THE EFFECTS OF SHARED COMMON EXPERIENCES ON LEARNING IN THE ENGLISH LANGUAGE LEARNERS' SCIENCE CLASSROOM

by

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In presenting this professional paper in partial fulfillment of the requirements for a master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

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For the past eight years, I have taught a variety of science classes at Roaring Fork High School in Carbondale, Colorado. These classes have ranged from beginning physics to advanced biology to agricultural biology, and each course has relied heavily on students' previous science process skills, prior knowledge, and science experiences. Five years ago, our science department felt the need to add an additional science class to reach the increasing number of students entering high school with little to no prior science background. Many of these students were second language learners who were not placed in science classes during middle school in order that they might take more English language learning courses, thus bringing them closer to grade level. Knowing that these students were ill-equipped for placement into the beginning earth science and biology course, and in consideration of the fact that these students would be assessed in science on our state standardized test their sophomore year, we felt the need to develop an intensive course in order to develop basic scientific literacy in these students. We named this course general science, and it focused on the key proficiencies for each area of middle school science based on the Colorado Model Content Science Standards (Colorado Department of Education, 2009). I have taught the general science class for four years now, and the greatest challenge I faced was connecting the content to what students had already experienced. Many of the common examples of experiences related to scientific concepts provided by the text sources and myself were in fact not common to these students.

The general science class in the fall of 2010 was composed of nine Latino male students, all in our English language learners (ELL) program. Seven of the students were classified as early intermediate students and two were classified as beginner students. These classifications are based on the Colorado English Language Assessment (CELA), which is given to students having a primary language other than English spoken at home. This assessment scores the students on listening, speaking, reading, and writing in English. Roaring Fork High School has a total of 35 students, out of the 307 member student body, who are active in the ELL program and an additional 86 in the ELL exit program. Latino students comprise 66% of the student population with 2% Asian or African American, and the remaining 38% Anglo (Infinite Campus student management software, 2010). The language barrier and differing educational background created a unique challenge in which many of the traditional resources were inaccessible to the students.

The purpose of this study was to make the science content being taught to the general science students more accessible by placing an emphasis on creating and using shared common experiences. Knowing that the range of experiences among these students was varied and limited in many ways, I felt it necessary to create a shared common experience for these students that we could then use as a foundation for our understanding in each unit of learning throughout the year. Emphasis was also placed on other common life experiences students had in an attempt to better connect their lives to science, which was one of the major goals of the study. Much has been reported about connecting what is taught in the classroom to students' lives, but I wanted to see if science could be taught more effectively based on experiences students already have when they walk into the classroom. Even with limited science background, students have many other life experiences that may be used to teach them about the nature of science, the habits of mind, and the science content. Shared common experiences also need to be created to ensure that certain areas of content can be effectively taught. The shared common experience in this action research project was a two-day camping trip that involved students constructing camp structures, cooking, hiking, and measuring our local rivers. Experiences from this field trip and biweekly trips to local river sites were used throughout the year for different science units as a means of assuring common background knowledge. The main content emphasis for the action research was motion, forces and energy, geology, and chemistry although this shared common experience supported all areas of science.

Focus Question

Determining the effects of shared common experiences was the major focus of this capstone project. The following questions guided the implementation of this project. How can shared common experiences be used to increase comprehension of struggling English language learners in physical science? What experiences do science texts and teachers assume students have, yet they do not? What cultural experiences do my students have that I can use as references in teaching physical science concepts?

CONCEPTUAL FRAMEWORK

Scientific literacy is a foundational component of science education and has become a major focus of educational societies such as the American Association for the Advancement of Science, the National Research Council, the National Association for Teachers of Science, and the National Science Teachers Association (AAAS, 1989). Project 2061 highlights the need of creating a scientifically literate population and has created benchmarks for what all students should know and be able to do in science by the time they graduate from high school (AAAS, 1993), as well as a recommendation for the sequence in which these learning benchmarks should be introduced (AAAS, 2001). Science literacy is defined as “knowledge and skills in science, technology, and mathematics, and their interconnections, along with scientific habits of mind, an understanding of the nature of science, and a comprehension of its role in society and impact on individuals” (AAAS, 1989). The development of scientific literacy is of even greater importance for English language learners, as it helps relate new content to their personal lives and helps to establish learning patterns. (Hart & Lee, 2003). In order for students to best understand science, they need to make sense of the natural world in multiple situations and find how these situations apply to their lives. Students, especially English language learners, also need to be able to draw on prior knowledge in order to best learn the interactions between science concepts (Fathman & Crowther, 2006; Medina-Jerez, Clark, Medinal, Ramirez-Marin, 2007; Mintzes, Wandersee, & Novak, 1988).

Incorporating scientific literacy into basic everyday knowledge should be an essential goal of all science educators (AAAS, 1989). Everyday knowledge can be described as common sense or general knowledge that is frequently used with the context of one's life (Mayoh & Knutton, 1997). Mayoh and Knutton identified twelve areas through classroom observations in which teachers reference background knowledge: references to mass media, references to personal experiences, references to common out of school experiences, references to common objects, references to images from out of school experiences, references to everyday knowledge, references to everyday words, using analogies and metaphors, everyday experiences, using everyday contexts for classroom activities, developing skills for everyday life, and references to industry. Of these twelve, eight can be interpreted as forms of everyday knowledge. Mayoh and Knutton also illustrate how classroom teachers commonly reference personal experience, common out-of-school experiences, common objects, everyday knowledge, and everyday contexts. The authors of this study also noted that teachers rarely checked out their assumptions that particular experiences were shared and common among their students, creating a great disconnect between what is taught and what is learned. Students' experiences, ideas, and interpretations influence the way they interact with the learning materials and concepts (Spurlin & Blanco, 1998). School science must be connected to the students' everyday lives and their background knowledge, but this process is complex. Effective science instruction should be designed to help students make sense of the knowledge they have as well as allow students to change previous meanings and integrate other knowledge areas (Cajas, 1999). Instruction that promotes the scientific literacy definition of understanding nature should also draw upon home and community cultures, allowing students to contribute more and to make stronger connections to prior knowledge (Schmidt, 2005). The AAAS (1993) concludes that curricula based on scientific literacy "enables teachers to design learning experiences for students that take into account state and district requirements, student backgrounds and interests, teacher preferences, and the local environment" (p. xii).

It is essential to align what is taught to previous instruction, background knowledge of students, and developmentally appropriate learning outcomes. Students must be able to see the story of science in and around their lives. In order to do this, they need to understand how science operates not only in the classroom, but also in their lives (Fathman & Crowther, 2006). Students must also attain an inventory of key science concepts as a basis for later learning (AAAS, 1993). Educators need to know previous science experiences of their students in order to develop appropriate learning objectives. One tool available to teachers is the Atlas of Science Literacy, which takes the benchmarks set forth by Project 2061 and aligns them in grade appropriate sub-sets that build upon each other. This resource is designed to help educators understand what students can be expected to learn in different grades, and to help them design coherent and comprehensive curricula, instruction, and assessments (AAAS, 2001).

Few studies have connected the importance of scientific literacy to second language learners, minority students, and students with learning disabilities. Multiple studies do identify key strategies that address the connections between background knowledge, culture, and learning. As America's schools, and culture, shift to former minorities becoming the majority, teachers must realize that students will have different cultural experiences and background knowledge than the traditional Anglo-European white-middle-class culture and knowledge (Schmidt, 2005). Second language and minority students are generally interested in the world around them and tend to be enthusiastic about hands-on projects and activities, and especially benefit from curricula that require students to interact and respond with their environment (Spurlin & Blanco, 1998; Sutman, 1993; Westervelt, 2007). These students also need to be exposed to a wide range of references in and out of the classroom, rather than a single text source. This allows students to investigate and compare a number of sources in order to learn the complex interactions in science (NRC, 1996; Sutman, 1993). When developing a curriculum of varied sources for struggling learners, Spurlin and Blanco (1998) note it is important to recognize the students' cognitive underlying proficiencies, which include vocabulary and concepts known in their first language and culture that can be readily transferred to English. Sources also identify the importance of instruction centered around a common theme, which allows students to further their understanding of science concepts by seeing how they play out in the world (Gonzalez, 1995; Sutman, 1993).

These cognitive underlying proficiencies are essential for connecting classroom knowledge to students' experiences, yet "the solution to build bridges between formal academic discourse and everyday life remains fraught by the presence of the gap between in-and-after-school experiences" (Cajas, 1999 p. 37).

Cajas has identified this gap between students' life experiences and what is taught in the classroom as a major weakness in our educational system, but his focus remained on how to incorporate classroom knowledge into out-of-school experiences. Incorporating out-of-school experiences into the classroom has had far less prior research. In recognizing the importance of incorporating students' background knowledge into classroom instruction, it is essential to know what out-of-school experiences students have that relate to the content being taught. Out-of-school experiences, also known as everyday experiences, are any experiences or understandings arising outside formal classroom-based instruction (Mayoh & Knutton, 1997). Watson (2004) states that complex scientific concepts are best understood when students engage themselves with the concept through activities and experiences.

Inquiry-based instruction also has its roots in relying on and creating experiences for the learner. One of the major components of inquiry-based instruction is providing shared common experiences for students (Dobb, 2004). In creating these shared common experiences, the teacher is able to help students better understand and explain what happens in life. The ideal, however, is to have students enter a class with a known collection of common experiences. Mayoh and Knutton (1997) highlight the importance of students' everyday out-of-school experiences in giving meaning to formal concepts in the science curriculum. Several studies point to the importance of changing science curriculum to better incorporate students' past out-of-school experience into what is being taught (Bybee, McCrae, & Laurie, 2009; Gonzalez, 1995; Roth, Boutonne, McRobbie, & Lucas, 1999). In analyzing the results of the 2006 Program for International Science Assessment (PISA), Bybee, McCrae, and Laurie (2009) recommended the need for science curriculum to start emphasizing life situations in which science plays a role. Results from the PISA 2006 assessment, in which science was the focus year, showed that students struggle to connect life situations that involve science and technology to scientific phenomena and scientific issues, and do not use prior life situations as scientific evidence of an event. Scott (1995) designed an at-home science program to be done with parents and their children to help develop scientific literacy through creating science experiences that has been implemented in Louisiana, Michigan, Missouri, New York, Oklahoma, and Texas. Project 2061, in *Benchmarks for Science Literacy* (1993), states that students' "strategies for finding out more and more about their surroundings improve as they gain experiences in conducting simple investigations of their own" (p.10), and that a key emphasis in the early grades should be "gaining experience with natural and social phenomena" (p.4). One curricular method that addresses these needs well is activity theory. Roth and Lee (2001) describe a series of science lessons that have students construct science knowledge from their own experiences outside of the classroom while providing a service to the local community. The idea of activity theory is that it pieces together six components of learning: human subjects, objects, tools, rules, community, and division of labor, into a holistic and applied curriculum. By creating a system where students' prior out-of-school experiences, culture, and group exploring were used in student learning, the instructors were able to increase the science literacy and knowledge of the students.

As mentioned earlier, little direct study has been reported on how students' prior out-of-school experiences influence in-class learning of science concepts. Multiple sources show the need for connecting what is learned in the classroom to life situations, especially among English language learners, but a tool has not yet been found that identifies what key life experiences students should have prior to a particular grade-level or content class. AAAS has mapped out a sequence of learning objectives to be taught at different grade levels, but these still fail to draw upon what would be assumed as shared common life experiences teachers should use to improve instruction.

METHODOLOGY

Creating a set of shared common experiences in which students could build content knowledge upon was the ultimate goal of my capstone project. I had noticed an increasing number of students who lacked what I, and our text sources, consider common knowledge and experiences. Based on the General Science Survey and Interview given to my 2009/2010 general science class, many of the students were lacking in local outdoor experiences (Appendix A). Though living in the mountains of Colorado, few of these students had camped, fished, rock climbed, or hiked a peak. The survey also revealed that few of the students had experiences using tools, starting fires, and cooking. These findings were further supported by the High School Science Teacher Survey given to fellow high school science teachers in my district (Appendix B). I then created a focus group among students in my upper-level biology classes and gave them the Focus Group Interview of Upper-Level Biology Students to solicit information about how their life experiences, especially involving outdoors and amusement parks, helped them learn science (Appendix C). Results from this focus group highlighted that much of these students' science knowledge could easily be referenced through application to the outdoors. In order to assess this year's general science students' confidence in science, background knowledge, and content pertaining to the focus unit, the General Science Confidence Survey was given prior to the treatment and following the main instructional unit (Appendix D). The purpose of the General Science Confidence Survey was to assess the students' behavioral and metacognitive skills towards science. Ten questions were asked about students' views of science and nature, and ten questions about students' views of their content knowledge; all ranked by a Likert scale.

Study Participants

The general science class was composed of nine male English Language Learners at Roaring Fork High School. All students were in their first year of high school science, and for three, this was their first formal science class ever. Many of the students had recently moved to the United States from Mexico and were in an intensive language development program. Grade level for these nine males ranged from ninth through eleventh grade. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

Creating background knowledge

The first component of this treatment was creating a shared common experience for my students, comprised of nine male beginning English Language Learners in their first high school science class. Many of these students recently moved to Carbondale from Mexico and had little to no formal education. After analyzing all initial data sources, the treatment was determined to be a local, two-day, one night camping trip. This trip was designed to have the students experience as much of the outdoors as possible without directly referring to the science behind what they were doing. The first day of the trip, the students set up camp, which consisted of a large 8-person tent and a kitchen area. A small lesson was then taught about the section of river we camped next to and was followed by students taking width, depth, slope, and velocity measurements of the river. The students had much of the rest of the day and evening to explore the area. On day two, the students broke down camp and we drove up to Snowmass ski resort where we hiked up to the top of one of the resort's mountains. During this hike the students were exposed to elements of our local geology and wildlife. From the top of the mountain the students were shown the boundaries of the Roaring Fork watershed. On the way back down the mountain the students found a headwater and took measurements of its width, depth, slope, and velocity. After descending the mountain, one more river location was assessed, at a site lower down than camp, giving the students a chance to see this local river at three different points and sizes.

Ongoing experiences included biweekly trips to two local river sites, where students continued to take measurements and observations and were exposed to the surroundings and the changes in the river system over time. Each of these trips had a specific purpose relating to the concept being introduced or reinforced. The first trip had students calculating the flow rate. During the second trip, the students found ways to measure the force of the river and sought evidence of the river's force. On the third and final trip of this unit, the students focused on the forms of energy in the river.

The next phase of the treatment was incorporating students' shared common experiences into the content of our class. This was done by creating a list of our shared common experiences from the trip and their life that focused on motion and energy. At the beginning of the unit on river physics, we listed the key learning objectives and connected each of those objectives to the experiences previously listed. This connected list was kept on an overhead and reviewed weekly as a means of intentionally connecting the upcoming knowledge to prior background experiences. Formative assessments were given throughout the river motion unit to assess the students' connections of the content to their experiences (Appendix E). Students were also given a pre and post Metacognitive Self-Assessment that caused them to reflect on how much they used the shared common experiences in their learning (Appendix F).

Connecting Content to Background Knowledge

The next phase of the treatment was incorporating students' shared common experiences into the content of our class. This was done by creating a list of our shared common experiences, both from the trips and from surveying the students prior to the unit. The general science class incorporates the fields of physics, chemistry, earth science, and biology. For this action research project, most of the emphasis was placed on three separate, but connected, units. The first unit was physics based and focused on how the river flows. The second unit was geology based and centered on the rocks found in our local streams. The final unit was river chemistry. At the beginning of each unit, we covered the goals and objectives, and the students listed what experiences they had that would help them understand the material best. The experiences were written out on an overhead, and throughout each unit we drew upon these shared common experiences. Formative assessments for the three units were given to students to promote their use of referencing the common experiences (Appendices E and F). Students were also given a pre and post Metacognitive Self-Assessment that caused them to reflect on how much they used the shared common experiences in their learning (Appendix H).

Unit Implementation

Prior to the focus unit, our class had completed its camping trip experience and had made several trips to two local rivers to aid in building background knowledge. During each of these trips, the students took quantitative measurements of the physical river and made qualitative observations about the rocks and wildlife observed in our river sections. Students kept these observations and measurements in their science log books.

At the beginning of this unit, students were presented with the How Does Your River Flow Vocabulary Assessment (Appendix E) in which they were asked to associate words and provide an example of the word. During the unit, the students spent two class periods at the river taking width, depth, and slope measurements.

Students then were asked to recreate the river to the best of their ability in an in-class stream table exploration. Through these experiences, students were given several formative assessments that intentionally had them focus on prior experiences from the class to deepen their understanding. Much of the remaining instruction was more traditional physics instruction with small lessons on specific concepts followed up by laboratory experiments to help further the students' understanding.

Data Collection Methods

In order to best see how well students use the shared common background experiences created in this class, a number of different data sources were collected. This allowed for a broader view of how the background experiences were used, as well as how effective they were in learning content. Table 1 shows how the different data sources were used to address the four guiding questions of this capstone project.

Table 1
Triangulation Matrix

Research questions	Data Source		
	1	2	3
1. How can shared common experiences be used to increase comprehension of struggling students in physical science?	Formative assessments: are the students using the experiences to answer questions?	Metacognitive self-assessment: do students think about the experiences during activities/ assessments?	Artifacts: are students creating projects that use the common experience?
2. What experiences do science texts and teachers assume students have, but they do not?	Teacher survey	Text survey	Student questionnaire
3. How often do students use the shared common experiences in understanding new science concepts?	Formative assessments during each unit that may require students to reflect on an experience.	Metacognitive self-assessment	Post-unit reflections
4. Does the use of shared common experiences allow for higher-level learning to occur?	Formative assessments written at Bloom's higher levels.	Artifacts: do the projects students produce show application, analysis,	Reflections of classroom discussions and activities.

		synthesis and evaluation?	

Surveys

Surveys were used primarily to collect the initial data used to create the common background experience. The General Science Survey (Appendix A) was created by reviewing science texts for what textbook editors considered to be common experiences as well as some local recreational activities commonly used by teachers in our district. Surveys were also given to high school science teachers in our district. The High School Science Teacher Survey (Appendix B) was designed to identify the key areas of science instruction where students most often struggle due to a lack of background knowledge. This survey was optional for teachers in our district, and responses were received from six of the eleven teachers. An end of unit survey was also completed with the general science students in order to assess how much they thought the focus on shared common background experiences aided in their learning of physics.

Interviews

Interviews were first used to gain an understanding of how my advanced science students learned much of what they know about science (Appendix C). These interview questions attempted to assess how often these students used background experiences of nature and amusement parks in learning science. Another question asked students what background knowledge they lacked which kept them from learning a particular concept well.

Observations

The largest component of data collection was observations. Many observations were kept during the camping trip and our bi-weekly river trips. Mostly, I was looking for how students responded to the new experiences while in the field. As time progressed, I was also interested in how often and accurately the students connected key vocabulary from the unit to learning objectives at the river. One aspect that made observations difficult to record and interpret was the fact that most of the students conversed primarily in Spanish with some broken English.

Interpretation of Data

Speaking limited Spanish myself created difficulties in trying to accurately interpret much of the data. Many days during class, I did have an ELL resource teacher in the room, which helped with class discussions about what was being learned and how the learning objectives applied to the students' lives. The resource teacher rarely came on our river trips however, greatly limiting the amount of verbal data I could collect then. For written reflections and assessments, many of the students were still writing in Spanish; many of them poorly. Google Translate was used often as an attempt to translate what was written, but rarely could it match what my students had recorded. The resource teacher was of some help with this, but her schedule did not provide her time to translate all data sources for me. For a majority of the data that was not translated for me, I attempted to identify the main idea being expressed and relate the statements made to my observations of their interactions with the river at that time. Because of this, I feel that I can see the big picture, but am missing many of the more subtle details; perhaps details that could have been very meaningful for this study.

DATA AND ANALYSIS

The results of the General Science Confidence Survey showed that students greatly enjoy science, being outside, and performing experiments, but did not view themselves as being good at science or thinking about science regularly (Appendix D). Students ranked their competencies highest in identifying forces at 78% and in identifying forms of energy at 74% (N=9). Students ranked their competencies lowest on chemistry and geology terms, both below 60%.

The students were also given the How Does Your River Flow Pre Vocabulary Survey to assess their actual knowledge before the unit using word association and written examples (Appendix E). In comparing the two pre-unit surveys, it is evident that students overestimated their collective knowledge by an average of 43% on four physical science concepts (Figure 1). Few students were able to show knowledge in matching related terms for all assessed terms, and even fewer were able to provide examples for each term. Each student viewed their knowledge of the specific science terms as higher than their performed knowledge on the How Does Your River Flow Pre Vocabulary survey. Students most closely assessed their knowledge for the terms speed and velocity by overestimating their collective knowledge by 18%. Additionally, more students were able to provide examples for these two terms, with nearly half of the responses directly reflecting on trips to the river for examples of speed. Three of these responses mentioned the need for time in calculating the speed of the river. "We take time on the river to see the velocity of the river how fast run [sic]," was the most fluent of the responses, with the other two being similar in the idea of connecting time to velocity. The greatest discrepancy between perceived knowledge and ability to show basic understanding of terms was when students were questioned about force. On the General Science Confidence Survey, students responded with 73% confidence in knowing how to identify forces. Yet, on the How Does Your River Flow Pre Vocabulary survey, the students could only correctly identify 18% of the terms related to force. Only one of the open-ended responses focused on the river as an example of force, and this answer still did not show an understanding of force in the way it was written.

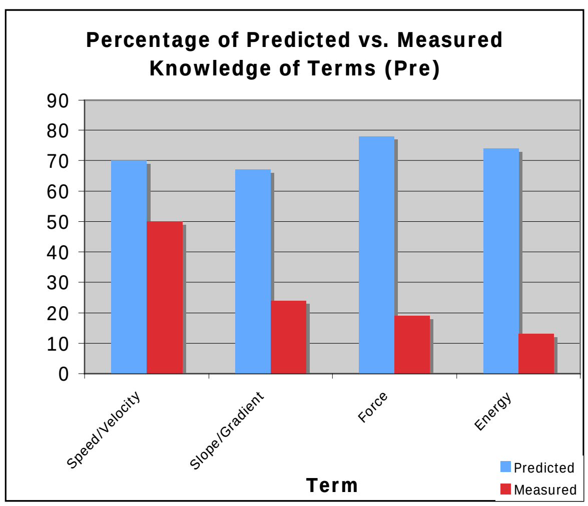


Figure 1. Percentage of Predicted Versus Measured Knowledge of Specific Science Terms from General Science Confidence Survey to How Does Your River Flow Pre Vocabulary Survey, (*N*=9).

The General Science Confidence Survey was also given at the end of the instructional unit and showed similar results as the pre-unit survey, though as a class, the students ranked themselves higher on each of the concepts. Measured knowledge only showed growth in two of the four key terms. Energy knowledge grew by 6.25%, slope by 1.4%. A decrease in speed and velocity of 8.3% was recorded and there was no change in identifying forces. Students ranked themselves at 100% competent in identifying forces and at 96% competent in calculating speed and velocity, over 50% higher than their measured scores. When compared to the end of unit vocabulary, it is evident that the students once again overestimated their knowledge (Figure 2). As in the pre-unit comparison, students most closely predicted their knowledge in speed and velocity, with a difference of 50%, and the greatest difference was in forces with a difference of 72%. When looking at basic formative assessments given throughout the unit, it could be said that students' knowledge is higher than the post vocabulary assessment however. Daily quizzes for knowledge show an average of 77% for speed and velocity, 65% for slope and gradient, 80% for identifying forces, and 72% for identifying energy. These daily quizzes range from written responses for each term to basic calculations to identifying experiences.

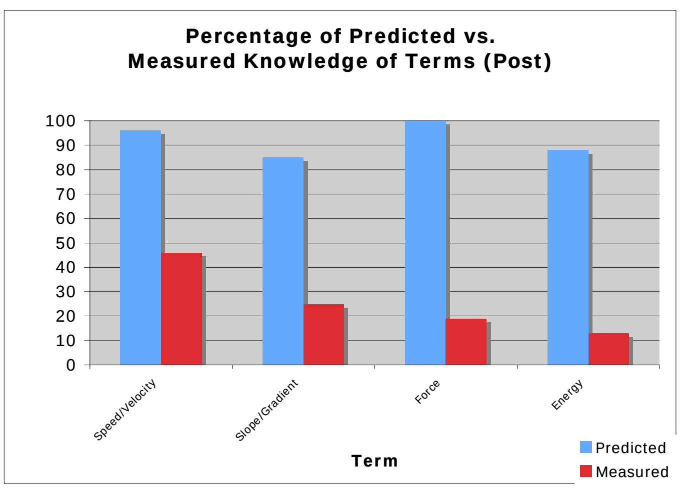


Figure 2. Percentage of Predicted Versus Measured Knowledge of Specific Science Terms from General Science Confidence Survey (Post) to How Does Your River Flow Post Vocabulary survey, (*N*=9).

Two other terms were included on the How Does Your River Flow Pre Vocabulary Survey that were not included on the General Science Confidence Survey. These terms were a bit more specific to our river units and showed the lowest scores for background knowledge of terms and examples. The terms were *erosion* and *work*. Of the two terms, *work* was the most attempted by the students, but fewer than half attempted to connect one or more words to *work*. Furthermore, not a single student was able to provide an example of either of these terms accurately. One student responded to *erosion* as “farmers put weathering to their crops,” showing no understanding of the concept prior to the unit being taught. Both of these terms did show growth on the post assessment, along with *slope* and *energy* (Figure 3). *Force* showed no growth from pre to post in average number of terms correctly matched, and *speed* and *velocity* actually had a decrease of nearly 5%.

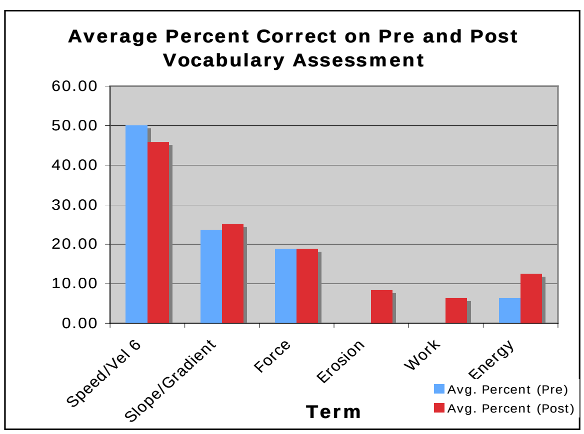


Figure 3. Average Percent Correct on Pre and Post Vocabulary Assessment for Six Key Terms, (*N*=9).

On the General Science Confidence Survey given at the end of the instructional unit on River Motion, students perceived their gains highest in balancing chemical equations at 53%, calculating speed and velocity at 37%, identifying forces at 29%, and calculating slope at 28%; the last three being directly taught in this unit. Concepts receiving less perceived growth by the students were use of periodic table at 21%, identifying forms of energy at 20%, naming acids and bases at 14%, and showing how energy transfers at 12%. Students ranked their perceived knowledge of rocks and minerals lower than in their pre-unit survey by 9% each. Overall through this unit, from pre to post self-assessment on the General Science Confidence Survey, the students ranked themselves 17% higher as a group on their knowledge, with 25% of the increase being on the terms directly taught in the unit and 8.5% being from related terms not directly taught. Data from the post Vocabulary Assessment does not fully support the students' self-perception of knowledge. Measured knowledge in this word association assessment showed an increase of only 8% for the terms speed and velocity, whereas students self-assessed themselves as 36% more intelligent on this term. Similar data exist for the concepts of slope and forces. Students showed greatest growth in the concepts of erosion, work, and energy of 400%, 100%, and 100% respectively; all concepts that were indirectly taught. Although the students still performed more poorly on these concepts than the directly taught concepts, they showed growth in both self-assessment and on the formative assessment. Responses in the written section of this assessment were more limited on the post assessment, though they were more accurate than during the pre assessment. Speed and velocity had two accurate responses that both related to the velocity of the river. Work also had two correct responses on the post assessment, up from zero on the pre. Neither of these responses related to the river or camping experiences, but they both related to collective experiences discussed in class. One student responded that work was when his “foot moves the soccer ball with a force,” and the other responded by stating that work was when “I use a force to move weights in the gym.” Students did not provide written examples for any of the other four terms on the post assessment.

The Camping Trip Reflection highlighted some of the key experiences for the students on our two- day trip (Appendix I). Only seven of nine boys participated in this outing and data was collected from six of these students anonymously. Four questions were asked on this reflection which focused on what they enjoyed, what they did not enjoy, what was a new experience, and if they enjoyed being outside. All students were allowed to answer in Spanish in order to best express themselves. However, the data received was still very minimal. Four of the students responded with *climbing the mountain* as their favorite experience, which also proved to be a new experience for three of these four students. Two other students reported *collecting insects from the river* as being a new experience. When asked about experiences that were not enjoyed, only one student commented about going up the mountain “because it made me tired.” This student also described his favorite activity as staying up all night telling stories. Two other students expressed dislike for being too close to Carbondale and the trip being too short. On this survey, all students stated that they enjoyed being outside, and two students furthered their responses by giving examples of what they like about learning outside. “I think it's all good and our work with real life outside helps me learn more,” was how one student responded when asked if he enjoyed being outside. “That we can learn outside about different animals and things,” is how the other student answered.

Personal observations about the students' interaction with the outdoors showed that they greatly enjoy being outside and having hands-on learning experiences, even in the snow and freezing temperatures. We spent one class out of five at the river, and the students were most engaged and on task during these experiences, especially compared to in class instruction and laboratory experiments. Two particular students had been extremely disruptive in class, which often led to being removed from the classroom, yet I continued to look to both of these students when out in the field to get the measurements needed as they were always anxious to put on the waders and jump in the river. These students also conversed best when learning on the river.

All students still struggled with explaining their knowledge in an understandable manner in English or Spanish. Students were able to demonstrate knowledge fairly accurately about river speed, slope, and erosion during a lab experiment where we built stream tables. Through discussion and demonstration students were able to relay their knowledge, yet on the formal write-up for this activity, students showed below basic-level understanding, averaging 43%. This has been a repeated pattern for activities on speed and slope as well.

Students showed an increase in their self-assessment of how often they use background knowledge from mid-unit to end of unit on the Metacognitive Self-Assessment (Appendix F). Students perceived their greatest metacognitive gains in using the activities from class trips to help learn, with an increase of 67% from mid-unit to end of unit (Figure 4).

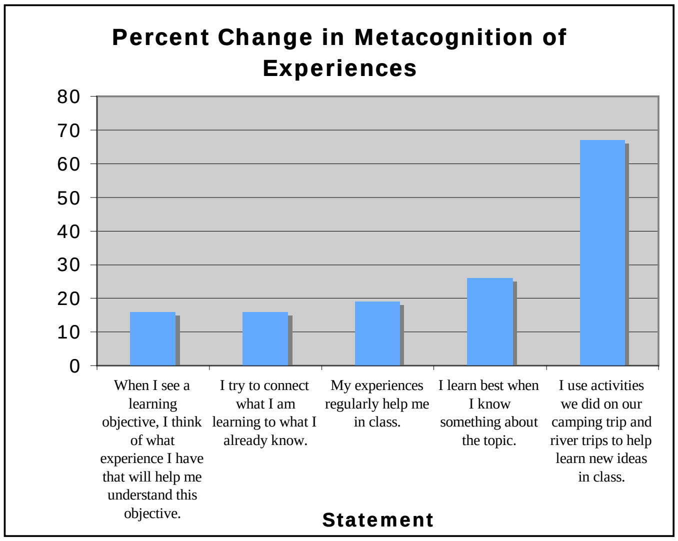


Figure 4. Percent Change in Metacognitive Experiences from Mid-Unit to End of Unit, (*N*=9).

The four other statements did not show as much of an increase in growth, though all statements received an average response between 81% and 93% on the end of unit Metacognitive Self-Assessment survey. The two highest scoring responses on the end of unit survey were “my experiences regularly help me in class” and “I use activities we did on our camping trip and river trips to help learn new ideas in class,” both averaging 93%. When asked about how these experiences actually help, one student responded, “I remember things best when I have to do it.” This statement was repeated in various forms from most other students. These data were also supported by field observations of the students. Most could easily measure the velocity of the river when given the task, and all but one group of three students could measure the slope of the river. These skills carried over to measuring velocity of other objects and slope of different terrain. The knowledge did not seem to carry over to daily quizzes however, as 66% of the students still struggled to give correct responses on word problems for slope and velocity. The students had a much harder time expressing which specific experiences helped them though as was evident on the Post Unit Reflection (Appendix H). When provided with the key learning objective, only 33% of the students provided meaningful examples or experiences for each objective. All students did provide examples for at least two objectives, with *Measure the speed/velocity of our stream* and *Calculate slope of a river* receiving the most responses. In every example for the measuring speed objective the students provided the basic procedure for how we measured speed of the river. For calculating the slope, all but two students referred to our stream table experiment for their examples.

INTERPRETATION AND CONCLUSION

Data from this study suggest that creating common background experiences do not necessarily increase the depth of English language learning students' acquired knowledge, but it does increase the breadth of students' acquired knowledge. Students showed little growth on the terms taught directly during this unit, but showed greater growth in the terms taught indirectly in this unit. In this physics unit, the terms *speed, slope, force,* and *energy* were all directly taught, and the students had a 4% average increase in knowledge on these terms. *Work* and *erosion* were secondary terms not directly taught but used throughout the lessons and river trips. The students averaged 250% growth on these two terms. Though more traditional assessments show little growth in knowledge of terms, the students' abilities to apply that information to studies in the field and lab did improve. This conflicting trend was observed for every physical science concept being taught, with application of terms in the field and lab ranking higher than identification of terms in the classroom.

Reliance on background knowledge to aid in learning showed consistent improvement from all nine students. While students did not always write about experiences from our trip, there were many class discussions where students brought up memories and examples from our field studies without prompting. Students also used experiences from their lives more regularly in lab conclusions and in our metaphor activities, showing a greater reliance on these experiences. The most commonly cited examples connected to soccer, a common past time for many of the students. Students also brought in experiences from cooking, skateboarding, and driving during in-class discussions and informal assessments. By the teacher intentionally drawing on past experiences during instruction, the students were then able to learn a valuable skill that is transferable to future classes as well.

Student confidence in learning science and in their understanding of the key terms did increase, which was a secondary goal of the study. Few students in this general science class had been previously enrolled in a science class in middle school or high school, and, therefore had lower confidence in their abilities to exhibit scientific knowledge. Through the combination of shared experiences and teaching, these students now rank themselves higher in confidence of the science terms and in their confidence and comfort in the outdoors. Because of the increased confidence and time spent out of the classroom learning, many of the students have a greater enjoyment of science. This increased appreciation for science has led to greater engagement in learning. This was noticeable in overall participation as well as in attendance. Although the class only had nine students, the first month averaged 1.4 absent students each period. By the end of the physics unit, absentee rates had dropped to .33 absent per period.

One major limitation to this study was the issue of language. With seven students being Non English Proficient and two being Limited English Proficient, it was very difficult to assess the students' knowledge. I did allow some work to be completed in Spanish with hopes of the students being able to relay more of their knowledge in their native language, but not being fluent in Spanish myself greatly hindered my ability to derive meaning from their responses. I did rely heavily on our ELL resource teacher at the beginning of the unit, but due to scheduling conflicts, she was no longer available regularly to translate or otherwise assist the class towards the end. Another major conflict with using Spanish as the language of assessment was that a number of the students were not proficient enough in their grammar and spelling of words for me to interpret with only the use of online translator tools and Spanish to English dictionaries.

VALUE

Finding and using student background knowledge has always been a primary focus for me while teaching. What this study has shown me is that there is also a pressing need to help create background experiences for my students, especially my struggling English language learners. Few of my lower-level students have outdoor experiences or knowledge, especially experiences and knowledge that are local to our area. I feel that it is very important that kids grow up knowing about where they live and having the confidence and comfort to enter the forests around them and recreate around their local rivers with an understanding of how these systems are working and their role and value to humans. These experiences should not only help them in their immediate learning, but can also provide a base upon which to build future knowledge. I would be interested to see how often the students rely on some of the experiences, such as climbing a mountain or collecting river insects, throughout the next few years of education. What has also proven essential is seeking out what experiences the students already have and building upon those experiences in their learning. With our extensive Latino population, especially in our more remedial classes, there are many experiences the students come to school with that may not align with traditional curriculum used or experiences I used to rely upon as examples when teaching. Surveying the students about experiences and keeping an on-going list of these experiences was a new strategy that I will continue to use as it is enlightening and educationally relevant. One specific example is playing marbles. This is an experience that all nine students in my general science class had growing up, and they are all quite good at it. So many of the physics concepts we learned about could be taught through the use of marbles. This did not follow the curriculum I had previously created, but it did provide an experience for all students, which then allowed us to deepen our knowledge of force and velocity.

One learning product of the MSSE program that I have become dependent on is the use of a variety of formative assessments. Although formative assessments were not an entirely new concept to me prior to starting my studies in the MSSE program, I had not used them in a way that accessed for their full value. I have now learned to include some mode of formative assessment daily in my classes. By regularly using formative assessments, I feel that I am better able to direct the knowledge of my students. Many of the formative assessments used in my classes turn in to ongoing dialogues in which the students deepen their understanding of more complex concepts and learn to connect multiple concepts. Another important use of formative assessments for me has been in evaluating the effectiveness of newly implemented teaching and learning strategies. During this study I was constantly assessing whether or not students were using background experiences to help them in their learning. These formative assessments ranged from quick written summaries of experiences to focused listings of experiences in specific units. By using a wide variety of these formative assessments, I have also been able to better identify misconceptions and learning blocks for my students. In using formative assessments as guides for not only learning, but also for the implementation of teaching and learning strategies, I feel that I now better reach all of my students and have a real-time understanding of their current knowledge level.

One of my passions is being outdoors. I try to bring many of my experiences from nature into the classroom, but it is hard to have students visualize and think about what they have never experienced. I now have a greater desire to get my students out of the classroom and into the field to learn science. What I also realized through this study is that many of my students are truly uncomfortable in outdoor settings. Through observations and interactions with the students, it became evident early on that their lack of positive experiences in nature have led to discomfort and a near distrust for being outside. This especially held true during our camping trip as many of the boys did not sleep because they were afraid of bears and coyotes, which were not a threat where we were. A new aim for me as an educator is to provide positive outdoor experiences for my students, especially among those who do not regularly spend time in nature.

I have grown much as an educator in the past three years of learning in the MSSE program. I feel greater confidence going into new and challenging teaching units because I have had the chance to develop essential strategies that provide for quality learning and quality teaching. A deeper awareness of student learning has also been developed, which I find most valuable. Knowing how well students understand the learning objectives during each instructional unit is essential to me now, and I now have a collection of tools that allows me to assess this knowledge. Combining these skills with an awareness of student background knowledge and experiences will allow me better teach the growing ability diversity in my classrooms and assure that quality instruction is provided for every student every day.

REFERENCES CITED

AAAS (2001). *Atlas of Science Literacy*. Washington, DC: American Association for the Advancement of Science & National Science Teachers Association.

AAAS (1993). *Benchmarks for Science Literacy*. New York, NY: American Association for the Advancement of Science.

AAAS (1989). *Science for All Americans*. Retrieved February 20, 2011 from http://www.project2061.org/publications/sfaa/online/sfaatoc.htm

Bybee, R., McCrae, B., & Laurie, R. (2009). PISA 2006: an assessment of scientific literacy. *Journal of Research in Science Teaching*. *46*(8). 865-883.

Cajas, F. (1999). Public understanding of science: using technology to enhance school science in everday life. *International Journal of Science Education*. *21*(7), 765-773.

Dobb, F. (2005). Inquiry-based instruction for English language learners: ten essential elements. *Integrating Inquiry Across the Curriculum*. 201-226.

Fathman, A.K., Crowther, D.T. (2006) *Science for English Language Learners: k-12 Classroom Strategies*. National Science Teachers Association.

Gonzalez, F. (1995). Teaching content areas to LEP students: 20 tips for teachers. *IDRA Newsletter*. Volume *22*, Number 2, 21 pages.

Hart, J.E. & Lee, O. (2003) Teacher professional development to improve the science and literacy achievement of English language learners. *Bilingual Research Journal*. *27*(3). 475-501.

Mayoh, K. & Knutton, S. (1997). Using out-of-school experience in science lessons: reality or rhetoric? *International Journal of Science Education*. *19*(7), 849-867.

Medina-Jerez, W., Clark, D.B., Medinal, A., Ramirez-Marin, F. (2007) Science for English language learners: rethinking our approach. *The Science Teacher*. *74*(3). 52-57.

Mintzes, J., Wandersee, & J. Novak, J. D. (1988). *Teaching Science for Understanding: A Human Constructionist View*. San Diego, CA: Academic Press.

NRC (1998). *Every Child a Scientist: Achieving Scientific Literacy for All.* Washington, DC: National Academy Press.

NRC (1996). *National Science Education Standards.* Washington DC: National Academy Press.

Roth, W.M., Boutonne, S., McRobbie, C., & Lucas, K. (1999). One class, many worlds. *International Journal of Science Education. 21*(1), 59-75.

Roth, W.M., & Lee, S. (2001). *Rethinking scientific literacy: From science education as a propaeduetic to participation in the community.* Paper presented at the Annual Meeting of the Educational Research Association.

Schmidt, P. (2005). *Culturally responsive instruction: Promoting literacy in secondary content areas.* Naperville, IL: Learning Point Associates.

Scott, B. (1995). Playtime is science expands in region four. *IDRA Newsletter*. *22*(2), 21 pages.

Spurlin, Q. & Blanco, G. (1998). *Que es la ciencia?What is science? A question for all students.* Paper presented at the Annual Meeting of the National Association for Bilingual Education.

Sutman, F.X. (1993). Teaching science effectively to limited English proficient students. ED357113 *ERIC/CUE Digest 87.*

Watson, S. (2004). Opening the science doorway: strategies and suggestions for incorporating English language learners in the science classroom. *The Science Teacher. 71:2,* 32-35.

Westervelt, M. (2007). Schoolyard inquiry for English language learners. *The Science Teacher. 74*(3), 47-51.

APPENDICES

APPENDIX A

GENERAL SCIENCE SURVEY AND INTERVIEW

General Science Survey and Interview:

Have you ever:

___ changed a car tire
___ been on a roller coaster
___ been in a car accident
___ been in an airplane
___ ridden in a boat
___ built an electronic device
___ ridden a skateboard
___ built a model car/boat/plane
___ built a box or object out of wood
___ flown a kite
___ shot a bow and arrow
___ ridden a multi-geared bicycle
___ swam at the beach
___ ridden a skateboard
___ played pool (billiards)
___ played an instrument
___ gone rollerblading
___ jumped on a trampoline
___ gone bowling
___ made and shot a model rocket

___ camped
___ gone fishing
___ gone skiing/snowboarding
___ hiked up a mountain
___ gone ice skating
___ gone rock climbing
___ been white water rafting

___ built a fire
___ baked cookies/brownies/cake

1. How often do you connect what you do in life to science, such as changing a tire, riding a bike, or cooking?

2. Do you think your parent or parents use science at work? Explain.

3. What examples or experiences are used in science class that you do not understand?

APPENDIX B

HIGH SCHOOL SCIENCE TEACHER SURVEY

For Teachers: to be performed as a form distributed through Google Forms.

1. What background knowledge do you feel your students are most lacking?

2. What life experiences do you feel are necessary to understand the content that you teach?

3. What references, or real-world connections, do you regularly make that students do not seem to understand?

4. If you could take your students on one field trip in order to increase background knowledge, where would that trip be and what would you like them to experience?

APPENDIX C

FOCUS GROUP INTERVIEW OF UPPER-LEVEL BIOLOGY STUDENTS

For Upper-level students (Jr/Sr Advanced Biology): performed in a focus group.

1. Describe some of your life experiences that have taught you about science.

2. What have you learned/observed about science by being outside in nature?

3. What have you learned/observed about science by visiting amusement parks?

4. What area(s) of science seemed hardest for you because of not having enough background knowledge?

5. How often do you connect what you do in life to science, such as changing a tire, riding a bike, or cooking?

APPENDIX D

GENERAL SCIENCE CONFIDENCE SURVEY

General Science Confidence Survey:

Behavioral Questions:

I like science:	**Totally agree**	**Somewhat agree**	**Not sure**	**Somewhat disagree**	**Totally disagree**
I am good at science:	**Totally agree**	**Somewhat agree**	**Not sure**	**Somewhat disagree**	**Totally disagree**
I am good at taking notes:	**Totally agree**	**Somewhat agree**	**Not sure**	**Somewhat disagree**	**Totally disagree**
I am good at performing laboratory experiments:	**Totally agree**	**Somewhat agree**	**Not sure**	**Somewhat disagree**	**Totally disagree**
I enjoy being outside:	**Totally agree**	**Somewhat agree**	**Not sure**	**Somewhat disagree**	**Totally disagree**
I experience science daily:	**Totally agree**	**Somewhat agree**	**Not sure**	**Somewhat disagree**	**Totally disagree**
I think about science often:	**Totally agree**	**Somewhat agree**	**Not sure**	**Somewhat disagree**	**Totally disagree**
I use past experiences to help me learn:	**Totally agree**	**Somewhat agree**	**Not sure**	**Somewhat disagree**	**Totally disagree**
When I think of nature, I think of science:	**Totally agree**	**Somewhat agree**	**Not sure**	**Somewhat disagree**	**Totally disagree**
I like performing lab experiments:	**Totally agree**	**Somewhat agree**	**Not sure**	**Somewhat disagree**	**Totally disagree**

Content Questions:

I can calculate speed or velocity:	**Easily**	**Sometimes**	**Never**
I can calculate slope:	**Easily**	**Sometimes**	**Never**
I can identify forces:	**Easily**	**Sometimes**	**Never**
I can identify different forms of energy:	**Easily**	**Sometimes**	**Never`**
I can show how energy transfers:	**Easily**	**Sometimes**	**Never**
I can name common acids and bases:	**Easily**	**Sometimes**	**Never**
I can balance chemical reactions:	**Easily**	**Sometimes**	**Never**
I can use a periodic table to describe elements:	**Easily**	**Sometimes**	**Never**
I can identify rocks around where I live:	**Easily**	**Sometimes**	**Never**
I can name common minerals in my region:	**Easily**	**Sometimes**	**Never**

APPENDIX E

UNIT 1 FORMATIVE ASSESSMENTS

How Does Your River Flow Vocab: **Name:** _______________

Word Bank:

fast	time	rise	push	gravity	slow
elevation	shallow	gradual	angle	run	incline
distance	pace	acceleration	Newton's 1st Law	rate	weight
Newton's 3rd Law	Newton's 2nd Law	steep grade		pressure	pull

	Word Association	Example
Speed/ Velocity:		
Slope/ Gradient:		
Force:		
Erosion:		
Work:		
Energy:		

How Does Your River Flow Vocab Set 2: **Name:** _______________

Word Bank:

Downcutting	Distance	Gravity	Channel
Force	Removal	Motion	Weathering
Potential	Kinetic	Transfer	Sediment

Erosion:		
Work:		
Energy:		

Speed and Slope: **Name: ______________**

Speed:

1. A boat in the river floats 800m in 20 seconds. How fast is the boat floating?

Known:

Need to know:

Equation:

2. When measure the speed of the river, the ball floats 50m in 2.5 seconds. How fast is the river flowing?

Known:

Need to know:

Equation:

3. A stick floating down the river travels 12km in 0.5 hours. How fast is this river flowing?

Known:

Need to know:

Equation:

4. A boat travels for 3 hours on the river that is flowing 5 km/hr. How many kilometers does the boat travel?

Known:

Need to know:

Equation:

5. The river is flowing at 6 m/s. How many seconds will it take the ball to float 50 meters down the river?

Known:

Need to know:

Equation:

<u>Slope:</u>

6. The map shows that the river drops 500 ft of elevation in 10 miles. What is the slope of this river in ft/miles?

Known:

Need to know:

Equation:

7. The starting elevation of the river is 11,350 ft and it ends in another river at 8,800 ft. It travels 30 miles from start to end. What is the slope of this river in ft/miles?

Known:

Need to know:

Equation:

8. The Colorado River starts at an elevation of 12,000 ft and ends in the Gulf of Mexico. It travels 1,450 miles. What is the slope of this river?

Known:

Need to know:

Equation:

9. The Roaring Fork River has an average slope of 80 ft/mile. The elevation of the river in Carbondale is 6,200ft. What is the elevation of Basalt if Basalt is 13 miles from Carbondale?

Known:

Need to know:

Equation:

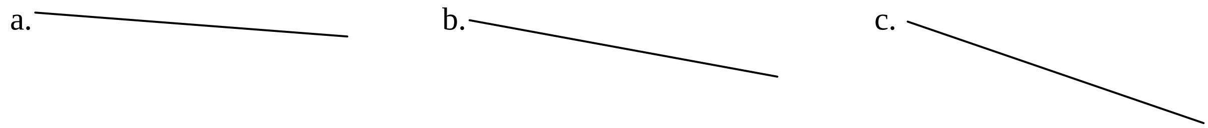
Stream Tables Part 2: **Name: _______________**

1. What is the relationship between energy and velocity? *Que es la relación entre la energía y la velocidad?*

2. Which stream table had the most energy? *Cual mesa rio tiene la mayoria de energia?*

3. Measure and calculate the slope of the three river models. *Media y calcula la inclinar o pendiente de las tres rios.*

How Does Your River Flow Unit Exam: **Name: ________________**



Which river has the steepest slope? *Cual rio es mas pronunciada?*

Which river will have the greatest energy? *Cual rio tiene mas energia?*

Which river will have the greatest velocity? *Cual rio tiene mas velocidad?*

Which river is most like a stream order 1? *Cual rio es primero orden?*

Which river is most like a stream order 4? *Cual rio es cuarto orden?*

As the slope of the river increases, what happens to its energy and velocity?
Como la pendiente de las subidas de río, lo que ocurre con su energía y velocidad?

True/False: Verdad o Falso

Write true if the statement is true. IF the statement is false, change the underlined term to make the statement true.

Energy is the ability to do work. *La energía es la capacidad de hacer el trabajo.*

Stored energy is kinetic energy. *La energía almacenada es la energía cinética.*

Potential energy is energy of motion. *La energía potencial es la energía del movimiento.*

Energy cannot be created or destroyed. *La energía no se crea ni se destruye.*

<u>Force Diagrams</u>

Draw the forces on the chair as it rests on the floor. *Dibujar las fuerzas en la silla.*

Draw the forces of a person pushing the box. *Dibujar las fuerzas de una persona que empuja la caja.*

Draw the forces acting on the car as it drives down the road. *Dibujar las fuerzas que actúan sobre el coche.*

<u>Vocabulary:</u> Match the words with the correct term.

Distance	Gravity	Rise	Newtons Laws	Time
Elevation	Potential	Run	Motion	Transfer
Force	Kinetic	Push	Pull	Removal
Gradient	Acceleration	Rate	Steep	Fast

Speed/Velocity:

Slope:

Force:

Erosion:

Work:

Energy:

APPENDIX F

METACOGNITIVE SELF-ASSESSMENT

Metacognitive Self-Assessment:

When I see a learning objective, I think of what experience I have that will help me understand this objective.	*Always*	*Sometimes*	*Never*
I try to connect what I am learning to what I already know.	*Always*	*Sometimes*	*Never*
My experiences regularly help me in class.	*Always*	*Sometimes*	*Never*
I learn best when I know something about the topic.	*Always*	*Sometimes*	*Never*
I use activities we did on our camping trip and river trips to help learn new ideas in class.	*Always*	*Sometimes*	*Never*

Give an example of an experience you had that helped you learn about river *physics / geology / chemistry*. (Select the appropriate choice for the unit we are learning.)

APPENDIX G

CAMPING TRIP REFLECTION

Camping Trip Reflection:

What was your favorite part of the trip? Why?
Que te gusta mas? Por que?

What was a new experience?
Que era nuevo?

What did you not enjoy? Why?
Que no le gusta? Por que?

Do you enjoy being outside doing science?
Te gusta aprender ciencias a fuera?

APPENDIX H

STUDENT POST UNIT REFLECTION

Post Unit Reflection: **Name: ________________**

Write the key learning objectives for the unit in the boxes on the left.
Provide an example that best describes this learning objective in the box on the right.

Objective:	Example/Experience:

Were you able to use examples and experiences from our trips to learn these objectives?

Yes *No*

Were you able to use examples and experiences from your life that do not include those from our trips to better learn these objectives?

Yes *No*

What experiences from our trips do you think are the best examples of what we learned in this unit?

What experience from your life do you think are the best examples of what we learned in this unit?