#2: all of them?
Matt: sure. Let's start with… glaciers.
#1: I have a picture right here of the mountains and all the small drops and here's the land where the does this to the land, and destroys it. And the second question, [*inaudible word*], glaciers, it is caused by bad weather or if there is too much snow and it will start to make glaciers. Also, it will destroy houses and the land.
Matt: okay. Go ahead [*to #2*].
#2; I didn't get to draw a picture, because I'm used to writing so,…
Matt: okay.
#2: I would maybe say that a glacier is a massive river of ice that flows down slowly on or around the mountains valleys and sometimes covers that land.
Matt: okay. [*nods to #3*].
#3: I got a picture of this mountain and the glacier is coming down to these trees and rocks, [*inaudible words*] because the glacier pushes the things out of its way.
Matt: okay. [*nods to #4*].
#4: I think a glacier is something that has to do with snow that forms on a mountain and forms into a glacier. [*Inaudible words*].
Matt: all, all good definitions. Okay, an earthquake?
#1: an earthquake, an earthquake, an earthquake is a roud… rumbling move that shakes places also an earthquake can destroy a place on land.
Matt: good.
#2: well on number two I put what causes glaciers.
Matt: you can read that, you can say that too if you want.
#2: okay. I think what causes the glacier is when a bunch of the snowflakes exceed the sum of [*inaudible*] years.
Matt: Kay. And earthquake?
#2: If I was to explain the word earthquake I would maybe say that the earth shakes motionally and sometimes strong.
Matt: Kay.
#3: [*inaudible, reading, so will check poster later*].
#4: [*inaudible, reading, so will check poster later*].

Matt: the last one had to do with superposition.
#1: superposition is [*inaudible, reading, so will check poster later*].
Matt: you can read what causes earthquakes to occur.
#2: yeah, [*inaudible, reading, so will check poster later*].
And, I didn't really know what superposition is, so I…
Matt; so let's see what you got?
#1: after her, can I read what I think it is?
#2: superposition is [*inaudible, reading, so will check poster later*].
Matt: Kay. Then, what causes superposition to occur?
#2: [*inaudible, reading, so will check poster later*].
Matt: Kay.
#3: [*inaudible, something about how she wants to read what caused an earthquake to occur or maybe glacier too*].
Matt: do you remember what causes it.
#3: I don't know.
Matt: that's okay.
#4: I think it has to do with the position of earthquake [*inaudible, reading, so will check poster later*].
#1: can I read what I had for number six?
Matt: yeah.
#1; I think that superposition is caused by an earthquake or an glacier or a rock that is turned into a fault.
Matt: okay. Good. So, does anybody remember… So you guys were right in the beginning of the video, and there were a few other kids, in the video, from different schools. And you [*looking at #4*] right in the beginning of the video said your definition of superposition. Did you guys all here what he said?
#2: yes.
#1,#3: no [*#3 shakes head*].
Matt: what did he say?
#1" what is superposition.
Matt: did you here what you said [*to #4*]?
#4: no.
Matt: do you want me to play it again?
#4: yeah.
Matt: let's play it again, and ill put it closer so that you can hear it a little better. Uhh, let's see if I can make it louder, that's as loud as it goes, yeah I'll put it down here in just a second.
[*23:26:09 begin Superposition.mov, end 23:59:10,for transcription refer to Appendix.II.E.4]*
What did you say [*to #4*]
#1,#2,#3: the older rock is on the top and the younger rock is on the bottom.
Matt: that's what happened after the earthquake. Before the earthquake, how was it?
#1; the younger is on the top and the older rock is on the bottom.

Matt: yeah.
#2: so it's like switched.
Matt: exactly. So, why is that important that it switched?
#1: cuz, the dirt it can get old, and then like turn into something so then you have it switched so you can make a new one and you know that something has happened to the land.
Matt: yeah. It tells us that something has happened… like what?
#1: an earthquake.
Matt; an earthquake. Exactly. And that's what this picture was [*slide #2*]. Right? This rock over here is the old rock.
#4: the top is the newer rock.
Matt: then this rock here is the…
#2,#1: the younger rock.
Matt: so, then these orange pins are, are what? They're right between the two rocks
#1: dividing.
Matt: right dividing, but it's also showing… what happened?
#4: where the earth, the earthquake.
Matt: where the earthquake happened, and the superposition has changed [*to #4, who nods head*].

Okay if you want to correct your answers, you may use the back. Use a different color pen. Then I will ask you three more questions and we'll be done.

[*Inaudible comments to #4, about using a different pen, and not worrying about crossing out existing answer*].

It's always a good idea to correct your answers.
#2: superposition means the younger rock on top of the older rock?
Matt: [*nods*].
[*All students silently writing…*].
#1: [*inaudible, something about the camera*].
Matt: I have to download it onto the computer, then I will make sure to get you guys a copy. Okay, last three questions, on science in general.

So, how often do you think that learning about the earth, earthquakes and glaciers is too complicated? All the time? How often do you think that learning about the earth, earthquakes and glaciers is too complicated? All the time? Most of the time? Rarely? Or not at all? You can say your answer out loud if you want?
#4: rarely.
#1: wait, can you say the question again?
Matt: how often do you think that learning about the earth, earthquakes and glaciers is too complicated? All the time? Occasionally? Most of the time or rarely?
[*All students silently writing…*].

The next question is, does your teacher make it too complicated? All of the time, most of the time, occasionally, or rarely? Does your teacher make learning about earthquakes, the earth and glaciers complicated? All the time, most of the time, occasionally, rarely?

#4: occasionally.
Matt: occasionally.
[*All students silently writing…*].
#3: occasionally.
Matt: Kay. How often do you take field trips in science? As often as possible, occasionally, or not at all?
#1: field trips, you mean science field trips?
Matt: science trips.
#2: occasionally.
#1: occasionally.
#3: occasionally.
Matt: where do you usually go?
[*All students silently writing…*].
#1: we went to a college and studied science there in the lab.
Matt: did you go to rivers?
#1: um, we went to a class, and then we studied about water and then weight…
#2: we take field trips, we take the field trips that mostly have educational value for us.
Matt: so, what places do you go to?
#2: we went to the college, then we had a field trip where we went to Seward Park.
#3: and going hiking in the mountains.
Matt: Kay. Do you enjoy going on field trips?
[*All students silently writing…*].
#1: yes.
Matt: why or why not?
[*All students silently writing…*].
#1: can you repeat that?
Matt: do you enjoy going on field trips?
[*All students silently writing…*].
#1: it's because we get do something fun and outside the classroom [*check with written words on poster*].
#4 [*inaudible, check with written words on poster*].
Matt: okay. That's all I have, that's all the questions that I have for you. But do you have any questions for me?
#2: do you think that we'll be finished with this in a day?
Matt: we're done. We're done now. But, just do you have any questions for me?
#2: [*inaudible comment, too much background noise*].
Matt: just so you know, the stuff that we are doing here, what I'm doing, I'm taking this information here that you guys remember after a year and what the kids that were just there and compare so that we can change some science curriculum so that you see more, do more.

#1: are you doing this because when another school comes they will be able to see the same that we saw and they will be also be able to explain more.
Matt: uh-huh.
#2: have you done this in other schools that went to IslandWood?
Matt: only a few other schools.
#2: why did you choose us?
Matt: I chose you because I had the video of you guys.
So, good. Thank you. That is all I have for you.
#1: do we write our names on it?
Matt: if you want to.
#2: what are you going to do with these?
Matt: I'm going to hang onto them for a while and take pictures of them and then I will get them to you. Before you guys go, I have something for you.
[*End Transcript 33:27:27*].

2. IW 2005 pre

[Conference room at school. Seven kids around the table. Clockwise from lower left: author, Asian girl (#1), Asian boy with glasses (#2), Latino boy (#3), African American boy (#4), African American girl (#5), Asian/Filipino girl (#6), and Filipino boy (#7). Latter two are not fully visible.
Each student has a large sheet of paper (about 11x17 inches) in front of them, and several markers to choose from.]

[Total time – 19 min. 34 seconds]

[Part I – 00:00:00]
Matt: my name is Matt… Brewer…[sitting down]
All: Hi Matt [at different times]
Matt: …and this is Shira…[motion toward Shira off screen behind]
Shira: Hiii…
All: Hi Shira [at different times]
Matt: …and I'm going to ask you some questions that you answered in the questionnaire…umm… it's about when you guys come to IslandWood in two weeks I'm going to be there for the week teaching about science and geology. So that's my connection to IslandWood. So, do you guys agree to participate in the interview?
All: yes!
Matt: so, what we're gonna do. We're gonna do this in a group video. It's okay if everybody talks, just be respectful of other people talking. I', gonna ask several questions in three parts. The first part is about concepts in geology?
#6: what's that?
Matt: umm.. words and definitions…
Shira: Matt, is it on?
Matt: I think so.
#6: is it recording?
Matt: it should be [gets up]
Shira: I just don't know.
Matt: [laugh]
#2: slight difficulty
[Inaudible mumbling between students and Shira and I]
Matt: yeah it's recording [readjusts camera, all students are visible, and I am not in lower left]…ummm, so the second part is gonna be… I'm gonna show you a video of what the fifth graders learned last year when they were at IslandWood. And then I'm gonna give you a chance to correct of the answers from the first part. And then I'm gonna give you some general questions about science. Okay?
All: yes.. okay! [at different times]
Matt: so you have the piece of paper in front of you, write your answers, draw your answers, anyway you want to answer the question, say it out loud, I'm gonna write a

few things down… umm, that's what the paper is for, you can use both sides. Okay?... yes, question?

#4: when you ask the question, and we write it down, can you go from one person to one person, and ask them what's their answer?

Matt: we can do that, I want to do it as quickly as possible, but we can do that. Definitely.

So, the first question is… if you had to explain the word glaciers to a friend what would you say? And draw your answer if you want. [hands raised]

What's a glacier? [to #6)

#6: ummm… sprinkles of snow

Matt: what's a glacier? [to #7]

#7: a big mass of ice or snow, uh falling down a mountain or across [asking like a question at end].

Matt: anyone else want to add anything?

#3: umm.. [raises hand, looks down at page]

Matt: yeah?.. yeah?... Go ahead.

#5: me?

Matt: yeah, go ahead.

#5: to slow ice? [as a question, almost]

Matt: [moves mic into middle of table] okay,

What… please explain the event or events that you think might cause a glacier to occur….

Yeah? [points with pencil to #5]

#5: all right… like… like, if they're in Alaska, and you stand, like, near a mountain, and you scream really loud, it would like come falling down.

Matt: [pause to write] yeah

#7: an earthquake? [questions/statement.]

Matt: yeah

#4: a very loud echo.

Matt: anyone else?... yeah go ahead.

#3: a very loud noise.

#2: a little shake [laughs]

#1: a big huge boom box.

Matt: okay, good… if you had to explain the word earthquakes to a friend what would you say? You may also draw an answer.

What would you say? [to #1]

#1: it's when the earth shakes.

#4, #6: she took mine [at different times].

Matt: yeah.

#7: it's when a rock underground shakes.

Matt: anyone else?

#2: when the lands underground crashes.

Matt: please explain how you think an earthquake might occur. You may also draw your answer…. Yeah?

#6: well, the earth hits something and it slips.
Matt: yeah
#5: like if you's underground or in a volcano, umm, like, a big 'ol huge heavy rock falls onto the ground and then the whole earth shakes.
#1: when a volcano erupts.
Matt: anyone else?... yeah.
#4: when a small meteoroid… meteor hits it.
#2: when mountains hit each other.
Matt: okay, everybody ready to move on?
All: Yes, no, yes sir, no [all at same time, in chorus]
Matt: okay, we'll wait just a moment.
#2: I don't know what the, uh, the next one means.
#6: I know
All: superposition
Matt: we'll go over that, we'll go over that. If you know what it means that's good, if you don't I'm hoping that you'll learn at some point, and it's not really important that we know what it means right now.
#4: super posing?
#3: superposition.
Matt: I'll read the question in just a moment. Are you done? Is everybody ready? Okay.
If you had to explain the word superposition to a friend what would you say? What would you say? [to #6]
#6: this is what my teacher told me. [audible okay by author] when, ummm, something lands on something else.
Matt: Kay. Why don't you guys please explain what you think might let superposition occur. Draw it because it's a confusing one, or you can write it, or you may speak it.
#4" I don't even know what it means.
Mat: that's okay; we'll come back to it. We might have a chance correct… we'll have a chance to add later when we see the video.
#6: we're gonna see a video?
Matt: um-huh.
[audible mumblings between students, no content]
Okay, are we ready, are you guys ready to move on?
All: yes. yeah [in chorus]
Matt: the last question in this section. Shira, can you use yours, and show this one. I want everyone to look at these four pictures, and Shira has another one we can look, and say which one you think best looks like the way the earth tectonic plates move. A tectonic plate is how, are plates that move and may cause mountains, and volcanoes, and that kind of think. So, how are the plates on the ground, in the earth?
Shira: you guys should look at them, make sure that they all can see too [audible in text above].
Matt: So, which one do you think it is? [audible "ummm" from students]

#4: I think it's A.
Matt: Which one do you think it is?
#7: I think it's B.
Several: I think it's B. [#1,#2,#5,#6]
#4: I think it's A.
#3: I think it's B.
#4: I think it's A.
#3: B.
Matt: Which one do you think it is?
#2: Me?
Matt: Yeah.
#2: Uhhh… B.
#3: C. [laughter]… Uhh No.
Matt. Good. We'll come back to that later, and we'll see that if when we learn new things we can change our answers. So, you can give that back to Shira.
Shira: Thank you.
Matt: I'm going to show everybody a video… Can everybody see the screen?
All: Yes… No… Sorta… Can we turn off the lights?... We can see sorta… Can we turn off the lights? Umm…Yeah. [all at same time over each other]
Matt: The lights are right…
Shira: Yeah, I'm just gonna…
All: Yeah it's better like that… yeah that's better. [several at same time]
Matt: It's okay. Close the door, it's okay… All right, so, these are… this is a video from some of the students, you may recognize some, they're fifth graders, they went to IslandWood last year, and there's other students from other schools explaining what they learned at IslandWood with my groups when I was a teacher there.

[Part II – 09:26:00]
Video Superposition for transcription refer to <u>Appendix.II.E.4</u>]

Matt: All right. So, that's that video. If you wanna correct your answers or change answers that you have from before you may do that. If you want me to read the questions again, I can read the questions again.
#4: The older rock is on the bottom, right?
#7: Older rock? The older rock is on the bottom and the younger rock is on the top.
#3: The new ones are on top, or the old ones are on top and the new ones are on the bottom.
Matt: After what?
#1,#6: Earthquake.
Matt: Good… You said?... Good.
#2: New rocks on the bottom.
#5: After the earthquake.
Matt: So, who remembers what superposition is then?... Yeah.

#3: Uhhh… I just forgot.
Matt: Yeah.
#7: The younger rock is on the top and the older rock is on the bottom.
Matt: Unless what happens?
#7: They switch, no like, an earthquake… makes it switch.
#5: An earthquake happens.
Matt: Good….. We'll wait for others to finish up, no hurry. [some students are writing, drawing on posters in front of them, some are not].
#4: How do you spell earthquake again?
#7: E-A-R-T-H-Q-U-A-C….
#6: K!
#7: K!-E.
#5: A-K-E.
Matt: Okay, does anyone want to share something that they learned from watching the video?
#3: Uhhh…
#5: Show or tell?
Matt: Show. Tell. Both.
#4: Alright, I learned that, uhhh, what a, ummm, what superposition means.
Matt: Okay,
#6: That's all he learned.
Matt: That's all. Okay.
#5: I learned that superposition [trouble saying word] … superposition means, like, a big, old rock is on the bottom and the little new one is on the top. But if an earthquake comes, then it like knocks those rocks down, then it like switches up.
Matt: Very good. Yeah.
#2: I learned that earthquake causes superposition.

[Part III – 14:42:00]
Matt: Good… Okay, last section of our interview. These are some general questions about science. Okay, so they're not very… well, you'll see.

So, how often do you think that learning about earthquakes, glaciers, and the earth is too complicated? All the time, most of the time, occasionally, or rarely?
#5: All the time.
#6: Rarely.
#7: Most of the time.
#2: Most of the time.
#3: Most of the time.
#5: All of the time.
#4: Rarely.
#6: Rarely.
#1: Rarely.
Matt: Rarely. And what did you say?
#1: Most of the time.

Matt: He said rarely. And what did you both say? You both said most of the time?
#4: Rarely.
Matt: Good.
#7: I said most of the time.
Matt; You said most of the time.
Good. Does your teacher make it too complicated? All the time, most of the time, occasionally, or rarely?
All: [all speaking at same time, hard to discern who is speaking].
Matt: Rarely… Occasionally is like sometimes.
#6: Occasionally
Matt: You two down there?
#4: Rarely.
Shira: Is it too complicated? Does the teacher make it too complicated?
All: [all students at same time, hard to discern who.]
Matt: Okay, how often do you take a field trip in science? As often as possible, occasionally, or not at all?
All: [all at same time, hard to discern who.]
Matt: Did you get… occasionally, not at all?
Shira: We've got occasionally for everyone.
Matt: Where do you usually go?
All: Pacific Science Center… Cedar River Watershed.
Matt: Anywhere else?... Do you enjoy going on field trips?
All: Yeah… Yes.
Matt: Why?
#5: Because… Because you get to learn something a lot more new outside of the classroom.
#6: And it's fun.
#2: I know why… You learn. But you have fun at the same time that you're learning. [end of statement inaudible]
#5: Yeah, but you can do that in the classroom.
#6: no, you can't.
#5: Yeah [laughs].
#4: You can't have fun while you're in the classroom. But, uhh, you can have fun on field trips, and at the same time you can be learning, that's why I like them.
#3: is that the last one?
#7: the last one is, do you have any questions for Matt Brewer.
Matt: Yes. Do you have any questions for me? Thank you all for participating. I will see you and your classes at IslandWood. And I look forward to working with you more. Did you have any questions for me? Yeah.
#6: Ummm, what do you do at IslandWood?
Matt: I was a teacher at IslandWood last year?
#6: No, what will we…
Matt: Ohh, what will you do…

#6: Yeah.
Matt: They have a curriculum that will… well you'll explore the land in different ways, and when you work with me we'll focus on investigating the earth, geology…
#7: Geology?
Matt: …geology and the earth.
#6: Oh.
#5: What does the rooms look like? [others answer together – *cabins, boys and girls together?* Etc.]
Matt: It's all girls in one room… and all boys in one room… And they're kind like a bunk, like several bunk beds that kind of thing.
#3: Do they have private bathroom?
Matt: Yes,
#3: Good.
#5: Like, umm, like, all the girls from Mrs. [inaudible] class are in one room?
Matt: No, there'll be four to five people in each room… but probably all the girls on one floor and all the boys, it depends on what they decide.
[inaudible comments]
Any other questions? I'm gonna collect these.
[?] Do we write our names?
Matt: You can write your names on these if you want to, but you don't have to. Ummm, and then we're gonna do another interview after you visit IslandWood, with the same questions, and I'll give these back…
[?] Same People?
Matt: Same people. Yeah-up. And we'll have a chance to add to what we wrote. Okay? Thank you again for participating.
#4: Do we go back to our classrooms?
Matt: Yes.

[END – 19:34:07]

3. IW 2005 post

[Conference room at School. Three students at table to start: #1, Asian boy with glasses (pre #2); #2, Latino (?) boy (pre #3); #3, Filipino boy (pre #7).
Each has poster from pre interview with markers in front of them.]

[Total time – 39 minutes, 46 seconds]

[Part I – 00:00:00]
Matt: So, we will begin. [Sits down at table] So, do you all agree to participate in this interview again?
All: Yes.
Matt: Okay. So, ummm…
#2: Do solemnly swear. [Matt laughs].
Matt: So, it's the same questions as last time. So go ahead and use the other side of your paper or use a different color pen then… and use a different color pen then you used before. You can use the same side or the other side if you want.
#2: The other side.
Matt: Ummm…
#2: Use a different color pen then the last time. [to #3].
Matt: Okay. So, if you were to… and I say that you guys wrote down your answers too, so that's good. If you were to explain the word glaciers to a friend what would you say or how would you draw it?
#3: A large mass of ice, that uhhh, umm, uhh, falling down very slowly, down a mountain or across it.
Matt: I forgot to turn on the microphone.
#2: So, do you want to start us over?
Matt: No, we'll just continue because there's a microphone on that thing… Ummm, Okay.
#1: ` A big chunk of ice.
Matt: Okay. And how does a… explain the events of a glacier…. Yeah?
#2: Ice and water form together and make a huge glacier and move together very slowly to like other places and start hitting things on the earth.
#3: Never mind, he said mine.
Matt: okay. Good.
#1: We didn't go to your earthquake thing.
#2: Yeah, I did.
Matt: Some of you did, some of you did.
#3: Remember we did. We went to the fault line with you and then…
#1: Yeah, we just saw the fault line.
Matt: Yeah we're talk about that in a minute.
#2: Yeah and you talked to us about the, well we were on our way to the, then you found these two rocks, well [inaudible, Matt says "right"]… one was like really pitch

black and it had like pointed stuff on it, and the other one was like not pointed and curvy and smooth, and like kinda like whitish brown and stuff.

Matt: What did those two rocks tell you?

2: Ummm… It tells two stories.

Matt: Uh-huh? Do you remember some of the stories?

#2: I don't know.

Matt: Can you help him out?

#3: I was gonna say superposition.

Matt: Well, we'll get to that, but if you know what that is, explain that.

#3: Right now.

Matt: Yeah.

#3: Okay. Superposition is when the young rock is on the top and the old rock is on the bottom.

#2: unless if there's an earthquake then the position switches.

#1: they switches… with the earthquake.

Matt: Okay. Good. So, that leads us into our second question, which is about earthquakes. If you had to explain earthquakes to a friend what would you say?... We'll just go around the room this way [clockwise].

#1: The floor shaking.

Matt: The floor shaking.

#2: okay… ummm, when the earth's surface, when like there's a huge, really strong rock slide then the earth's surface starts to shake, and then that's how an earthquake happens.

#3: I thought the earth's crust…

#1: I thought the plates like push back and forth… and then one, like goes over… and [motions with pen to make a wave]

Matt: Kay. Good… it does make waves

#2: Yeah, --

#1: I have a question.

#2: -- I remember once that you taught us, like, when like we were all connected together, then like someone pushed, then like most of the people kept on falling.

Matt: do you remember what kind of wave was?

#3: E-wave!

Matt: not quite and E-wave.

#3: P-wave?

Matt: P-wave.

#2: Second wave!

Matt: Which one was the secondary wave?

#3: Secondary wave.

Matt: There was the P-wave, which was—

#3: Secondary!

#2: Perfe—per, uhh

#3: Perpendicular.

Matt: No.
#2: Perpenetic.
#3: oh I know there is… [almost inaudible under #2]
Matt: No. It means first. It's another word for first… Pri…
#3: Primary!
Matt: Primary… [laughs] And then the secondary wave.
#3: and then the, there was something else.
#1: he just knew it.
#3: Primary, right?
Matt: Primary, Secondary and then it's on the… on the ground
#3: P-wave.
Matt: No
#2: Wait, umm, it was push, grab back and what else it, oh yeah when you…
Matt: side to side, right?
#2: oh yeah, side to side… oh yeah when you were using that cord, and kept putting like a rope.
Matt: uh-hub… Surface waves.
#2: Oh yeah surface waves.
#1: I have a question. You know how the primary one works, you know it just moves around. Is it kinda like a person doing the worm on the floor moving?
Matt: Ummm… Yeah… kind of. It would, well the wave is moving from between me and my car out in the parking lot, right?, going through us, so when it passes us we're staying in the same spot. So, even though, even though like when it goes this way, even though it may bounce the pen up, like this each time it passes, the pen is staying more or less the same position. Right? It may move side to side like this, but it's more or less staying in the same place. So, if the ground moves, and sometimes it does, as—
#2: So, So… [audible through last sentence]… So what you're saying is when there is something in a spot, and there's a wave, a strong wave, then it keeps on moving back and it doesn't stay in that same spot for a lot?
Matt: like imagine your house. Okay? And imagine the earthquake wave coming through your house, right? You guys felt the earthquake in 2001?
All: Yeah. [other inaudible comments]
Matt: Okay, yeah, right. So the wave is coming and your house bounces. Maybe your house moves when the earth is done shaking a quarter-of-an-inch, but for the most part it's gonna stay right where it is. But it feels like its moving ten feet back and forth, right?
#3: I wasn't here in 2001.
Matt: I wasn't either.
#3: I was in Florida… I was born here. Then I went to Florida. Then I came back
#2: I… Wait a minute… I imagine that beaver are shaking my house.

Matt: Uh-huh. That might be. I mean, that's a way to think about it, but, so it's moving back and forth but it's not necessarily moving [motion side to side, words not audible].
#1: I have a question… Can it move like, can it move trees?
Matt: uh-huh.
#2: it can.?
Matt: uh-huh.
#3: But, like you know like the earthquakes, like the little earthquakes, why can't we feel them?
Matt: Because sometimes they're—
#3: They just pop up
Matt: --in the ground, Right, They happen and the earth kinda absorbs that impact, energy. So, by—
#2: the impact?
Matt: the impact and, right, so, as you were saying a minute ago, the plates move and that releases energy, right—
#2: Oh, so!
Matt: --and as it gets further and further out, by the time it gets to the surface the energy is less, right, the earth absorbs the energy so we don't feel them all.
#2: So, what you're saying is—
[Knock on door]
Matt: come on in. [gets up to open]
#2 so what you're saying is that when the, so when the plates move and it opens up a little bit, and the core's energy starts rising.
Matt: [focused on student that just entered, #1 first interview, #4 hereafter]
Go ahead and have a seat on the other side. Is this one is yours? Find yours. And we're going to use a different color pen then we used before. So, I'm sorry we were talking about?
#2: the plates.
Matt: so we don't feel the smaller earthquakes because the ground absorbs that energy, and the bigger ones, they send more energy, so the earth can't absorb all that energy, so we feel it on the surface if you're nearer to the area that it occurred.
#1 I have a question. When there's like a little earthquake underwater will the waves be like a little bigger than normal?
Matt: Well, yeah, that's what happened—remember the tsunami. That's what happened with the tsunami.
#1: What about a very small earthquake?
Matt: Ummm, it's possible. I've read that it takes a larger earthquake to cause a tsunami but I don't know exactly how big it would be. That would be something that we could try and figure out.
#2: But, Matt, what if like, for example, remember the tsunami?
Matt: uh-huh.
#2: what if that was even stronger, could we feel it from India to Washington?

Matt: We might see, we might feel some of it, but because it was on the other side of the world it would, by the time it got to us it be too much bigger than a normal wave. But it did go all the way around the world. Ummm. Actually, I have a video of that, would you like to see it?
All: yeah.
#2: you video recorded it?
Matt: [opening computer] I didn't video record, this is from, this is from, give me just a moment to find it. This is a, this is from, I think it's from NASA.
#2: remember that time when we were watching that presentation and the whole world was trembling, [sound of zipping and motion with finger in circles]. Everybody was laughing…. [inaudible name]…what are you doing? Why are you shaving it? [it refers to the microphone].
#1: it looks like a shaver.
#2: it's from Radio Shack, boundary microphone. Wait is it microshoe or microphone? What? What?
Matt: give me just a moment…
#2: What? What?
#1: Shhhh
#2: What? What? Shouldn't we just call the National, NASA International Airport Society and give us one.
Matt: yeah, I moved it so it's in a different location, sorry for getting you so excited. We'll figure out a way to get you to see it. But basically, it shows the wave going through and it goes all the way around the world. And after about eight hours, eight to ten hours, it got around to the Pacific Northwest but it didn't do much because it had traveled so far. It did the most damage around in Asia and Africa.
#2; So there's two tsunami, one moving over from India and the other moving into the pacific ocean?
Matt: it's the same force, the same tsunami, but the earth, the earthquake occurred here and it radiates... You know when you throw a pebble in the water, the waves go in 360 degrees. Well the tsunami did the same thing, and it spread out, and then when it hit Africa, some of it went around Africa and spilled into the pacific, or the Atlantic on the other side, and as it went around Africa it started to go out here and some hit the western side of south America and some continued down below. And then it was able to spread out, but where it hit land it kinda bounced back and went a different way.
#2: did it hit Antarctica?
Matt: uh-huh. Uh-huh.
#3: did it hit the artic?
#4: did it hit Greenland?
Matt: Ummm, maybe, but Greenland is so far north and the distance, the way the earth is shaped, it's unlikely that it had much, that is was very strong when it hit there.
#3: so, is the highest earthquake, what was the highest earthquake that ever happened?
Matt: the highest earthquake ever recorded was the one that happened last December in Sumatra.

#3: Yeah, I mean how big was it?
Matt: it was a 9.3.
#3: what is the highest?
Matt: it's on a scale of, the scale that people use to measure it is on a scale of ten
#2, #3: Ten?
Matt: Ten. But a Ten, a 9.3 earthquake, I've read that, let's see, you've seen a bomb explode?
#2: Yeah, like the atomic bomb.
Matt: like the atomic bomb, it's like a hundred and eighty atomic bombs exploding at the same time.
[Audible silence]
#3: Whoa
#2 Whoa
#1 That's crazy
Matt: So it's a lot of energy, like a 9.3 or something
#1: I have a question… when it goes around the earth, it gets like, it gets weaker, and then the earth absorbs the energy is like when you're standing in water and pouring it down a little hill, the water, like a little drop, keeps getting smaller and smaller till its gone, right?.
Matt: Uh-huh, something like that. Okay good, let's get back to this. Let's see, I'm going to show you the video that I showed you before that has… about superposition and that, then show you some a couple other pictures that I want to talk through. All right? So,
#2: Oh it's on full screen.
[*14:41:02 – Movie superposition.mov; for transcription refer to Appendix.II.E.4. Matt responds to a knock on the door by setting the computer on the table and opens door and lets additional students enter*]
Matt: Come on in. Welcome. We're just going through some questions. Find your own
[*#5 (African American girl) and #6 (Asian/Filipina girl) from Pre enter. Hereafter-same numbers*
15:27:00 Matt stops the movie and continues to the next slide- Photo of Trench (#2).]
Matt: Kay, I'm gonna skip this for a moment. I'm gonna go to this picture.
All: Oh yeah, that, that's the picture.
Matt: Explain to me what's going on in this picture. [All raise hands]
Ummm… Come have a seat here [to #5, moves in front of #1], and I'll move back.
#6 Can you put it forward?
Matt: yeah, I'll move it forward a little bit.
#1: there we go, now I can see it.
Matt: okay, so, explain to me what's going on in this picture.
#3: fault line.
Matt: okay, he said that, what is that, what does that mean?
#1: superposition.

Matt: kay, so we hear lots of things, go ahead [to #6]
#6: a fault line means when an earthquake happens and it made the fault lines and stuff
[*Matt is giving inaudible directions (same that are above) to #6, who is sitting adjacent.*]
Matt: kay so the fault line?
#4: the fault line is like around here [points to screen].
#5: the fault is the red line.
Matt: the fault line is the red line, kay? And then what else is going on in this drawing?
#4: someone put the pins in.
Matt: they out the pins in it, kay?
#1: what's the pins?
#4: those dots.
Matt: and what are the pins separating?
#3: the old rock and the new rock
#2: The river rock and the glacier rock.
#4: peanut butter.
#2: chunky peanut butter.
Matt: kay, good, then you said superposition [to #1]. So how is this illustrating, how does this describe superposition?
#1: Uhhh…..the….
[*Others interject, Matt indicates to wait*]
Matt: Hang on. We'll come to each one.
#1: The new rock is always on the top and the old rock is always on the bottom.
Matt: and is that going on in this picture?
#2 I can's see that well. It looks dark.
[*Matt adjusts the screen*]
Matt: there we go.
#1: I can't tell.
#4: I think this is the river rock.
#1: how do you tell that a new rock is on top and an old rock is on the bottom?
#3: I think that, like, you know the rocks that you see right now, I think that the old rocks – [*motions with fingers like typing a keypad, words are inaudible*].
Matt: Kay.
#4: What? It could be.
Matt: Okay. Okay. So, umm, okay, so what else is going on in this picture?
#1: what's that blue thing?
Matt: the blue on the bottom, right here?
#1: no, right here [*points to screen.*]
Matt: that's the rock, more of the rock.
#1: are those diamonds?
Matt: They're different color, they're smaller pins that are separating different soils, soils within the rock.

#1: I thought they were minerals.
Matt: No, they're highlighting different, the main, or different kinds of soils and rocks that were others than we were looking at. We were looking at this one here. Where's my mouse? I lost it. We were looking at this rock here and this one here [*pointing to screen*], and you guys described that one as the chunky peanut butter, which was the, the glacier or the river, which one?
#1, #2: [*simultaneously*] the river.
4: the glacier.
Matt: the glacier was the chunky peanut butter, right? And then the super chunky, the one that has lots more rocks, was the…
#1, #4: [*simultaneously*] the river.
Matt: so, is the river on the top of the glacier in this picture?
#2: No.
#1, #4: Yes.
Matt: it's kind of hard to see from far away [*to #2*]
#2: no, I can see that well.
Matt: okay, the river is on top of the glacier. So the river is older, right? So what's going in this picture?
#2: isn't it switched?
Matt: it's switched.
#2: it switched!?
Matt: yep, this is the fault line, right, this orange that you guys pointed out, the red-orange, that was the fault line right? That you guys saw? Okay. Good. All right. Next picture.
[*Advances to Erratics at Dining Hall (#3)*].
Matt: Does anybody recognize where that is at IslandWood?
[*Several interjections "Ohhhh!"*]
#5: Dining Room.
Matt: Dining Room. So, what's it a picture of?
#2, #4: Igneous rocks
Matt Igneous rocks.
#1: what's an igneous rock?
Matt: rocks that were made by volcanoes. Right, so how did those rocks get there?
All: by glaciers!
#6: by glaciers.
Matt: all right, by glaciers, and, umm, how did they get carried in the glaciers?
All: [*simultaneously talking over each other with own idea (difficult to discern exactly who), each follows as heard-*] the glaciers keep moving, under it, and drags them, yeah, it picks up dirts and rock, and it keeps going over and over, it sweeps, and it keeps getting rolled, that's how it keeps moving.
Matt: Okay. Okay. Let's try and speak one at a time so it's easier for me to record what we're saying later, but that's good. I'm glad that you guys are excited about that.

Okay, so the glaciers came. They brought these rocks, and does anybody remember the word that they're called?
#3: igneous rocks
Matt: they are igneous rocks…
#2: metaphor…
Matt: but the rocks that the, there's a special word that describes the rocks that the glaciers brought. I don't think that, I wonder if we taught it?. It starts with an "E".
#4 erosion.
Matt: not erosion. But it starts like that.
#2: Umm, e, umm, you taught us this word.
#4: equation
#2: e, umm, umm
Matt: e-r-r-a-t-i-c.
#4: erack.
Matt: erratic. Okay, next picture.
[*Advances to superposition in three steps image (#4)*.]
So, what is it?
#4: it's superposition.
Matt: what is superposition?
#6: it's when the younger rocks are on top of the older rocks.
Matt: so, is this a fair picture of something that describes superposition?
[*Referring to image on screen of horizontal layers-orange on bottom, gray on top*.]
The orange would be what?
#6: the older, the river
#2: the river.
Matt: the river, the older rock. And then the gray would be?
#4: chunky peanut butter.
#2: I think glacier.
Matt: as the glacier. Okay, so, what happens if we squeeze this picture?
#4: it will like squish.
#2; it will like squish and squeeze together.
Matt: what's the black line represent if we squeeze it? [*Referring to next image with black arrows pointing towards the layers, and a diagonal black line from upper left to lower right*.]
#4: the fault.
Matt: the fault.
#1: what's a fault line?
Matt: the fault is… can somebody describe the fault?
#4: it's when the chunky peanut butter is on the bottom and the river rock is on the top.
Matt: okay, that's one way that it shows, but what's it doing?
#1: It's breaking apart.
Matt: it's breaking apart.
[*Inaudible and simultaneous speaking, of "ohh I get it!" nature*.]

So we continue to squeeze this picture, and this happens [*referring to next image of a reverse fault*.]

Now what's happening?

#6: now it's starting to switch…

#1: and there was an earthquake.

Matt: it's starting to switch and there was an earthquake. Okay, so, let's summarize those [*referring to last image of the last three images with text explaining*.]

So what's going on in picture one?

#4: the bedrock

#2: [*reading text*] (red) is deposed…

#3: deposited…

#2: deposited first, [*all joining to read*] and the glacial till (gray) – superposition. And then an earthquake occurs 110 years ago.

#3: 1,100 years ago.

#2: [*all continue*] the bedrock has been lifted 23 feet above sea level and now it is over the glacial till.

Matt: Okay, now that you have read what's going on. What do the pictures show? What's going on in this picture, what's this picture showing?

[*Many shouts over each other, not all are audible*.]

#2: superposition.

#6: it's showing the river rock on the bottom and the glacier rock is on the bottom [*motions with hands to indicate that the glacier is on top of the river*.]

Matt: okay in this second picture?

#6: once you squeeze it breaks apart.

Matt: so here it broke apart, right? So then?

#6: so then the earthquake came and it started to switch.

Matt: Okay, so let's go back to this picture now [*slide #2*.]

And which stage is this picture showing?

#2: umm, the earthquake superposition.

Matt: the earthquake superposition.

#2; The second one.

#5: and it's breaking apart.

Matt: and it's breaking apart?

#1: also this part here is, umm,….Wait, ummm….

#2: I can't see.

#6: This stuff up here must be – no, no this stuff down here must the chunky and up there is the river rocks.

#5: so they're switched around.

#6: and switched around.

#1: goes BOOM!

Matt: all right. So, one of the things that I want to know after you've visited IslandWood is we did this interview before and you guys had lots of questions and you weren't sure about some of these. Now that you've gone to IslandWood, and you saw this earthquake, and we talked about some how of this occurs, and we've talked more

about it, do you think that learning about science and earth science after seeing it is much more, is much, is easier?
All: yeah.
Matt: why do you think, why do you think it is easier?
#3: cuz you get a picture in real life.
Matt: let's go around and share one thing each.
#5: cuz, umm, so if it's in real life you can identify it more.
#4: uhh…. ,
Matt: you can pass and we can come back to you, if you want?
#4: pass.
#3: get a better picture looking at it, instead of looking at the picture.
#2: that one, he got mine.
Matt: kay.
#1: uhh, ummm, like give another example.
Matt: umm-huh….. okay. And what were you going to say?
#6: I was gonna say, ummm, that it's easier, it's easier because now that you, like, seen what it looks like and what it does and stuff, now, now like, you can, like, once you've seen it happen like on a computer or something, now you can like actually get it straight than like somebody speaking it.
Matt: good. Good. That's one thing that, the information that you guys are giving me is going to help. I'm going to take this information, and I'm going to look at some the curriculum, the ways that teachers present this information and to you and your classes and try and find a way that it can be presented so, just like you said, that instead of looking at the picture in the book there can be a way that you can have a model and it makes much more sense.
#6: yeah.
Matt: All right. The last thing that I want to do is to go back this picture here [*tectonic models diagram*].

That we did before, remember it has the three, the four models of where the plates are. And I wanna again ask which you think is, it is?
#2: B.
#3: everybody B.
Matt: everybody thinks B?
#2: yeah
#6: umm-huh.
#1: yeah. I made a guess.
Matt: why? Tell me why?
#1: I think because…
#2; it just looks cool to me.
#1: I think because, umm, if it's like right here and the plates go up, it's, like, it's not gonna like, I think it's not gonna move as much, but if it goes here, it goes up and then hits it a little bit and starts to make some waves, or something like that.
#6: like like…

#1: and if it's like here it's just gonna tilt up and it's here it's gonna [*inaudible words*].
#6: but this one, but this one, this one, like once you, once it moves up and then it hits this space, then this thing will go up more so it can up farther. [*Referring to B*].
#1: yeah, and then it makes the little waves.
Matt: umm-kay.
#3: what's the earth's core?
Matt: the earth's core is the middle of the earth.
#4: the hot middle. Hot.
#6: this one [*referring to A*] , this one, if it goes up it doesn't have like extra help to go up more. And this one [*referring to C*] , I don't know
#5: can't move and go through. It's too straight.
#6: yeah it's too straight. This too straight because this line is where the –
Matt: okay.
#1: and if this one, it's like, it's like, umm, something like that moving, and then like there's a log and then there's something moving and it goes back and it hits it, and it doesn't move anymore—
#3: sorry [*make noise on heater*].
#1 --goes really far back and then hit it, it might move a little bit.
#6: this is too small [*referring to D*].
Matt: okay, too small.
#5: it would take like too long too.
#1: yeah, it would take like 500o earthquakes.
#6: exactly.
Matt: okay, so everyone agrees that it's either A or B?
All: yeah.
Matt: it wouldn't be C or it wouldn't be D?
All: yes. No.
#5: I agree it would be B.
Matt: okay, so, we saw an earthquake, right? And we saw what happened when the plates, when something happens and the ground moves, right?
All: umm-huuh.
Matt: and causes the ground to lift up, right?
All: umm-huh.
Matt: so, which one, A or B, do you think, if, if the plates move and they cause the earth to go up and down, to lift up parts of the earth, which one would best describe, which could best show that the plates go up?
#2: A. A!
Matt: why do you think A? Why do you think A now?
#6: because this one doesn't have this line here. So it will like take less years to move up farther.
#1: yeah, it will push it, like—
Matt: so it will be less effort.

#1: --like when the plate moves it pushes it up and it makes the earth move a little bit. And then on this one [*B*] maybe if it pushes it the earth move up a little bit, or the people move.
Matt: okay, good. Do you guys have any questions for me?
#3: yeah I have one.
Matt: kay?
#3: will we go to IslandWood in fifth grade?
Matt: I don't think so. I wish you could. I don't know I think that is up to the teachers.
[*29:20:24—30:53:24, begin section of questions about IslandWood, deleted because not relevant to study. Questions include who are the teachers, how long are they there.*]

Matt: okay. So, for those of you who joined in late the first part of our questions were the same as before. How you describe a glacier, or how you describe an earthquake, but I think that we have covered most everything, umm, you guys have questions for me or you want clarification on something please ask?

And I'll tell you what I'm going to do with this information. Umm, I'm going to take the video from these interviews and put it my computer, and go through and write down everything that we've said and then I'm going to write up the data. Umm, none of our names will be used, I promise that, umm… the uh…, and I'm going to hang on these drawings and take pictures of them…
#4: we didn't do anything.
Matt: that's okay, I still need to take pictures of the other side. And then, uh… I'll provide you guys with a summary of the final project when it's completed.

So, any more questions?
#6; yeah, I have a question. Because I knew, before I came here, before I went to IslandWood I didn't know any of this stuff, so how'd I know to draw this stuff? Did we like see pictures of something?
Matt: you guys guessed, yeah. So now is your chance to correct it, if you want?
#5: I got a question. Do we get to keep this paper?
Matt: you get to keep the paper, but I'm going to hang on to it until I take pictures of it, then I will bring it back to you, I'll bring it to the school and bring it back to you.
[*32:48:25—33:24:14 Comments deleted pertaining to request for lyrics to a song that was sung at IslandWood.*]

Umm, Good, so, yeah, now is your, now that you've gone over the information, you may draw a different interpretation of what some of these things are.
#6: this is kinda like what I saw [*pointing to her drawing*].

[*33:47:19—39:30:24 Comments deleted pertaining to emailing past instructors at IslandWood, events at the lodge, and favorite places at IslandWood; students are drawing on there pages in the mean time, but comments are not relevant to study*].
Matt is everyone done? Okay thank you for your time.
All: bye 39:46:20 – end transcript.

4. Superposition Movie

Video Superposition taken, edited, and compiled by Matthew John Brewer at IslandWood 2003-2004.

[Scene 1—DBP 2004]
Teacher: Who can tell me what happened eleven-hundred years ago, one-thousand on hundred years ago?
Students: An earthquake! The earthquake
Teacher: The earthquake happened right. And what did it do to the land?
Student: Uhhh, it made a space. It made this one going up and this on going down.
Teacher: And what do we call that?
Student: Superposition!
Teacher: What does superposition mean?
Student: It's like when the older rock is on the bottom and the younger rock is on the top.
Teacher: Okay.

[Scene 2 – ZPA 2004]
Student: Okay, superposition is when the younger rock is on the bottom and older rock is on the bottom, man!

[Scene 3 – OL 2004]
Student: So, this is an earthquake fault, and under that white tarp, right there, there is some glacier rocks… like rocks that were brought by glaciers, and uhh, on the bottom and on top of that there is a rock that is called bedrock in the Puget Sound. And so, normally the position bedrock is on the bottom and the glacier rock is on top…[almost inaudible because of background noise]… but what happened was that there was an earthquake, and that pushed up the bedrock and dumped it on top of the glacier rock, so they can tell that this is where an earthquake is. And it raised the ground up a lot.

[Scene 4 – OL 2004]
Student: The earthquake shifted the rock so that old rock was on the top and new rock was on the bottom.

[Scene 5 – ZPA 2004]
Student: Superposition is when the older rock is on the bottom and the younger rock is on the top. But then, an earthquake fault switched it, and uhh…but it pushed the [audible second student]…but then the younger on the bottom and the older rock the top in certain places… because it pushed the rock up [same audible student as above].

5. Instruction at the IslandWood Fault during SIR May 23-25, 2005

All videos in this section were compiled, filmed, and edited by Matthew John Brewer during the Scientist in Residence program, May 23-26, 2005, at IslandWood, Bainbridge Island, Washington.

Clip: "Fault Introduction"

[*At the IslandWood fault. Matt is kneeling next to the trench wall in blue, Brian Sherrod is to Matt's left (in the foreground on the screen) wearing an orange vest. Seven students are seated on the ground looking at the trench wall. Each student has a journal and a pencil; they are beginning a drawing of the trench wall.*]

[Begin 00:00:00

[*audible comments about getting situated, needing a pencil, etc. not transcribed because not relevant. Matt begins at 00:15:00.*]
Matt: So, while you're drawing, using our keen observation skills, look and think about what, what you're looking at, and we already know that there are different types of rocks that are out there, right? So, we wanna try to identify as many different types of rocks as we can.

00:19:12
We're gonna spend about three minutes, three to five minutes drawing.
If you wanna move down that way, you can [*to girl in foreground*].

01:32:29

How much more time do you guys want? A couple more minutes? [*students mumble yes and nod*] Okay.

02:37:06

Clip: "What is Superposition?"

Okay, you can finish your drawing, but I want to start talking for a moment. I'm gonna teach you guys a law of geology. Yesterday you reviewed the laws of nature, the ABCs, right? I'm gonna teach you a law of geology. There's five of them, but we're just gonna focus on one. And this is the law of superposition. Kay? So, you might wanna write this down. It's important word, it will help you later… on our quiz, …no I'm just kiddin', but this is important to understand what is going on here. So, the law of superposition is that the older rock is always on the bottom and the younger rock is always on top.

What's the law of superposition? What did I say [*inaudible name*]?

Student: the older bottom, the older rock is always on the bottom or the top?
Matt: older rock is always on the bottom.
Student: and the younger rock is always on top.
Matt: always on top… Unless! And that's the key word. The older rock is always on the bottom, the younger rock is always on top, unless! what?
[*inaudible comment by student*]
Somebody moves the rock. What else could cause rock to move?
[*inaudible comment by student*]
Possibly. A glacier. But what else?
[*inaudible comment by student*]
An earthquake. And what would an earthquake do?
Student: shake the plates around
Matt: so that, older rock were on top of younger rock. Okay. So, the law of superposition is important because it tells us if we see something that is out of place it tells us that there was an earthquake.

01:50:06, since last time

So, now you guys have drawn a little bit. And I'd really like to see a drawing, whose drawing they think they'd like to share?
[*inaudible comment by student*]
Okay. So, how many types of rocks do you guys see in this wall? How many big types of rocks, two different types of rocks, or three or four different types of rocks do you see?
Brian: Well, I think I would, I would just be a little bit broader. Tell me in general, how would you just describe this wall to me. What do you, what do you see?
Student: it's diverse.
Brian: what's diverse about it?
Student: the rocks, they're different types.
Brian: well where are there different types?
Matt: you can get up and point at if you want.

Student: there's these bumpy rocks in this area, and then is area there is these smooth ones [*points to area at the left screen edge*].
Brian: Uh-huh.
Student: then over here there's actually some colored ones, [*off screen, below the camera*]
Brian: well, if you were to look down here.
Matt: down here. Did you look at the whole wall?
Brian: down here, in this area, versus that area up there, what do you see?
[*inaudible comment by student*]
This doesn't look as rocky as that up there, does it?
[*inaudible comment by student*]
Matt: what do you see?
Student: it starts up there, [*inaudible comment by student*]
Matt: okay. Okay.
Brian: so, you're sayin' the land surface up there is kinda flat, then it slopes right here, right. Okay? Those are all really good observations.

01:56:24, since last time

Clip: "Sedimentation"

Matt: Okay, so if we know that there was a glacier that came, would that rock be older or younger than the rock that was there before the glacier came?

It's kinda a tricky question.

Is the rock that came with the glacier older or younger than the rock that was already on the ground surface.

[*inaudible comment by student*]

Younger. So, it should be on top, right? Cuz, we know that the law of superposition is what?

[*inaudible comment by student, explains superposition by next comments*]

Kay. So which one of these rocks did you see that looks like it coulda been brought by a glacier? Anybody can get up and point.

[*students get up to wall]*

Student: this sorta has a smooth surface

Matt: okay, so there's those smooth rocks

Student: like that one there.

Matt: um-kay. But we're not just talking about one rock, remember a glacier is a big river of ice, it brings lots of rocks, it doesn't just bring one. It brings big, big rocks.

[*inaudible comment by student*]

Okay. Then when a river, a river brings rocks, what, have you guys seen the bottom of a river surface, of a stream? What's it look like? Can you describe it in as much detail as you can?

[*inaudible comment by student*]

Bumpy with? …Rocks… and then beneath those rocks?

[*inaudible comment by student*]

Um-huh. So, if you were to compact that into a rock, it would be sedimentary rock, and what would it look like?

[*inaudible comment by student, possibly describes sorting*]

All right. Good description. So, Now look at the rock over here and see if you think that there's a rock that looks like that.

Think bigger, don't just look at one rock, look at the whole wall.

Student: this rock here [*rest inaudible*].

Matt: okay,

02:04:06, since last time

Clip: "Bedrock"

Matt: so this rock here, you described a rock that had lots of pebbles, lots of rock, and dirt compacted together, right? Is that what this looks like? This whole rock right here?
Student: yeah, sorta.
Matt: sorta. Okay. That rock is bedrock. That rock came down from the rivers from all the cascades and the Olympics, starting fifteen, twenty million years ago.
Brian: an old rock.
Matt: it's an old rock, it started a long time ago, rocks piling on top of each other, just the way, …you described, that if you were to compact the stream, they would pile on top of each other. And then a glacier came, and we already know that it rolled and, rocks, but… have you ever seen a bulldozer? What happens when the bulldozer pushes ground/
[*inaudible comment by student*]
The ground topples over, but what's out in front of the bulldozer?
Brian: A big a pile of dirt.
A big pile of dirt?! Seems like a dumb answer right? A big pile of dirt. So, when the glacier came, it pushed all this dirt out in front, and that would be fine sand, kinda like the dirt that gets picked up by the bulldozer. So, which one these, where do you think you see that on this wall here? Is there a rock that looks like that? Look all the way down here.
Anybody have a guess?
Brian: I'll tell you how I like to describe what a glacier deposits and as it moves, and that's. Who likes peanut butter? Do you like crunchy or smooth? I like crunchy. Kay, and we all know what crunchy peanut butter looks like right. It's basically smooth peanut butter with a bunch of ground up peanuts, with chunks of peanuts in it. Then when you make your sandwich, you take your knife, or your bulldozer blade, and you smear that chunky peanut butter all over the bread, right? Think of the bread as the landscape, and the blade being the ice. And you're smearing that peanut butter all over the landscape with the ice and so what you get when the glacier leaves, is you get a layer of soil, or a layer of sediment, it's called soil, okay, that looks like kinda chunky peanut butter. It's kinda smooth with a bunch of huge, big rocks randomly placed allover, okay?
So, it's not like that [*points to bedrock*], where It's just loaded with rocks, but it's more like, he's at this down here, it's more like this down here. You see how this stuff down here… this stuff down here [*pointing at the glacial till*] kinda looks like it's smooth and it's got big chunks of peanuts in it, all over. But you notice how different it is from this stuff right here [*bedrock*]? This stuff and this stuff is just chock full of rocks, with little round rocks, right? Okay, so there's a big difference here. This [*glacial till*] is chunky peanut butter, and that's [*bedrock*] not. okay?

End 11:57:00]

Clip: "Identify the Fault"

[*At the IslandWood fault. Matt is standing next to the trench wall in blue, Brian Sherrod is to Matt's right (left on the screen) wearing an orange vest. Seven students are seated on the ground looking at the trench wall. Each student has a journal and a pencil; they have just completed their drawing of the trench wall.*]

[Begin 0:00:00].

Matt:

So, now that we know that this is the bedrock [*places hand on the wall on the bedrock*] and this is brought by glaciers [*places hand on the wall on the glacial till*], if it were perfect and we had our law of superposition where would the rocks be?

Let me rephrase that. What is superposition, again?

Student:

Older rock on the bottom, younger rock on the top

Matt:

No, you started the younger rock on the top and the older rock on the bottom. Good. Unless what happens?

Student: *[inaudible]...*

Matt:

Okay, so, the bedrock is older or younger?

Student: older.

Matt: older.

And the glacier is?

Student: younger.

Matt:

So, how come it's on top? How come the bedrock is on top?

Student: there was an earthquake.

Matt:

Where is the earthquake? Where's the, where does it divide between the two?

Student: there's a fault right there.

Brian: So, you say there's a fault right there, eh?

Matt:

Where's the fault? Get up and point at it. Get up and point at it. [*Student goes up to the wall and traces his hand along the fault*]. Excellent.

Brian:

Very good. But what's the thing that jumps put in your mind when you first look at that? You guys probably saw that as soon as you walked in here. What's the first thing that you recognize there? Just real quick what's the first thing that you see where that fault is?

Student: a different color.

Brian:

A different color. It can be, it can be as quick as that. Look! Those things are different colors. You automatically saw that something was different there and that probably drew you mind, drew your eye that.

[End 1:35:00].

F. Student Interview Responses

All Interview questions in Part I were qualitative and are reported as numbers one, two, and three herein. Each question contains two parts; questions and answers are separated by "————————————". Responses separated by "Δ" denotes a response from the video interview[9].

Students were provided written interview questions in advance of each video interview, which provides a mechanism to cross-reference their process throughout, as well as amend responses previously written or articulated during the interview. Additionally, each student had a poster do write, draw, or otherwise record their answers during each interview (Appendix.II.B) and the group was shown a PowerPoint (Appendix.II.C).

1. Interview 2004

Question #1: If you had to explain the word "glaciers" to a friend, what would you say? You may also draw your answer.————————————
Please explain the event or events that you think might cause a glacier to occur. You may also draw your answer.

Response #1: [scan drawing]. ———————————— "In Washington, like long time age there was a big Glacier.

Response #2: [scan drawing]. ———————————— "A bad weather."

Response #3: "If I was to explain to a friend what a glacier meant I would maybe say that glacier is a mass of snow that flows down slowly through or on mountains, valley and also is sometimes covers land areas. ———————————— What I think might cause a glacier is that glacier is formed into snow and it causes by when it comes to winter snowfalls exceed to summer for many melting years."

Response #4: "A great mass of ice moving really slow. ———————————— Forms at big ices."

[9] Responses from the video interview may not correspond to the same student response presented herein, but for the most part accurately reflect changes that students made throughout the interview.

Question #2: If you had to explain the word "earthquakes" to a friend, what would you say? You may also draw your answer.————————————— Please explain the event or events that you think might cause an earthquake to occur. You may also draw your answer.

Response #1: [No Answer. ————————————— No Answer.]

Response #2: "It form into snow. ————————————— earthquakes shakes motionly [sic]."

Response #3: "I would explain to a friend what earthquakes means by saying it means how the earth shakes motionly of the earths surface. ————————————— What I think that might cause an earthquake is by how a sudden of rocks that is breaking along a fault but sometime earthquakes are not unimportant."

Response #4: "A shaking or shifting motion. ————————————— It is caused by a breaking massavie [sic] of rocks."

Question #3: If you had to explain the word "superposition" to a friend, what would you say? You may also draw your answer.————————————— Please explain the event or events that you think might cause superposition to occur. You may also draw your answer.

Response #1: [No Answer. ————————————— No Answer.]

Response #2: "Rocks braking [sic] into falt [sic]."

Response #3: "I would say to a friend that superposition means that ————————————— What I think might cause a superposition."

Response #4: "I think something that it superposition. ————————————— When something position ther [sic] right way."

2. Interview 2005 Pre

Question #1: If you had to explain the word "glaciers" to a friend, what would you say? You may also draw your answer.————————————
Please explain the event or events that you think might cause a glacier to occur. You may also draw your answer.

Response #1: [No Answer. ———————————— No Answer.]

Response #2: "I would say "a glacier is a big mass of ice and snow that moves very slowly down a mountain or across. ———————————— An earthquake."

Response #3: "To snow ice. ———————————— If you scream around mountains."

Response #4: [No answer]. ———————————— "Glacier means sprinkles of snow on mountains."

Response #5: "A huge chunk of ice that is in the coldest oceans. ———————————— The snow will fall in the water and will start to make ice."

Response #6: "A large mass of ice moving slowly. ———————————— If there is water it could be cold so the water freezes."

Response #7: "Glaciers are formed over may [sic] years on high land. ———————————— A very loud echo."

Question #2: If you had to explain the word "earthquakes" to a friend, what would you say? You may also draw your answer.————————————
Please explain the event or events that you think might cause an earthquake to occur. You may also draw your answer.

Response #1: "It's when the earth shaks [sic]. ———————————— [drawing]."

Response #2: "A shaking or trembling of the ground, caused by shifting underground rock or by the action of a volcano."

Response #3: "An earthquake is something that shakes the ground sometimes really hard or just a little. ——————————— Up in a volcano rocks may fall there so heavey [sic] and big that it shakes the ground."

Response #4: [No answer]. ——————————— "A earthquake is when the ground vibrates."
Response #5: "An earthquake is a very powerful shake. ——————————— A rock slide that is really strong and hits the water and the ground."

Response #6: "A little or big shake in the ground. ——————————— Lands crash."

Response #7: "A earthquakes [sic] is when the earth quakes. ——————————— A volcano erupshon [sic]."

Question #3: If you had to explain the word "superposition" to a friend, what would you say? You may also draw your answer.———————————
Please explain the event or events that you think might cause superposition to occur. You may also draw your answer.

Response #1: "One above the other. ——————————— [No answer]."

Response #2: "I don't no [sic]! ——————————— don't no [sic]."

Response #3: "I don't really know. ——————————— I don't really know."

Response #4: [No answer]. ——————————— "I think it means stop and freeze."

Response #5: [No answer]. ——————————— [No answer].

Response #6: ?. ——————————— ?.

Response #7: "don't no [sic]. ——————————— don't no [sic]."

3. Interview 2005 Post

Question #1: If you had to explain the word "glaciers" to a friend, what would you say? You may also draw your answer.————————————
Please explain the event or events that you think might cause a glacier to occur. You may also draw your answer.

Response #1: [This student was absent from this Interview].[10]

Response #2: "A big hunk of Ice that rolls very slowly and picks up things like pieces of land. ———————————— A big earthquake."

Response #3: "A glacier is a huge wall of ice. ———————————— Ice and water form together and make a glacier."

Response #4: "Sprinkles of snow. ———————————— When it starts to snow."

Response #5: "A large mass of ice and snow that moves very slowly down a mountain or across. ———————————— An earthquake."

Response #6: "A ice land that moves. ———————————— Water that turns into ice."

Response #7: [This student was absent from this Interview].

Question #2: If you had to explain the word "earthquakes" to a friend, what would you say? You may also draw your answer.————————————
Please explain the event or events that you think might cause an earthquake to occur. You may also draw your answer.

Response #1: [This student was absent from this interview].

Response #2: "A small or big vibration that can damage the earth. ———————————— A glacier."

Response #3: "That the earth's surface will make a huge shake and that will occur whenever. ———————————— When a strong rock slide happens, the earth's surface will start shaking."

[10] I have tried to maintain the same order in order to match student corresponding student responses; inevitably there is some error.

Response #4: “When the ground vibrates. ——————————— When you see a rock starting to move.”

Response #5: “A shaking of the earth’s crust. ——————————— Glaciers moving around.”

Response #6: “Earth shake or (crashes) contarys [sic] crash. ——————————— 2 plates pushing and one wins.”

Response #7: [This student was absent from this Interview].

Question #3: If you had to explain the word “superposition” to a friend, what would you say? You may also draw your answer.———————————
Please explain the event or events that you think might cause superposition to occur. You may also draw your answer.

Response #1: “[This student was absent from this interview].

Response #2: “Young rock on top, old rock on bottom. ——————————— An earthquake.”

Response #3: “When the old rock is on the bottom and the young rock is on top. But when there’s an earthquake the position switches. ——————————— When a glacier happens, the river rock is an old and the glacier is the new.”

Response #4: “When the younger rock is on top of the older rock. ——————————— When a earthquake starts and glacier starts that’s whe [sic] occers [sic].” [cf. drawing].

Response #5: “The young rock is on the top and old. ——————————— A fault line.”

Response #6: “Old rock is on the top and the new is on the bottom. ——————————— An earthquake.” [cf. drawing].

Response #7: [This student was absent from this Interview].

G. Questionnaire Responses

I have chosen two qualitative questions from the questionnaire for peer educators and four questions from the questionnaire for curriculum designers. Each follows with the question and responses received. Two part questions and answers are separated by "——————————". Responses are reported here and analyzed in the following sections (Data Analysis and Conclusion). The remaining questions are displayed with the quantitative data.

1. Questionnaire for Peer Educators

Question #1: What curricula do you use to teach Earth Sciences, such as Earthquakes —————————— Plate Tectonics?[11]

Response #1: "Our district does not have a set curriculum for Earth Sciences, however, we use Science investigations to teach Ecosystems, Electricity, and Food Chemistry. —————————— None."

Response #2: "Currently, earth sciences are only a minor part of the curriculum (if taught at all!) — we use own curriculum. —————————— FOSS and STC primarily.""

Response #3: "We use FOSS, Insights, and STC because they are researched based, inquiry oriented and sequential. —————————— see above."

Question #8: If you were to take a field trip where would you go?

Response #1: "Mt. St. Helens"

Response #2: "Olympic Natl. Park, Mt. St. Helens, or North Cascades NP"

Response #3: No Answer Provided

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[11] I have combined Questions #1 and #2. These questions are very similar and differ only with an alternate "such as…" example. I have separated the questions and answers by "——————————".

Question #9: What would be the most effective way to engage your students (i.e. tangible evidence, professional scientist, field trip, another educational facility)?

Response #1: “Tangible evidence, professional scientist”

Response #2: “Hands-on activities in class and outside on field trip.”

Response #3: “We engage all students at their conceptions.”

2. Questionnaire for Curriculum Designers

Question #3: How do you integrate technology, science and the arts into your Earth Sciences curriculum? ———————————— Why do you think this is important?

Response #1: "We have both science and some math units. Many of the science units integrate mathematics in significant way. Some GEMS units integrate social studies/literature-literacy/art. Several units include CD-ROMs/web links. New projects — seeds of science/ Roots of Reading integrate science and literacy in major way. New space science sequence will also have interactive technology component. ———————————— Learning is greatly enhanced by such integration and by making multiple links so students can see/apply how concepts bridge different disciplines."

Response #2: "Technology: K-6 FOSS Web (www.fossweb.com) — Middle School: multimedia CD-Rom and web resources; Language Arts, Math, etc. — included as extensions and also integrated. ———————————— Science is a vehicle/catalyst for catching in meaningful way."

Response #3: "CUES students draw upon the curriculum's web site for research. They also make frequent presentations using PowerPoint, video and other technologies. Students also use technologies that scientists use to study the planet in their laboratory investigations. ———————————— The geoscience community is moving more toward a systems approach to studying the planet, so we have designed CUES to reflect this integrated approach. We also want students to use technology and to communicate their findings to one another, as these are important aspects of science."

Question #6: How would you respond to a teacher that found your Earth Sciences curricula too complicated for themselves and/or for their students?

Response #1: "Ask them more about it, communicate our main goals, give them leeway to adapt and/or help them adapt for their students, without sacrificing essential content or scientific accuracy."

Response #2: "I would suggest getting professional development offered by district or publisher and/or take geology classes, field trips at local college or university."

Response #3: "We ask teachers to suggest ways in which we can adapt CUES for a variety of audiences. We have generated a set of literacy strategies that many of our teachers find very useful."

Question #9: What would be the most effective way to engage students (i.e. tangible evidence, professional scientist, field trip, another educational facility)?

Response #1: "Depends on subject. "Discrepant events" very helpful in classroom — tangible evidence — mysteries — giving students real sense of themselves as scientists. Field trips can be excellent but need to be well linked to lesson content. Professional scientists ONLY. If they are aware of inquiry methods/age-appropriate issues/not monopolizing with technical detail."

Response #2: "Direct field experience — before and after — see FOSS Earth History."

Response #3: "We have found that the most effective way off engaging students is having them do investigations related to issues in their local communities. They then present their findings to those officials in the community responsible for dealing with the issues. These might be such topics as water quality, land use, energy conservation, etc.

Question #10: What resources included in Earth Science curricula are the most important, and what do you think are missing from existing curricula?

Response #1: "For all the efforts, the biggest missing element is finding effective ways to convey and deeply implant a sense in students of the holistic/global systems science/nature — the interconnectedness of Earth. Better ways to convey "dynamism" of Earth's crust also."

Response #2: "Professional development, hands-on experiences for teachers and students."

Response #3: "We think it is very important to have students engage with the technologies that geoscientists use to study the planet. They can do this through webs sites such as NASA's Earth Observatory or by using GIS, GPS or other geospatial technologies in their investigations."

H. IslandWood Scientist in Residence Plan

A plan of what I accomplished during the SIR is presented below:

Group Schedule, 2 hours each group, 3 groups per day (total 6 groups):
- 930—1130, 1200-200, 215-415

- Gather at the Bird's Nest Lodge to view the fireplace
  (5 minutes)

- Discuss types of sedimentary rocks, layering, and ask students to write a definition of earthquake and glacier in their journal
  (20 minutes)

- Hike to the trench (looking for evidence of sedimentary rocks along the way, especially at the spine trail junction and around the dam)
  (20 minutes)

- Visit the fault; what is an earthquake, what is superposition, how do we know that an earthquake has occurred here, was there anyone living here then, where did they go, why is this important?
  (20 minutes)

- Redefine earthquake, glaciers, and introduce superposition; how does seeing an earthquake change your definition that you wrote earlier?
  (20 minutes)

- Create a group mural (Appendix II.A) of what is superposition, or what happened with the earthquake fault to share at the campfire.
  Group mural project to present at campfire: work together in two groups (of four or five each) to explain to the other groups that will not have a chance to work with me what is happening with earthquakes in the Puget sound; be as accurate as you can, and try to explain everything to the best of your ability; your instructors, teachers, and I will answer as many questions we can, but we want you to work together and agree on what you think is important.
  (25 minutes)

- Group reflection and closure — who will present at the campfire, importance *(10 minutes)*

- Campfire presentation — 5 minutes each group (10-20 min)

III. Recommendations

In this section I have included four items that provide opportunities to complement existing curricula: (1) a list of books, relevant to geology of the Pacific Northwest; (2) a lesson plan to create a digital video for assessment in geologic understanding; (3) an overview of the USGS Schoolyard Geology Website; and (4) an overview of a curriculum centered on tangible evidence.

1. Geology Related Books for the Pacific Northwest

The following list is compiled from visits to Amazon.com and each active link will provide an opportunity to view more about the book from that website:

Glacial Lake Missoula and Its Humongous Floods by David D. Alt

Cataclysms on the Columbia: A Layman's Guide to the Features Produced by the Catastrophic Bretz Floods in the Pacific Northwest (Scenic Trips to the) by John Eliot Allen

Roadside Geology of Washington by David Alt

Roadside Geology of Oregon by David D. Alt

Roadside Geology of Idaho by David Alt

Northwest Exposures: A Geologic Study of the Northwest by David Alt

In Search of Ancient Oregon: A Geological and Natural History by Ellen Morris Bishop

Fire, Faults, & Floods: A Road & Trail Guide Exploring the Origins of the Columbia River Basin (Northwest Naturalist Book) by Marge Mueller

Hiking Oregon's Geology (Hiking Geology) by Ellen Morris Bishop

Hiking Washington's Geology by Scott Babcock

Washington: Atlas & Gazetteer (Washington Atlas & Gazetteer) by Delorme

Oregon Atlas and Gazetteer (Oregon Atlas & Gazetteer) by Delorme

Benchmark Idaho Road & Recreation Atlas by Delorme

The Street-Smart Naturalist: Field Notes from Seattle by David B. Williams

2. Geology Movie Experience (GeoME) — iLife Creations

Lesson Title: Geology Movie Experience (GeoME)

Overview: Geologists interpret their findings from the landscape around them and then create an explanation to match the data. The purpose of this project is for students to demonstrate their understanding of geologic phenomena — glaciers, earthquakes, superposition, etc. — by creating a movie that can be shared with

Standards (EALRs and NCTM):
Please see the section with the same heading below.

Key goals and objectives:
After completing this project, SWBAT display the following geological knowledge:

- Understand how geological phenomena create a system of understanding.
- Understand the difference between different components of a specific geologic concept
- Understand how that concept changes the landscape.
- Use scientific and geology vocabulary to articulate process, solution, and application.
- Demonstrate the ability to work individually and cooperatively to solve problems.
- Provide a clear explanation of the solution to a problem and justify the processes used to solve it.
- Use appropriate pre-writing strategies to create a storyboard.
- Write and revise a script including concept explanation, supporting details, and logical flow.
- Use presentation skills in acting such as projection, concentration, inflection, diction, and body control.

After completing this project, SWBAT display the following Technology Skills:

- Produce a storyboard for a movie.
- Use a digital video camera to film a movie.
- Use iMovie to import and edit video clips to produce an effective movie.
- Understand the stages in completing a digital film production.

Theme: earth sciences, concepts, iMovie, digital movie

Concepts: Apply appropriate scientific problem-solving strategies to a real-life situation.

Skills: explanation, application, interpretation, perspective, and self-knowledge;

Age group: Sixth to Eighth Grades

Venue/s: indoor and outdoor

Materials:
Pre-production materials: poster board, colored pencils/markers, paper, class computers for word processing and storyboarding, Inspiration computer software (optional)
Production materials: Macintosh computers (with CD burner or SuperDrive optional), digital video camera, digital camera (optional), FireWire hard disk (optional), external microphone (optional), tripod, iMovie, iPhoto (optional), iDVD (optional), costumes (optional), scenery and props

Time: 45 minutes (actual time depends on students proficiency with computers and digital media)

Set up: None, except to collect technology equipment.

➢ Use iPhoto to import graphics or photos (optional).

Introduction and Activity:

Geologists interpret their findings from the landscape around them and then create an explanation to match the data. Find an example of how a geologic phenomenon has modified the landscape outside the classroom. For example how did the big rock in my backyard get there? How can you use the knowledge that you have already to describe how you know this? We are going to make a digital video to explain our knowledge of geology to the community. Be creative, don't be afraid to take risks, save often, and have fun!

The core lesson

Working in small groups, students create a two- to five-minute movie that focuses on geologic phenomena and landscape modification that other classes can use in the future.

1. Pass out *Student Guidelines for GeoMEs (p.8)*
2. Students research their topic and then complete a storyboard of their project that includes: the script, shots, props, and other elements of their movie.
    - Each movie should have:
        - Introductory scenes with group member names and definitions of relevant vocabulary (glacier, earthquake, superposition, etc.).
        - Data collection scenes where the actors are seen examining the landscape.
        - Documentation scenes where the effects and examples visible on the landscape are compared to actual definitions on screen.
        - Definitions of vocabulary that are relevant to the concept; for example, glacier terminology, earthquake terminology, etc.
        - A conclusion explaining why it is important to know how this phenomenon changes the landscape.
        - Credits and sources cited. Students rehearse and then film their movie.

Conclusion

3. Students import their video clips into iMovie, edit the footage, add text, graphics or photos, transitions, narration or other audio, and effects.
4. The finished movies are shown to the whole class (and other science classes) and the students evaluate each other's work and discuss the process.

Assessment:

Students are to be evaluated using the following rubric that combines science, presentation skills, language arts, and technology. Additional criteria for evaluation include: teamwork, planning and storyboard, accuracy of information, originality, acting and documentation, and documentation.

Score	Integration Of Math, Language Arts, And Technology	Movie Planning, Storyboard, And Originality	Accuracy Of Information, And Documentation	Student Self-Analysis
4	Scientific and Language Arts knowledge: ➢ Apply appropriate scientific problem-solving strategies to a real-life situation. ➢ Use scientific vocabulary to articulate process, solution, and application. ➢ Use appropriate pre-writing strategies to create a storyboard. ➢ Write and revise a script including concept explanation, supporting details, and logical flow. Technology Skills: ➢ Produce a movie storyboard ➢ Use a digital video camera to film a movie. ➢ Use iMovie to import and edit video clips to produce an effective movie. ➢ Understand the stages in completing a	A complete storyboard of the project includes: the script, shots, props, and other elements of their movie. Each movie should have: ➢ Introductory scenes defining relevant vocabulary (glacier, earthquake, superposition, etc.). ➢ Data collection scenes where the actors are seen examining the landscape. ➢ Documentation scenes where the effects and examples visible on the landscape are compared to actual definitions on screen. ➢ Definitions of vocabulary that are relevant to the concept; for example, glacier terminology, earthquake terminology, etc. ➢ A conclusion explaining why it is important to know how this phenomenon changes the landscape. ➢ Credits and sources cited. Students rehearse and then film their movie.	➢ Provide a clear explanation of the solution to a problem and justify the processes used to solve it. ➢ Use presentation skills in acting such as projection, concentration, inflection, diction, and body control. ➢ Sources and inspirations are included and clearly cited throughout. ➢ Information has been crosschecked with various sources, and by peers and the teacher for accuracy. ➢ Information makes an effort to explain and display the information in a variety of modes (i.e. visual, auditory, kinesthetic, etc.).	➢ I have demonstrated the ability to work individually and cooperatively to solve problems. ➢ I have done my best meet all the requirements listed under each of the headings labeled "4". ➢ I have accurately cited and listed all the information that I used and/or consulted. ➢ I have been able to navigate and use iMovie to the best of my ability, and have been vocal and diligent about asking for help.

Score	Integration Of Math, Language Arts, And Technology	Movie Planning, Storyboard, And Originality	Accuracy Of Information, And Documentation	Student Self-Analysis
	digital film production. ➢ Use iPhoto to import graphics or photos (optional).			
3	Integrates the above requirements but the steps are difficult to follow and/or confusing.	Movie meets the requirements above but is somewhat convoluted and/or confusing.	Information and documentation accuracy meets the requirements above but is somewhat convoluted and/or confusing.	I have done the best of my ability to meet all the requirements but I think that I have not been able to meet the standard of 4.
2	Knowledge needed is missing one or more of the above components. The content is not clear, convoluting and/or confusing.	Movie is missing one or more of the above components. The movie content is not clear, convoluted and/or confusing.	Information and documentation accuracy is missing one or more of the above components. The content is not clear, convoluted and/or confusing.	I have done the best of my ability to meet all the requirements but I think that I have not been able to meet the standard of 3.
1	Knowledge needed is missing most of the above components. The content is not clear, convoluted and/or confusing. The integration of skill knowledge does not meet the requirement.	Movie is missing most of the above components. The planning and storyboard are not clear, convoluted and/or confusing. The planning expectation does not meet the requirement.	Information and documentation accuracy is missing most of the above components. Citations are not clear, convoluted and/or confusing. The citation expectation does not meet the requirement.	I have done the best of my ability to meet all the requirements but I think that I have not been able to meet the standard of 2.

My group name ____

Group Members ____

____

____

____

Students Scores ______ ______ ______ ______
Average: ____________

Teacher Score ______
Comments:

Possible Topic Questions:

- How did the rock in my yard (in front of the school, etc.) get to be there?
- Why are there so many hills between my house when I drive East-West but not when I drive North-South?
- Why did Mt. St. Helens erupt?
- Want happens when an earthquake breaks the surface of the earth?
- What is superposition (or any other geologic principles)?

Topics are not limited to these questions, but provide a good beginning. Topics should be something that students are sure that they explain, find relevant data, and meet the expectations. At the same time, they should be challenged to provide as much information as possible.

Standards (EALRs):
For more detail about relevant standards (i.e. AAAS and NSES) please see pp. 10-18 of my master's thesis, "The Importance of Tangible Evidence in Earth Sciences," (Brewer 2005b).

The GLE provides these curricula expectations for Processes and Interactions in the Earth System, at the 3-8 grade level, defined by Science EALR 1.3.4 (OSPI 2005:32,33):

- Know processes that change the surface of Earth.
    - (5) Describe how weathering and erosion change the surface of the Earth.
    - (5) Describe how earthquakes, landslides, and volcanic eruptions change Earth's surface
- Understand the processes that continually change the surface of the Earth.
    - (7) Describe the processes by which soils are formed (e.g., erosion and deposition in river systems).
    - (7) Describe how heat (thermal) energy flow and movement (convection currents) beneath Earth's crust cause earthquakes and volcanoes.
    - (7) Describe how constructive processes change landforms (e.g., crustal deformation, volcanic eruption, and deposition of sediment).
    - (7) Describe how destructive processes change landforms (e.g., rivers erode landforms).
    - (7) Describe the processes involved in the rock cycle (e.g., magma cools into igneous rocks; rocks are eroded and deposited as sediments;

sediments solidify into sedimentary rocks; rocks can be changed by heat and pressure to form metamorphic rocks)

Background information:

When using iMovie, encourage students to *save often* and not be afraid to try new things. Also, know that it is entirely possible that the program will crash occasionally (depending on how much memory each computer has), and that students should know that and act accordingly.

Ideas from Apple Education on how to integrate iMovie and iPhoto into the classroom can be found at the following website: http://www.apple.com/education/ilife/.

Information from Apple Education about support for iMovie can be found at the following website: http://www.apple.com/support/imovie/.

Additional information, such as "10 tips for capturing great video" can be found at http://education.apple.com/education/ilife/howto/digitalmovie_tips/.

References:

Internet Resources the iMovie:

- Earthquake Image Glossary: http://earthquake.usgs.gov/image_glossary/
- BBC Education: http://www.bbc.co.uk/education/rocks/rocky.shtml
- Journey of an Erratic: http://www.sln.org.uk/geography/flash/cannock01.swf
- Glacier Glossary: http://www.sfu.ca/~jkoch/older_stuff/glacierglossary.html
- Glacier Types: http://pubs.usgs.gov/of/2004/1216/glaciertypes/glaciertypes.html
- USGS Education: http://vulcan.wr.usgs.gov/Glossary/Glaciers/framework.html
- http://www.apple.com/education/ilife/
- iLife How-To Guides: http://www.apple.com/education/ilife/howto/

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Created by Matthew John Brewer November 25, 2005.

Student Guidelines for GeoMEs ***page 1***

Geologists interpret their findings from the landscape around them and then create an explanation to match the data. Find an example of how a geologic phenomenon has modified the landscape outside the classroom. Create a digital video to explain our knowledge of geology to the community. Be creative, don't be afraid to take risks, save often, and have fun!

Possible Topic Questions:

- How did the rock in my yard (in front of the school, etc.) get to be there?
- Why are there so many hills between my house when I drive East-West but not when I drive North-South?
- Why did Mt. St. Helens erupt?
- Want happens when an earthquake breaks the surface of the earth?
- What is superposition (or any other geologic principles)?

Topics are not limited to these questions, but provide a good beginning. Topics should be something you are sure that you can explain, find relevant data, and meet the expectations. At the same time, you should be challenged to provide as much information as possible.

Directions:

1. Find a group of 3-4 students to create a two- to five-minute movie that focuses on geologic phenomena and landscape modification that other classes can use in the future.
2. Read the relevant textbook chapter and compare with notes from a class work.
3. Research your topic and then complete a storyboard of their project that includes: the script, shots, props, and other elements of their movie.
   teacher approval of script ___________________
4. Practice and film your scenes.
5. import your video clips into iMovie, edit the footage, add text, graphics or photos, transitions, narration or other audio, and effects. **SAVE OFTEN!**
6. The finished movies are shown to the whole class (and other science classes) and the students evaluate each other's work and discuss the process.

(over please)

Student Guidelines for GeoMEs *page 2*

Assessment:
You are to be evaluated using a rubric that combines science, presentation skills, language arts, and technology. Additional criteria for evaluation include: teamwork, planning and storyboard, accuracy of information, originality, acting and documentation, and documentation. This is an additional Sheet of Paper.

Your Movie Should Have:

- Introductory scenes with group member names and definitions of relevant vocabulary (glacier, earthquake, superposition, etc.).
- Data collection scenes where the actors are seen examining the landscape.
- Documentation scenes where the effects and examples visible on the landscape are compared to actual definitions on screen.
- Definitions of vocabulary that are relevant to the concept; for example, glacier terminology, earthquake terminology, etc.
- A conclusion explaining why it is important to know how a glacier changes the landscape.
- Credits and sources cited. Students rehearse and then film their movie.

Tools and Resources
Information from Apple Education about support for iMovie can be found at the following website: http://www.apple.com/support/imovie/.

Additional information, such as "10 tips for capturing great video" can be found at http://education.apple.com/education/ilife/howto/digitalmovie_tips/.

Internet Resources the iMovie:

- Earthquake Image Glossary: http://earthquake.usgs.gov/image_glossary/
- BBC Education: http://www.bbc.co.uk/education/rocks/rocky.shtml
- Journey of an Erratic: http://www.sln.org.uk/geography/flash/cannock01.swf
- Glacier Glossary: http://www.sfu.ca/~jkoch/older_stuff/glacierglossary.html
- Glacier Types: http://pubs.usgs.gov/of/2004/1216/glaciertypes/glaciertypes.html
- USGS Education: http://vulcan.wr.usgs.gov/Glossary/Glaciers/framework.html
- http://www.apple.com/education/ilife/
- iLife How-To Guides: http://www.apple.com/education/ilife/howto/

3. The USGS Schoolyard Geology Website

The United States Geologic Survey (2005) has recently created new website, "Schoolyard Geology" that provide "activities and examples of what to look for to turn your schoolyard into a rich geologic experience."

Below I have sampled the introductory page into a table to provide an overview of these lessons. Each active link provides views of various parts of the lesson. Even though the State Standards cited refer to California, the teaching sequence provides many lessons and ideas that may be used to complement existing curricula with tangible evidence.

<table>
<tr><td colspan="2">About Schoolyard Geology

Wish you could take more field trips? You can! Your own schoolyard is filled with great geologic features! This website is filled with activities and examples of what to look for to turn your schoolyard into a rich geologic experience.
How to use this Website (Teaching Sequence, State Science Standards, and Suggestions) .</td></tr>
<tr><td>Lesson 1
Mapping Your Schoolyard</td><td>Overview & Instructions
Map your schoolyard from above (Activity)
....Using the National Map (Download free maps of your school)
Navigate your Schoolyard (Activity)
Find the rocks (Activity)</td></tr>
<tr><td>Lesson 2
Rock Stories: Describing Sedimentary Rocks</td><td>Overview & Instructions
The Making of Sedimentary Rocks (Background)
Rock Stories: Describing Sedimentary Rocks (Background)
Preformatted Student Instructions
Examples of Rock Descriptions and their Geologic Interpretation</td></tr>
<tr><td>Lesson 3
GeoSleuth Schoolyard: Teaching Geologic Concepts with Schoolyard examples</td><td>Overview & Instructions
Ages of Rocks
Dinosaur Tracks
Fossils
Glacial Striations
Layers on top of layers
Slicing across layers
Sinkholes</td></tr>
</table>

4. Overview of a Suggested Curriculum Centered on Tangible Evidence

The following overview is a unit plan that I have created, centered on the IslandWood 4-day School Overnight Program and facilities, to teach geosciences with tangible evidence and amended as the curricular unit for completion of Graduate Teacher Preparation Residency Certificate at Antioch University Seattle.

Geology in the Pacific Northwest:
Explorations of Earthquake Hazards, Mitigation, and Processes

A hands-on inquiry based investigation of the land by the land

A Thematic Unit

Section 1:

- **Title**
- **Rationale (letter to parents)**

Section 2:

- **Concept Overview**
- **Unit Overview — sources follow each lesson**
  - **Introductory Day/Arrival Day**
  - **Middle Day: Forces**
  - **Middle Day: Time**
  - **Closing Day: Emergency Action Plan**

A note about page numbers — because some lessons are undeveloped all page numbers are approximate but should be considered accurate for the lessons that have been created (see color coded system to follow).

Rationale

Dear Families and Students,

We are starting a new unit in our classroom: *Geology and Hazard Mitigation of the Pacific Northwest Ecosystem*. This letter will familiarize you with the scope of our unit, what to expect along the way (lessons), intended learning outcomes (EALRs), and advance warning of anticipated adventures (field trips, etc.).

The lessons in our unit provide a background to understand the pertinent past geologic history of the PNW (beginning 40 million years with the Cascade Mountain formation, glacial impact starting 20,000 years before present, and events that continue to shape our landscape today). We will focus our attention on predominant, observable earth movements that are slow and gradual (i.e. glaciers, erosion, and weathering) and/or sudden and catastrophic (i.e. earthquakes, volcanoes, and tsunami). Additionally, we will continually focus and emphasize how people have been affected by geological processes in the PNW.

More importantly, our overarching questions and goals continually incorporate hazard mitigation and community stewardship, which allows the lessons to integrate not only the force of geologic processes and their impact on people, but how our understanding can better prepare actions in the future. We will integrate as much tangible evidence as possible to supplement out understandings.

The Washington State EALRs and GLEs make an important distinction in the language between the fifth grade and eighth grade benchmark understanding of earth sciences: at the fifth grade level students should *know* and *describe* that geological processes occur and can be slow and gradual or sudden and catastrophic, whereas at the eighth grade level students should *identify* and *explain* such geological processes (OSPI 2005:32-33).

All lessons align with Washington State EALRs (OSPI 2002), GLEs (OSPI 2005), National Science Education Standards (NSES 1995), and the America Academy for the Advancement of Sciences (AAAS) Project 2061 Science Benchmarks (AAAS 1993, 2001). Additionally, some curricula, such as the Tremor Troops (K-6) and Seismic Sleuths (7-12) from the Federal Emergency Management Agency (FEMA), provide a logical place to integrate understanding with earthquake mitigation (FEMA 1993, 1995, 1997a, 1997b, 1999, 2005). So that I do not inundate you with too much information now, I will include alignment of the standards in the next twice-monthly newsletter.

We will, no doubt, ask many questions throughout our unit, but below are some of the guiding and overarching questions of our geology unit:

- What is this place we call the Pacific Northwest? How have the ecosystems in the PNW formed? How many different ecosystems are there?

- What are the forces of geology? How do they change the world and this place? What do we look for in the landscape?
- How do we know the force of geology? How do geologists measure time? How old is the earth? How old is the Pacific Northwest?
- What role do humans have in the Pacific Northwest? How can we better prepare for earthquakes at home?

To answer these questions and others that surface, we will our urban community and natural resources to explore for evidence of how geologic processes have shaped the land before us, and how people can prepare for sudden life changing events.
In the process we will incorporate:

- EVIDENCE OF HUMANS AND THEIR IMPACTS: Exploring the harbor, Native American settlements, faults, ponds, dams and the forest for evidence of erosion and weathering, people and what they did here (watching videos, tree-cutting, invasive plants, and forest succession)
- INVESTIGATING HABITATS, including animals and the people here, now (sustainable design elements (with an emphasis on earthquake preventions) compared to historic uses of resources…)
- INVESTIGATING GEOLOGIC PRINCIPLES, including technology to find faults (LIDAR), differentiating local rock types, building considerations, relative dating, earthquake evidence, and earthquake preparation
- ETHNOBOTANICAL studies, from before the European and Asian influx
- EXPLORING DIVERSITY: cultural and biological
- INSPIRING & EMPOWERING students to contribute to their communities

Throughout our learning adventures and experiences we will develop the following skills:

- OBSERVING: (five senses, and emotional) and through different media
- COLLECTING & RECORDING quantitative & qualitative data,
- ANALYZING, INTERPRETING and REPRESENTING information
- EXPRESSING ideas gained, through creative, scientific, visual and verbal means
- APPLYING what has been learned to new situations
- EMPATHY & PERSPECTIVE, by putting ourselves in the place of others.
- SELF-KNOWLEDGE, by reflecting on what we already know and challenging our selves to learn more with continued perseverance.

Using Hazard Mitigation and Stewardship as an Integrating Theme

Stewardship is action that arises from caring and informed relationships in one's natural and cultural communities.

What overarching understandings are desired?	What are the overarching "essential questions"?
The value of being a steward of one's self, community and the environment	How do we come to know and care about our natural and cultural communities?
What will students understand as a result of learning this Unit?	What essential questions will focus this learning experience?
The joys of exploration, discovery and wonder	How does my learning in this Unit experience affect the way I see the world?
Basic ecological and geological concepts that may include ecosystems, habitats, adaptations, biodiversity, earthquakes, glacial erratics, and seismology.	What do I need to know about my environment to understand it?
The interconnectedness of natural and cultural communities	How am I connected to my natural and cultural communities?
The impact that humans have on their environment.	How do I impact my natural and cultural communities?
The benefits of working together cooperatively	How can I care for my community and make a difference in it?

Lastly, the unit will incorporate the themes outlined in the above table. I hope that you have found this informative, helpful, and worthy of learning. We are bound to have lots of fun learning and exploring these concepts.

<u>Concept Overview:</u>

This Unit is framed by four concepts of Forces and Time: Geological Change, Geological Cycles, Geological Time, and the Earth as Home

<u>Concept #1</u>: Geological Time - Looking back over the millions of years of the Earth's history, scientists have found evidence of times when climates were very different from today's. A geologist measures time in billions and millions of years.

<u>Concept #2</u>: Geological Change - Changes to the Earth by geological processes can be slow, gradual changes (i.e. erosion, weathering, glaciers, or global warming), or sudden, catastrophic changes (i.e. earthquakes, landslides, volcanoes, or tsunami).

<u>Concept #3</u>: Geological Cycles - Many natural phenomena vary on a regular or periodic basis. An example of this is the changing seasons. Some of the images on the back of the poster demonstrate natural cycles. The concentration of CO_2 in the atmosphere fluctuates regularly with the seasons. Temperature records reveal a history of thermal cycles in the Earth's climate. Students should be asked to consider cycles and to discuss how cyclical change can be distinguished from change that moves in only one direction.

<u>Concept #4</u>: The Earth as Home - We live on planet earth and must understand basic geologic processes so that we understand our role in the ecosystem and can encourage responsible stewardship.

Unit Overview:

The lessons herein are presented in a four-day manner to be adapted into the School Overnight Program at IslandWood, and, at present, are site specific to learning earthquake hazards, mitigation and processes.

However, many of the lessons may be adapted to other locations, and are therefore valid for a teaching more generally about earthquake hazards, mitigation and processes.

Further the lessons herein need not be limited to four days.

Lessons in {..} were created by IslandWood and provide cohesiveness as well as emphasize a sense of place and wonder.

Lessons in [..] were adapted and/or created by Matthew John Brewer as part of the 2004 Independent Study Project and/or classes at IslandWood Education in Environment and Community (EEC) Graduate Program.

Lessons in (..) were subsequently created and/or adapted by Matthew John Brewer since completion of the IslandWood EEC Graduate Program.

Lessons in <..> have yet to be developed but have a small synopsis for scope and sequence (sources are indicated).

Lessons in ".." were adapted and/or created for this thematic unit. These lessons can be provided upon request.

<u>Introductory/Arrival Day:</u>

Pre-assessment and Introductions

? What is this place? How have the ecosystems formed?

{Name Toss} 3

<u>Overview</u>: This is a group juggling exercise to facilitate people relaxing in a new group as well as learning each other's names.

<u>Source</u>: IslandWood

{Gear Up!} 5

<u>Overview</u>: Students will look at packing techniques and essentials for the naturalist, and pack their own pack daily accordingly. The group visits the Gear Room for any items that need to be borrowed (this includes the teachers and chaperones). There is a schedule for each group's time at the Gear Room that will impact your arrival day.

<u>Source</u>: IslandWood

{Unnature Walk} 6

<u>Overview</u>: Students walk singly (about twenty yards apart) along a trail, looking for items that do not belong there. When they see them, they count them (or write them in a journal), but do not point at or touch the items. Afterwards, the group discusses what they saw and then returns along the trail to see what's there.

<u>Source</u>: IslandWood

{Ecosystem ABC's} 8

<u>Overview</u>: Students learn about the abiotic, biotic and cultural parts of an ecosystem through a series of short lessons.

- Abiotic Factors: the L.A.W.S. of nature (Light, Air, water, and Soil)
- Biotic Factors: Producers, Consumers, Decomposers and Scavengers
- Cultural Factors: the human influence on an environment

<u>Source</u>: IslandWood

<u>Middle Day</u>:

Forces and Principles of Geology

?: What are the forces of geology? How do they change the world and this place?

<u>Overview</u>: To begin the day, the group checks in with each other and discusses the learning plan for the day… an unusual day since the focus is on the built environment for most of it, with fun smatterings of natural explorations, as well.

<u>Source</u>: IslandWood

<u>Overview</u>: Students will be able to describe the physical characteristics of rocks, prepare a dichotomous key representing rock characteristics, and demonstrate an ability to test predictions about rock types.

<u>Source</u>: *Geologic History: Investigating Your Environment: Teaching Materials for Environmental Education (Grades 7-12)*. United States Department of Agriculture Forest Service. Pacific Northwest Region. 1993. Adapted by Matthew John Brewer

<u>Overview</u>: Students consider the importance of remote sensing technology, such as aerial photography, LIDAR, and geomagnetism. Students use real data from the USGS and other agencies (PSLC, IRIS, etc.), and match the data with ground truth (i.e. physical examination of the potential sites).

<u>Source</u>: Adapted and Created by Matthew John Brewer from data by USGS Earthquake Hazards (http://earthquake.usgs.gov/regional/pacnw/),
Pacific Northwest Seismograph Network (http://www.pnsn.org/recenteqs/latest.htm), and
Puget Sound LIDAR Consortium (http://duff.geology.washington.edu/data/raster/lidar/)

Source: Adapted and Created by Matthew John Brewer from data by USGS Earthquake Hazards (http://earthquake.usgs.gov/regional/pacnw/), and Geologic Principles at IslandWood (http://resources.islandwood.org/geology/princples.htm)

"Making Mountains from Islands (GH, DH)" 66

Overview: Students examine the processes that shape the geologic formation of the Pacific Northwest, Cascade Mountains, and the Olympic Mountains using a variety of sources — websites, fireplaces, investigations, and self-knowledge.

Source: Adapted and Created by Matthew John Brewer from data by USGS Earthquake Hazards (http://earthquake.usgs.gov/regional/pacnw/), and Fireplaces at IslandWood Teach about Geology (http://resources.islandwood.org/geology/fireplaces.htm)

{Back to the Map} 67

Overview: It is *essential* to leave time at the end of each day to return to the footprints mind map and review what has happened and what has been learned.

Source: IslandWood

Middle Day:

Geologic Time and Understanding Past Events
?: How do we know the force of geology? How do geologist measure time? How old is the earth?

{Check-In, Mind Map} 70

Overview: To begin the day, the group checks in with each other and discusses the learning plan for the day… an unusual day since the focus is on the built environment for most of it, with fun smatterings of natural explorations, as well.

Source: IslandWood

Overview: In a whole body activity students experience Primary (P), Secondary (S_1), and Surface (S_2) waves that occur during earthquakes. Students learn to interpret their arrival on a seismograph display.

Source: Adapted and Created by Matthew John Brewer from data by Pacific Northwest Seismograph Network (http://www.pnsn.org/recenteqs/latest.htm), and Incorporated Research Institutions in Seismology (IRIS) (http://www.iris.edu/about/publications.htm)

[What Would You do? (Shell Midden)] 100

Overview: In this lesson students will recognize an archaeological feature (the Shell Midden), and consider what would have happened when the earthquake, evidenced in the fault, forced abandonment of the site. Students will also make inferences as to what life might have been like before, during, and after the earthquake event and compare local myth(s).

Source: Adapted and Created by Matthew John Brewer

<Looking For Glaciers (FRT — cont. glaciers)> 108

Overview: Students look for evidence of continental glacial movement in the Puget Sound region, and investigate how this process has changed the earth's surface.

Source: Adapted and Created by Matthew John Brewer from data by USGS Earthquake Hazards (http://earthquake.usgs.gov/regional/pacnw/), and Glaciers (IslandWood resources website) (http://resources.islandwood.org/geology/glacier.htm)

{Back to the Map} 109

Overview: It is *essential* to leave time at the end of each day to return to the footprints mind map and review what has happened and what has been learned.

Source: IslandWood

Wrap-Up Day:

Bringing the Ideas Home

?: How can we better prepare for earthquakes at home?

{Check-In, Mind Map} 111

Overview: To begin the day, the group checks in with each other and discusses the learning plan for the day… an unusual day since the focus is on the built environment for most of it, with fun smatterings of natural explorations, as well.

Source: IslandWood

(Sustainability E1T1 with EQ precautions) 112

Overview: Students become teachers of sustainable elements, focusing on the learning studios, and earthquake building precautions (visible on the exterior).

Source: IslandWood, adapted by Matthew John Brewer

[Building Matters (paper models)] 125

Overview: Students explore earthquake hazards and building damage by constructing model buildings and subjecting the buildings to ground vibration (similar to an earthquake) on a small shake table. Buildings are tested after construction, and compared to photographs of earthquake damage to reinforce building design and earthquake risk.

Source: Larry Braile, Purdue University (http://www.eas.purdue.edu/~braile/edumod/building/building.htm), adapted by Matthew John Brewer

<Putting Down Roots — EAP (Part 2)> 131

Overview: Students will reconsider the range of their needs and the state of their personal preparedness for an emergency. Students will establish their own Emergency Action Plan (that can be continually refined).

Source: Seismic Sleuths, adapted by Matthew John Brewer

Overview: This post-assessment activity is designed to focus students on what they have learned, assess their current knowledge, and provide them and you with a gauge of what they have learned from this earthquake curriculum.

Source: Seismic Sleuths, adapted by Matthew John Brewer

Overview: Students write letters to themselves, possibly using the attached template, that the instructor will send to them in about a month. This is an opportunity for reflection and possibly goal-setting.

Source: IslandWood, adapted by Matthew John Brewer

Overview: It is *essential* to leave time at the end of each day to return to the footprints mind map and review what has happened and what has been learned.

Source: IslandWood

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