Students' Understanding of Weathering and Erosion

by

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ABSTRACT

Conceptual change has been a large part of science education research for several decades due to the fact that it allows teachers to think about what students' preconceptions are and how to change these to the correct scientific conceptions. To have students change their preconceptions teachers need to allow students to confront what they think they know in the presence of the phenomena. Students then collect and analyze evidence pertaining to the phenomena. The goal in the end is for students to reorganize their concepts and change or correct their preconceptions, so that they hold more accurate scientific conceptions.

The purpose of this study was to investigate how students' conceptions of the Earth's surface, specifically weathering and erosion, change using the conceptual change framework to guide the instructional decisions. The subjects of the study were a class of 25 seventh grade students. This class received a three-week unit on weathering and erosion that was structured using the conceptual change framework set by Posner, Strike, Hewson, and Gertzog (1982). This framework starts by looking at students' misconceptions, then uses scientific data that students collect to confront their misconceptions. The changes in students' conceptions were measured by a pre concept sketch and post concept sketch.

The results of this study showed that the conceptual change framework can modify students' preconceptions of weathering and erosion to correct scientific conceptions. There was statistical significant difference between students' pre concept sketches and post concept sketches scores. After examining the concept sketches, differences were found in how students’ concepts had changed from pre to post concept sketch. Further research needs to be done with conceptual change and the geosciences to see if conceptual change is an effective method to use to teach students about the geosciences.

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INTRODUCTION

Students observe the moon every night and they see that the size of the moon changes every couple of nights. They make inferences from their observations that the Earth's shadow is covering the moon and that is why the shape of the moon keeps changing. This is how many students build their conceptions of different scientific phenomena. Conceptions can be defined as students' schemas or ideas that are "one's beliefs, understandings, and explanations, in short, one's necessarily subjective knowledge of the world," (Suanders, 1992, p. 136). Many students take these misconceptions, hold on to them, and bring them into their classrooms. It is a science teacher's job to take these misconceptions and help students understand the accepted scientific understanding of the conceptions.

Based on their daily observations, students build schemas that persist as long as their experiences continue to show that these schemas are useful (Saunders, 1992). If students can make sense of phenomena by looking at what is around them they will believe these are correct ideas and hold onto these ideas until something comes along that doesn't fit. These ideas that students are building become their preconceptions of many natural phenomena. In science education many of these preconceptions can be partial conceptions or misconceptions that students will hold onto throughout their schooling years unless new knowledge changes those conceptions.

In science class, teachers see how these daily observations play into students' conceptions of different scientific concepts. As a result, science class needs to be a place where students have the opportunity to use data to form the correct scientific concepts.

Conceptual change is defined as "knowledge acquisition in specific domains and describes learning as a process that requires the significant reorganization of existing knowledge structures and not just their enrichment" (Vosniadou, Ioannides, Dimitrakopoulou, &Papademetriou, 2001, pg. 383). In science education, conceptual change looks at students' preconceptions and alters them through the use of scientific evidence. To have students change their preconceptions teachers need to allow students to confront what they think they know in the presence of the phenomena. In this model, students collect and analyze evidence pertaining to the phenomena. Students make an explanation that may question their existing idea. Students can then discuss different concepts and look at different models to develop more robust conceptions (Posner et al, 1982). The goal in the end is for students to reorganize their concepts and change or correct their conceptions, so that they hold more accurate scientific conception.

Research on conceptual change in Earth science has addressed many areas, most notably the phases of the moon (Stahly, Krockover, & Shepardson, 1999; Bell & Trundle, 2008; Trundle, Atwood, & Christopher, 2007), Earth's shape (Vosniadou, 1994; Vosniadou & Brewer, 1992), and seasons (Hsu, 2008; Tsai and Chang, 2005). Earth processes are one area of Earth science where there has not been a lot of research conducted in regards to conceptual change.

One of the preconceptions students have about Earth processes is that the Earth's surface has stayed the same over time (Gosselin & Macklem-Hurst, 2002). This misconception makes sense considering many students are unable to see the Earth's surface changing in their daily life. As a result, they build the schema that the Earth's surface has always been the same. Due to the lack of current research this study will focus on Earth's processes and students' conceptual change.

One type of assessment has been used to measure conceptual change are concept sketches. Concept sketches look at students' understandings of a concept through words and pictures (Johnson &Reynolds, 2005). Concept sketches are similar to concept maps in that they can reveal students' misconceptions and how their understandings of concepts may change over time (Ingec, 2009).

While there is little research about concept sketches, the research on concept maps provides insight into their utility. Markow and Lonning (1998) looked at how concept maps could increase students' understanding when they did a pre concept map and a post concept map during a lab experiment. In their study they found that students who constructed a pre concept map and a post concept map were better able to explain the important relationships of different concepts in the experiment. The value of this study is that it showed how students' concepts have changed over time through a concept map assessment. "When a teacher uses a post instruction/activity concept map, he can see the progress made by individual students in assimilating and accommodating new knowledge into their existing cognitive structures" (Markow & Lonning, 1998, p.

1016). While concept maps use only words concept sketches add the visual aspect that is especially important in Earth science.

Problem Statement

The research question guiding this study is: Does instruction, which is conducted with in a conceptual change framework, improve students' understanding of weathering and erosion? If so, how? Students' understanding will be measured through concept sketches.

Purpose

In this study I will investigate how students conceptions of the Earth's surface change, specifically weathering and erosion, using the conceptual change framework to guide my instructional decisions. Students' misconceptions will be addressed by first looking at why weathering and erosion happen, in what places does erosion occur in the natural environment, what are some of the agents that cause erosion, and what are the results of erosion and weathering that we can see around us. Following these investigations students will reinterpret the new information into what they already know about weathering and erosion. The purpose of this study is to see if using the conceptual change framework will improve students' understandings of weathering and erosion.

Rationale

Many science teachers teach students to memorize information, which is inefficient in developing a deep conceptual understanding. Frequently, students don't retain what they are taught in school, because the knowledge is not situated within their conceptual schema. In the end, if students are asked about these concepts, they revert back to their preconceptions, which are their own naïve ideas about the phenomena. When students revert to their own ideas, it demonstrates that students didn't fully understand the scientific concept or more rightly, that the new evidence was not deemed compelling enough to discard a concept that has proved useful for a long time. One of the ways teachers can help modify students' conceptions is through the conceptual change model.

Conceptual change research has been at the forefront of science education research for several decades. It specifically explores how students modify their misconceptions into the correct scientific concepts. The potential of this work resides in the model it provides teachers to enhance their instruction, which can impact student learning

In this thesis, the topic of weathering and erosion had been chosen due to the fact that students have the misconception that the Earth's surface never changes. They have a schema that the way the Earth's surface looks is how it has always looked and how it will always look. According to the *National Science Education Standards* (National Research Council, 1996), students should know "land forms are the result of a combination of constructive and destructive forces... destructive forces include weathering and erosion." (p. 160). Also according to the Earth Science Literacy Initiative (2009) students should know that the Earth is continuously changing, "weathered and unstable rock materials erode from some parts of Earth's surface and deposited in others." Not only are these big ideas that students should understand but they are also stated that students need to know them according to the standards.

Concept sketches are being used as an assessment recently due to the fact that they add the visual part that is missing from concept maps. Concept sketches are a sketch of students' understanding of a concept through pictures and words (Johnson & Reynolds, 2005). According to Reynolds, Johnson, Piburn, Leedy, Coya, and Busch (2005), "geology is a visual science" and "most geologic events occur over such long time scales that they cannot be witnessed within a single lifetime." Since geology is a difficult idea for students to see, concept sketches help students take big abstract ideas that are difficult to see and put them into pictures and words. Concept sketches will also allow students to stay active in their learning and to think about what would be the important big ideas that need to be included in their picture.

Chapter 2

LITERATURE REVIEW

Conceptual Change

Conceptual change starts with the idea that students construct their own concepts from what they see around them. According to Piaget, learning is provoked by students' thinking about situations and the patterns of constancy among them (Piaget, 1964), meaning that when students experience a situation such as the sun rising and setting, they create the conception that the sun revolves around the Earth. This is an example of why students have misconceptions—an egocentric worldview shapes the interpretation of the sun's apparent motion

Students learn as they explore and investigate different ideas especially in science. "Learners respond to their sensory experiences by building or constructing in their minds, schemas or cognitive structures which constitute the meaning and understanding of their world" (Saunders, 1992, p. 136). Students' experiences are necessary to generate a complete understanding of a phenomena, yet it is through these experiences that students build their preconceptions. The problem is, however, that unless students have constructed the correct conceptions, it is difficult to change them.

Ideally in science class students will be able to experience conceptual change allowing them to understand natural phenomena and the theories of science. One of the first frameworks for conceptual change was introduced by Posner, Strike, Hewson, and Gertzog (1982), who thought it was important for students to understand the concepts and learn them through a sense of inquiry, unlike other learning that is just “the acquisition of a set of correct responses, a verbal repertoire or a set of behaviors” (Posner et al., 1982, p. 212). They proposed this idea of conceptual change through a gradual process of taking in a new concept and adding it to their old concept through the process of assimilation. Eventually understanding the new concept and making their old concept a new concept would be considered accommodation. This process of conceptual change would happen as students encountered examples that did not fit their explanations. The more students encountered these “cognitive conflicts” the more they would begin to change their conceptual ideas.

Another researcher for conceptual change that has been seen throughout the research is Stella Vosniadou (1994). She saw students’ ideas as embedded in a bigger, personal theory, which makes it difficult for students to change their ideas. From these theories students build mental models of situations. Vosniadou believes the way to change students is through engaging students in new experiences that allow them to discuss, defend, and analyze their conceptions. She refers to this as “metaconceptual awareness.” “Lack of metaconceptual awareness of this sort prevents children from understanding that their presuppositions and beliefs can be questioned and encourages the creation of misconception.” (Vosniadou, 1994, p. 67).

Some suggestions Vosniadou gives to create this metaconceptual awareness to restructure students’ concepts include allowing students to do hand-on activities that require them to collect data and make observations, have them verbally explain their explanations and defend their answers, and allow them to look at their models and manipulate them to help them revise their models.

For conceptual change to occur in the science classroom it is important to introduce students to the scientific concept and allow them to add it to their preconceptions by discussing their ideas, verbalizing what they understand and explaining their reasoning. Students will be able to develop concepts and ideas that they can then make into their own understandings of the correct scientific concept.

The success of the many frameworks of conceptual change is unclear because research is mixed. Most of the research shows that students' ideas have been changed when using the conceptual change framework in the classroom. Research on longitudinal studies of conceptual change showed that some concepts changed for a short period, but that students reverted back to their old ideas over time.

Tsai and Chang (2005) used the framework of cognitive conflict in the form of a "conflict map" in their conceptual change study. They were looking to see if the conceptual conflicts approach would help students reconcile between their alternative conceptions and the true scientific conception. They specifically looked at students' alternative conceptions on seasons. In the conflict map group the instructor would start out by asking students their ideas of a specific concept, like why do we have seasons. Then the instructor would challenge these ideas with an alternative concept and would allow students to work through these new alternative concepts to see how they fit into their preconceptions. In the traditional classroom there was more direct teaching and lecturing, not as much discussing and discovering what students' preconceptions were. They found that cognitive conflict could be an effective framework to change students' concepts and allow them to retain them over a long period of time.

In another study that focused on cognitive conflict, Eryilmaz (2002) looked at students' misconceptions about force and motion. In this study they had two different treatments. One study looked at conceptual assignments, which are when "students perform or observe a phenomenon and explain it" (p. 1006). The other treatment looked at conceptual discussions; where students would be given a conceptual question and then the students would have to respond and discuss using their own conceptions or hypotheses. Instructors were instructed to encourage students to interact and debate their different conceptions or hypotheses. Eryilmaz found that students assigned to the conceptual discussions improved their ideas more than those that had the conceptual assignments. Results support that the more students can discuss their ideas and see the gaps in their understanding of the concept, the greater the likelihood that they will be able to develop the correct scientific conceptions.

Another successful study done by Bell and Trundle (2008), looked at pre-service teachers and their concepts on the moon phases. To help change teachers' preconceptions they used computer simulation. The computer simulation was effective in changing the teachers' conceptions due to the fact that the program allowed teachers to compare their conceptions to the scientific conceptions that were shown during the simulation.

In a longitudinal study done with pre-service teachers and their concepts of moon phases (Trundle, Atwood, & Christopher, 2007), pre-service teachers did not retain the correct conceptions of the moon phases. In this study the pre-service teachers drew the moon phases each night for nine weeks and then would discuss what they observed in small groups. Unlike the other studies this looked at the effect of the conceptual change over a long period of time. They found that a majority of the pre-service teachers held the correct scientific conception six months after instruction, but there were some that had reverted back to their old conceptions. This is an example of how some students can hold on to their preconceptions even after instruction. Students hold on to their preconceptions even after instruction due to the fact that they have deeply embedded schemas that the lessons were unable to change.

Conceptual change is still a growing field as new frameworks are being researched. The important piece is finding ways to take students preconceptions and help them change to and retain the accepted scientific conceptions. "We need to study more deeply the views held by children, to learn the purposes they serve, to learn their innate structures, and to learn how they are formed and used" (Watson & Konicek, 1990, p. 685). Research shows the more teachers are able to understand what students' preconceptions are, the more they will be able to set up lesson plans that consist of ways to change students' preconceptions to the correct scientific conception. To do this, science teachers need to focus on incorporating students' preconceptions into their instruction and allow students to struggle to reinterpret the correct scientific conception into their new conceptions. Teachers can help modify students' conceptions by allowing them to discuss, defend, and explain their conceptions and collect data to help support or reject their conceptions.

Geosciences Education

One of the more neglected fields in science education research is Earth science. According to the Earth Science Literacy Initiative (2009) it is important for people to be able to understand the science behind geosciences for several different reasons. Due to the ever-growing Internet, there is a lot of information about geosciences that is available to the public. As citizens we need to be able to understand this information and how it can affect our lives. We also need to be able to distinguish between accurate information and misinformation. As we go into the new century we need to understand the future implications of our actions and the effects we can leave on our Earth. As a society we need to understand how we are causing problems. The more we can educate the general population on the big scientific ideas behind geosciences the more they can understand their part in taking care of the Earth.

Educating society starts with our students. Middle school science students begin to look at many of the big ideas associated with geosciences including the interactions of the geosphere, hydrosphere, atmosphere, and biosphere (National Research Council [*NRC*], 1996). Geosciences are important for students to be learning in their science education courses, not only because it helps them understand the world around them, but because it also integrates many of the other sciences including physics, chemistry, and biology. These students will grow to become functioning citizens of society that will have to make decisions about their actions that may affect our Earth. As the Earth Science Literacy Initiative pointed out “America has one of the most advanced and educated scientific communities in the world but one of the most scientifically ignorant populations”(Earth Science Literacy Initiative, 2009, Background and Motivation para. 10). The more we expose students to these big ideas in Earth science the more they can become educated and understand the importance of geosciences in their daily lives.

Students can also build many skills like visualization and spatial reasoning through studying geosciences. They learn how to make observations of the world around them. If we can develop our students’ understanding of these big ideas of geosciences it will benefit not only their future but also the Earth’s future. The purpose of this study is to look at the ideas of weathering and erosion and help students see the importance of this topic and how this can affect their everyday lives.

Visualization in Geology

Geology is one of the more difficult sciences for students to understand because a lot of the ideas in geology are on a larger scale and it is difficult for students to literally see them to understand them conceptually. Along with students struggling to see geology they also struggle to grasp the idea of how long many of the geologic processes take place. Students struggle with geology due to the fact that it is a visual science (Reynolds, Johnson, Piburn, Leedy, Coyan, Busch, 2005). One of the many misconceptions students have in geology is that they don't consider that Earth is constantly changing. This is due to the fact that many students look at the Earth and believe it has always looked the way it looks now. Students can't see it is changing, so it is difficult for them to grasp that idea. Because of this many of the teaching methods used in geology are based on helping students' visualization and spatial reasoning.

Reynolds, Johnson, Piburn, Leedy, Coyan and Busch (2005), used interactive animations to help students visualize the Earth's surface as it has changed overtime. One of the problems they had was helping students visualize 3D ideas. They taught students how to visualize using topographic maps and constructing 3D models from movies. The movies they created helped students to look at geological structures and allowed students to be able to manipulate and rotate the picture so they could get an understanding of the layers of the Earth's surface and subsurface. After students looked at the 3D images through the virtual world they were then able to go out into the field and apply what they had learned in the classroom in the real world. By looking at the images before they were able to visualize more of what the Earth's surface and subsurface looked like and why it looked that way. Overall, they were able to improve their abilities to visualize and use the topographic maps after they had been able to interact with the animations through the computer program.

In a similar study done by Piburn, Reynolds, Leedy, McAuliffe, Brik, and Johnson (2002), they looked at how to teach students visual spatial skills, like geologists have, so they can use them to visualize geological phenomena. To build these skills students need to be able to use topographic and geologic maps, visualize geology below the Earth's surface, be able to construct environments from the past, and understand how geology affects our every day life. To do this they had students construct their own geologic and topographic maps to practice their spatial visualization skills. As students built their models they then could change them to fit what they believed should happen. The researchers found that students can improve spatial ability skills, learning, and even performances in spatial visualization. If we are able to build students spatial visualization skills then students will be able to build models in geology that can help them to understand the correct scientific conceptions.

In a study done by Libarkin and Brick (2002), they looked at the overall research of models in geosciences and narrowed them down to three basic models: static, animations, and interactive models. All three models are used in geology courses and all of them have different benefits and drawbacks. Static images are pictures and diagrams, which have been used the most in geology classes. The problem with static images is that students need to know what they are looking at, so students need to be taught how to observe these static images correctly.

Animations are another model that is used in studying geology. Animations are three-dimensional pictures that give a bigger and different picture than static images. Once again students need to be taught how to look at these to learn from them. Finally interactive models and visualizations are the most helpful for students to build models in geology because they allow students to actively engage in the image. Students are able to manipulate the images directly and are able to understand complex processes better by actually being able to physically work with the models. These are the best of the three studied models for students because these models allow students to work with a larger range of data and build their spatial skills and visualization so they can actually see geologic phenomena.

As the research shows it is important for students to be able to build their visualization skill for them to have a deeper understanding of geological concepts. The best way for students to understand geological concepts is by using interactive models that students can manipulate to visually see how the model would work in a real life situation. This can help students with conceptual change as they look at their preconceptions and then modify them to form the correct conceptions as they manipulate the models.

Concept Sketches

To understand whether students have learned a scientific concept it is important to assess the students. Assessment is the best way teachers can measure students' understanding of what has been taught. Since geology is a visual science it helps to understand what students know by having them draw pictures of their understanding. Johnson and Reynolds (2005) set forth the basic principles of concept sketches that are defined as

> A simplified sketch illustrating the main aspects of a concept or system, annotated with concise but complete labels, that (1) identify the features, (2) depict the processes that are occurring, and (3) characterize the relationships between features and processes (86).

Through students' drawings the teacher can assess their understanding of the underlying concepts. Johnson and Reynolds (2005) found many benefits to using concept sketches in the classroom, which include students being actively engaged in the material, which allowed them to create a deeper meaning of the material and students being forced to use the correct scientific language.

Research shows that if students are able to construct their own diagrams from their learning they will create a stronger understanding of the concept. "Explanative illustrations support cognitive processes required for meaningful learning by helping the learner select, organize, and integrate the words and images into coherent mental model" (Edens and Potter, 2003, 139). In a study done by Gobert and Clement (1999), they looked at how student-generated drawings helped students' conceptual understanding of plate tectonics versus student-generated summaries. They found that students who generated diagrams were more successful on a posttest that measured students' conceptual understanding of the content they were taught.

Edens and Potter (2003) did a similar study, where they looked to see which strategy, students who copied a picture, illustrated their own picture, or wrote a summary after reading a text, would have a better conceptual understanding of the material they read. The findings show that students, who drew pictures, whether they were copied or generated by the student, showed a better conceptual understanding on the posttest. This study shows that students who illustrate their learning are better able to show their conceptual ideas than students who write about what they learned. When students are asked to summarize their learning they tend to explain some of the factual information that doesn't reveal whether they understand the information conceptually or not. "Drawing activities in which students utilize visual tools appear to have provided a way for students to elaborate on scientific concepts and visually encode them" (Edens & Potter, 2003, 142).

Research with conceptual change shows that students first need to identify what their concepts may be and then they need to analyze data to help change those conceptions (Posner et al., 1982). Along with being able to collect and analyze data students need to be able to discuss their ideas to process their understanding (Vosnaidou, 1994).

The purpose of this study is to see if students' ideas of the Earth science processes weathering and erosion will change through the use of a conceptual change framework. Through the lessons, students will be collecting data, manipulating models, and discussing their ideas on weathering and erosion to come up with the bigger conceptual understanding of this topic. The topic of weathering and erosion was chosen due to the limited amount of research in this area and the importance for students to understand geosciences (Earth Science Literacy Initiative, 2009). To see whether students' concepts of weathering and erosion have changed, students will create a concept sketch at the beginning of the instruction and at the end of the instruction. Since geology is a visual science (Reynolds et al., 2005) the concept sketch allows students to create a visual of their understanding of the processes of weathering and erosion.

Chapter 3

METHODS

Research Design

This study was an action research project that looked at how one class's concept of Earth's changing surface transformed from the pre assessment to the post assessment of a unit. The research was a quasi -experimental design because the group of students was not randomly assigned. They were chosen because they were already in a regular seventh grade science class. The research was conducted without a comparison group since the purpose of the experiment was to see whether students' understanding of weathering and erosion would improve using the conceptual change framework. No comparison group was needed because all the necessary data was provided with one group through their pre and post assessments.

To see if conceptual change occurred in the class, the instructor measured students' change in understanding by having them create a pre and post concept sketch. A concept sketch looks at students' understanding of a concept through pictures and words (Johnson & Reynolds, 2005). The prompt for the concept sketch was designed to see what students know about Earth's changing surface. The prompt for this study was "What are flowing water, wind, and ice doing to the Earth's surface?"

The instructor used the conceptual change framework set by Posner et al (1982). This framework starts by looking at students' misconceptions, then uses scientific data, that students collect, to confront their misconceptions. In this process, students modify their old conceptions by inputting the new information they had gained. To accomplish this in this study, the instructor started by having students discuss and define their initial conceptions, and then students participated in hands-on activities that allowed them to see how their conceptions aligned with or helped them to discover new conceptions. Finally the students discussed their new conceptions.

There were three lessons on Earth's changing surface that took place over a three-week period (see Appendix A). At the end of the three lessons the student then made a post concept sketch using the same prompt that was used before. The pre and post concept sketches were evaluated using the same rubric each time.

Subjects and Setting

The 25 subjects of this study were from a classroom in a K-8 school in Avondale, Arizona. The participants consist of 10 males and 15 females ranging in age from 12 to 14. The students were in a general seventh grade science classroom in a Title I school. The school is located in a low socioeconomic area with 81% of students on free and reduced lunch. The school consists of students classified as 53.85% Hispanic, 21.67% Caucasian, 15.82% African American, 5.63% Asian, 1.08% Hawaiian/Islander, and 1.95% American Indian. Students had science five times a week for 80 minutes each day. The curriculum closely followed the Arizona State Standards for science in the seventh grade. Table 1 contains the demographic information for the class.

Table 1

Demographics Participants

n	Males	Females	White	Hispanic	Black	Asian/ Pacific Islander
25	10	15	5	15	4	1

Unit of Instruction

The unit was created for one-seventh-grade general science class to increase in their understanding of the concepts of weathering and erosion. Through the framework, students were posed questions to get them to think about what they already knew about the topics in the lessons that were taught. Students then were introduced to hands-on activities that allowed them to explore their understanding and help them to reinterpret their understandings of weathering and erosion. Finally, students put together their ideas to portray their conceptual understanding of weathering and erosion.

The unit was created specifically to address the *National Education Science Standards* (NRC, 1996), and Arizona State Standards that state respectively:

> Content Standard D: Structure of Earth System: Landforms 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 (160).
>
> Strand 6: Earth and Space Science, Concept 1: Structure of the Earth Describe the composition and interactions between the structure of the Earth and its atmosphere. PO 3. Explain the following processes involved in the formation of the Earth's structure: • erosion (7).

The lesson plans were self-created and revised based on feedback from a Professor in science education (also the graduate advisor) and an Associate Professor of geology at Arizona State University. In developing lessons I drew on resources from the FOSS kit landforms (Lawerence Hall of Science, 1993) curriculum, Focus on Earth Science (Charles E. Merrill, 1984) curriculum, and from the Associate Professor of geology at Arizona State University. This helped to establish content validity of the unit because it was examined by experts and aligned with the standards.

There were three lessons that focused on: 1) why weathering and erosion happen, 2) in what places does erosion occur in the natural environment and what are some of the agents that cause erosion, and 3) what are the results of erosion and weathering that we can see around us. The lessons were set up using the idea of White and Gunstone's (1992), predict, observe, and explain (POE) strategy. The purpose of POE is for students to take knowledge they may already have and apply it. In the case of this study, since we were looking at conceptual change, the use of the POE method helped the instructor look at what the students already knew through the prediction part of the lesson. Through the observe part of the lesson the instructor set up hands-on activities that allowed students to observe what happened to fit their previous conceptions with their new conceptions. The explain part allowed students to explain their new conceptual understanding. Table 2 is an explanation of all three lessons.

Table 2

Weathering and Erosion Lessons Layout

	Focus Question	Predict	Observe	Explain
Lesson 1	Why does weathering and erosion happen?	Can rocks be broken and how?	Students make observations of a fresh rock versus and a rotten rock. Students do an experiment to test different methods of breaking down the rocks.	Students explain through small group and a class discussions why rocks weather and break?
Lesson 2	In what places does erosion occur in the natural environment, and what are some of the agents that cause erosion?	How does weathering and erosion occur?	Students did three different experiments to observe erosion caused by water, wind, and ice.	Students explain through small group and a class discussions places erosion occurs and what some agents of weathering and erosion are.
Lesson 3	What are the results of weathering and erosion?	What are the results of weathering and erosion?	Students made observations from their experiments they did throughout the lessons to collect information on what weathering and erosion give us. Students also observed several examples of weathering and erosion through pictures.	Students explain through small group and class discussions what the results of weathering and erosion are.

To illustrate how the lessons were taught, I will provide an overview of the lessons. In the first lesson the focus question was why does weathering and erosion happen. To find students previous understanding of weathering and erosion the students were asked to predict "Can rocks be broken and how?" Students first wrote down their predictions, and then discussed their ideas in small groups. Students then discussed their predictions in a class discussion where they came to a consensus on whether rocks can break and how.

In the observation of this lesson, students conducted a hands-on activity that allowed them to see how their conceptions did or did not fit. In the first lesson students made observations of a fresh rock, which is a rock that had been taken directly from underground, and a rotten rock, which is a rock that had weathered and eroded over time. Students discussed the difference between the rocks and tried to figure out why the two rocks were different. Students then observed different ways to break down rocks to understand how rocks break down on Earth's surface.

In the explain part students explained their new conceptual understanding of weathering and erosion by answering the focus question. In the case of lesson one, students answered the question why does weathering and erosion happen. They started by writing down the answer to the question on their own, then discussing in small groups and finally discussing as a class and coming to a class consensus.

The second and third lesson were set up in a similar manner, where students made a prediction by answering a question, then they conducted a hands-on activity to see how their initial conceptions did or did not fit, and finally students explained their new conceptual understanding of weathering and erosion by answering the focus question of the lesson.

Assessment Tool

Since this study focused on conceptual change and how students' ideas change from the beginning to the end of the lessons, the students produced a pre and post concept sketch to evaluate their knowledge on the subject of weathering and erosion. To introduce the students to concept sketches, the instructor first demonstrated a concept sketch on a previous topic the class had studied earlier in the school year. After the instructor's concept sketch, the students then did a practice concept sketch on their own using the same topic the instructor had used. The instructor monitored the students while they completed the practice concept sketch to encourage them to use more details. This was done to model to students what the instructor expected them to do on their concept sketch for this study.

A concept sketch is "a simplified sketch illustrating the main aspects of a concept or system, annotated with concise but complete labels" (Johnson & Reynolds, 2005, 85-86). Since geology is a visual science, concept sketches add the visual part of students understanding. Johnson and Reynolds (2005) said one of the advantages of concept sketches is students are actively engaged- that is, they have to interact with the material in a meaningful way to create a sketch" (87). The more students are able to visually show through their sketches, the more the instructor can understand their conceptions.

The concept sketches were evaluated using a general rubric that was created by Johnson and Reynolds (2005). The general rubric allowed for a holistic evaluation of the students' understanding of weathering and erosion. To adapt this rubric to this study, the phrase "weathering and erosion" was added to the rubric to specify the concepts that were to be focused on during the evaluation of the concept sketches. Table 3 is the rubric that was used during this study.

Table 3

Rubric for Conceptual Sketches of Weathering and Erosion

	10, 9, or 8 points	7, 6, 5, or 4 points	3, 2, 1 or 0 points
Content	Essential concepts of weathering and erosion are shown; important relationships correctly portrayed; no conceptual evidence of misunderstanding of weathering and erosion.	Most concepts and relationships of weathering and erosion shown correctly; some aspects left out; minor conceptual errors or misunderstandings of weathering and erosion.	Essential concepts left out; relationships not correctly portrayed; major conceptual errors or misunderstandings.
	2 points	1 point	0 points
Detail and Presentation	Sketch detailed and clearly drawn and labeled.	Sketch lacks some detail or not clearly drawn or labeled.	Sketch lacks details or is illegible; difficult to interpret.

Data Collection

The students were given the prompt "What are flowing water, wind, and ice doing to the Earth's surface?" Students were then instructed to draw pictures and use words to demonstrate their understanding of the prompt. Students were given as much time as they needed to complete their concept sketches, prior to the unit of instruction being taught and after the unit of instruction was taught.

Data Analysis

The concept sketches were evaluated using a rubric that can be seen in Table 3 above. To establish reliability the same person using the same rubric evaluated both sets of concept sketches.

The rubric had two rows: the content and the detail/presentation. In the content category the evaluator looked for whether students showed the essential concepts of weathering and erosion, whether they showed the relationships correctly, and had no misunderstanding of weathering and erosion. Within the category of content, variations were described that ranged from essential concepts left out and conceptual misunderstandings to essential concepts shown and no conceptual misunderstanding. Students earned zero to three points if they left out essential concepts and showed major misunderstandings of weathering and erosion. They earned four to seven points if they showed most of the concepts and relationships and had some errors of misunderstandings of weathering and erosion. In the last column they earned eight to ten points if they showed the essential concepts and no conceptual misunderstanding of weathering and erosion.

The total number of points students could receive on the content category was ten points.

In the detail/presentation category students were evaluated on the detail and how clearly they drew and labeled their pictures. Within the category of detail/presentation variations ranged from the sketch had lack of detail and was difficult to interpret to the sketch was detailed, clearly drawn and labeled. Students earned zero points if the sketch lacked detail, were illegible and difficult to interpret. They earned one point if the sketch lacked some detail, and was not clearly drawn or labeled. In the last column they earned two points if the sketch was detailed and clearly drawn and labeled. The total number of points students could receive on the detail/presentation category was two points. The total points students could receive on their concept sketch were 12 points.

To illustrate how the rubric was used to analyze the concept sketches, I will give an example of how one of the concept sketches was evaluated. The following example is a post concept sketch that received a 7 out of 12 points (See Figure 6 for picture of the concept sketch). The concept sketch received a 6 for content because the student was able to show how weathering and erosion were shaping the Earth. Specifically, most of the concepts and relationships were shown correctly, but some aspects were left out and there were some minor conceptual errors. In the example, the student showed that over time water could change the shape of the rock, but the student did not explain how the water was causing the land to change. The student also had a minor conceptual error of how gravity erosion changes the Earth's surface when he explained, "these rocks have been here so long that is just gave out." The absence of a complete example and the minor conceptual understanding resulted in a score of 6 instead of 7. The student earned a 6 instead of a 4 because he was able to show several examples of how water, wind, and ice can change the surface. For the detail and presentation he received a 1. If the student had more detail of how the wind, water, and ice could change the Earth's surface he would have received a 2.

To determine whether the conceptual change framework changed students' conceptions of the Earth's surface both quantitative and qualitative data was analyzed. The quantitative data was taken from students' scores on their pre and post concept sketches. A *t-test* was used to see if there was any significant difference between pre and post scores. The pre and post scores were broken further down to determine if there was any significant difference between students' pre and the post scores for the two different categories: content and the detail/ presentation. A *t-test* was also used to analyze whether there was any significant difference between males and females pre and post concept sketch scores.

Qualitative data was analyzed to determine how students' conceptions changed throughout the unit of instruction. Students' concept sketches were carefully examined to find specific examples of what students drew and said to explain their concepts prior to instruction and after the unit had been taught. Concept sketches were examined by looking at all of the pre concept sketches to find what common concepts were drawn and described or what concepts were not discussed at all. Then the post concept sketches were examined to see what common concepts were drawn and described after the unit of instruction. The common concepts that were found in the pre concept sketches were compared to the common concepts that were found in the post concept sketches to see how the students' ideas of weathering and erosion had changed. The examiner looked specifically at what concepts the students described in the post concept sketches that hadn't been described in the pre concept sketches and also looked at the concepts that had been modified to the correct conceptions from pre to post concept sketch.

Chapter 4

RESULTS

Overview

The instruction was presented to one class of 25 students to see whether the conceptual change framework improved students' understanding of weathering and erosion. Students completed a pre and post concept sketch to see whether their understanding improved. The pre and post concept sketches were analyzed using a general rubric that was adapted from Johnson and Reynolds (2005). Several *t-tests* were performed to see if there was any significant difference in students' concept sketch scores before the instruction and after the last instructional unit. Table 4 shows a summary of the data that was collected throughout the study. The concept sketchers were then analyzed to find specific examples of what students described in their concept sketches to probe how their concepts changed.

Table 4

Summary of Data Collected

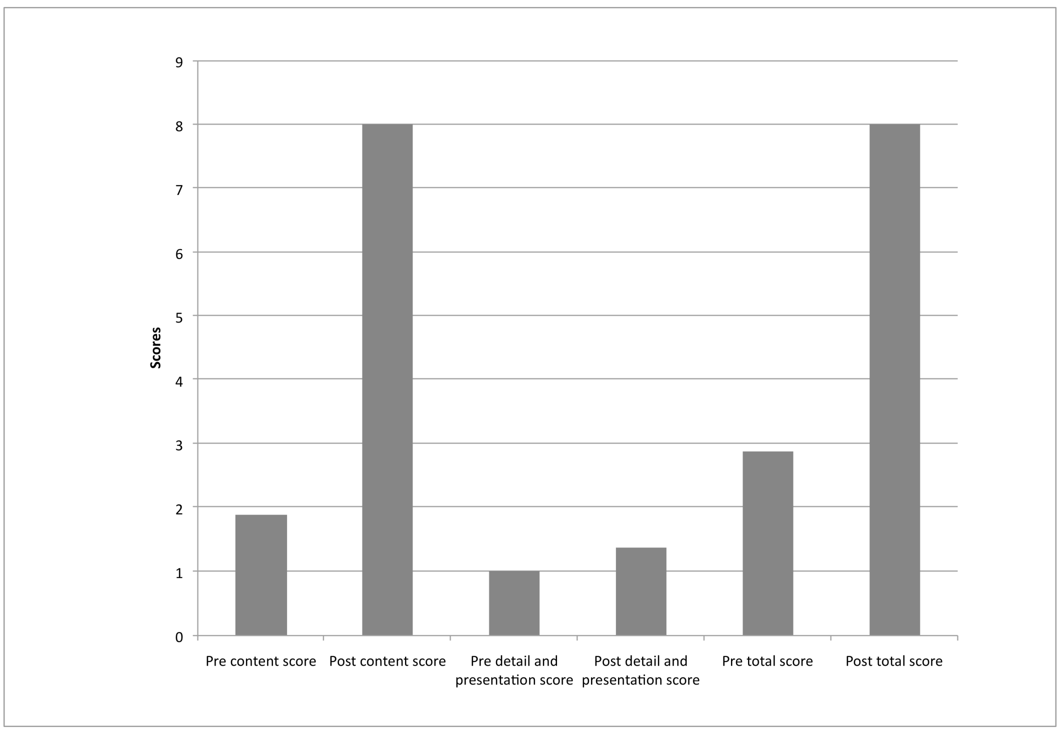
	Pre Concept Sketch Average	Standard Deviation	Post Concept Sketch Average	Standard Deviation
Total	2.9	2.5	8.0	2.1
Content	1.9	1.9	6.6	1.8
Detail and Presentation	1.0	0.7	1.4	0.5
Female	2.8	2.6	6.9	2.1
Male	3.0	2.5	7.6	2.1

Total Concept Sketch Scores

Average scores were found for students' pre concept sketches and post concept sketches. Pre concept sketches had an average of 2.9 points out of 12 while the post concept sketches had and average of 8 out of 12 points. Figure 1 shows a graphical representation of average scores from pre to post concept sketch and the break down of each category.

Figure 1

Average Scores for Pre and Post Concept Sketches



The *t-test* was used to compare students' total scores for their pre concept sketch and their post concept sketch showed a significant difference ($p=0.00$). The results of the analysis can be found in Table 5.

Table 5

Average Total Scores for the Pre and Post Concept Sketches

	Average Scores	SD	Results of *t-test* *
Pre Concept sketch	2.9	2.5	p= 0.00
Post Concept sketch	8.0	2.1	

* Significant at the $p<0.05$ level

Concept Sketch Categories

Students' total score on their concept sketches were broken down into the two categories, content and detail/presentation, to see if there was any significant difference between these pre and post scores. The *t-test* for the content category showed there was a significant difference between students' pre and post concept sketches ($p=0.00$). Table 6 shows the results of the analysis

Table 6

Average Scores for the Content Category for the Pre and Post Concept Sketches

	Average Scores	SD	Results of *t-test* *
Pre Concept sketch	1.9	1.9	p= 0.00
Post Concept sketch	6.6	1.8	

* Significant at the $p<0.05$ level.

The analysis of the detail and presentation category was done with a *t-test* at the $p=0.05$ level. This analysis revealed a significant difference. The results of this analysis can be found in Table 7.

Table 7

Average Scores for the Detail and Presentation Category for Pre and Post Concept Sketches

	Average Scores	SD	Results of *t-test* *
Pre Concept sketch	1.0	0.8	p= 0.05
Post Concept sketch	1.4	0.5	

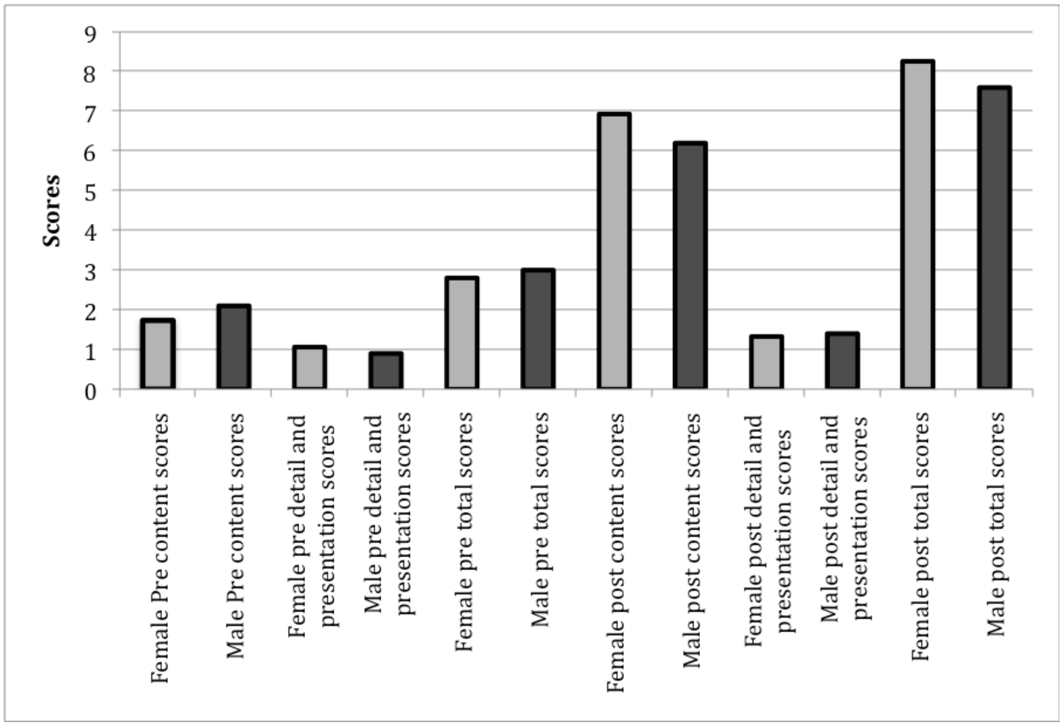
* Significant at the $p<0.05$ level.

Gender Concept Sketch Scores

To see if there was any difference between the genders' understanding of weathering and erosion, scores were broken down by female and male. Figure 2 shows the average scores for each category broken down by gender. The sample consisted of 15 females and 10 males. The average pre total score for female concept sketches was 2.8 points out of 12 points while the average pre total score for males was 3.0 points out of 12 points. After the unit was taught the females' post total score increased to 8.3 points and the males' post total scores increased to 7.6.

Figure 2

Average Scores for Pre and Post Concept Sketches by Gender



To see whether the female and male population was similar in the beginning of the unit a *t-test* was used to see if there was any significant difference between female and male total pre concept sketch scores. The analysis showed there was no significant difference (p=0.8), which means that the populations were similar before the unit of instruction. A *t-test* was then used to analyze if there was any significant difference between female and male total post concept sketch scores. The *t-test* results show that there was also no significant difference in the females and the males post scores (p=0.5) after the unit of instruction. The results of the analysis can be found in Table 8.

Table 8

Total Concept Sketch Scores for Males and Females

	N	Average Scores	SD	Results of *t-test*
Female pre concept sketch	15	2.8	2.6	p= 0.8
Male pre concept sketch	9	3.0	2.5	
Female post concept sketch	15	8.3	2.1	p= 0.5
Male post concept sketch	9	7.6	2.2	

Since there was no significant difference between male and female post total scores the data was broken down more to see whether there was a significant difference between each genders' pre and post concept sketch scores. A *t-test* was performed to see if there was any significant difference between females pre and post scores and males pre and post scores. There was a significant difference found for both females and males when their pre and post total concept sketch scores were compared. The results from the analysis can be found in Table 9 for females and Table 10 for males.

Table 9

Average Scores for Females for Pre and Post Concept Sketches

	Average Scores	SD	Results of *t-test* *
Pre Concept sketch	2.8	2.6	p= 0.00
Post Concept sketch	8.3	2.1	

*Significant at the p<0.05 level.

Table 10

Average Scores for Males for Pre and Post Concept Sketches

	Average Scores	SD	Results of *t-test* *
Pre Concept sketch	3.0	2.5	p= 0.00
Post Concept sketch	7.6	2.2	

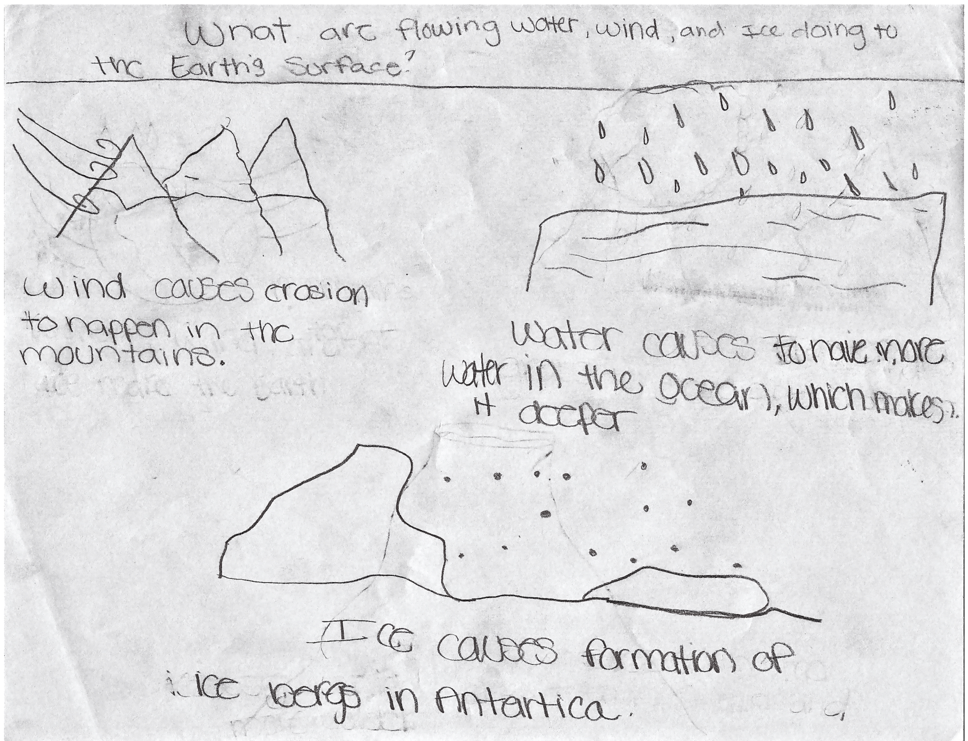
* Significant at the $p<0.05$ level.

Concept Sketch Analysis

The concept sketches revealed to the evaluator how the students' conceptions had changed from pre to post. Students' pre concept sketches had a limited understanding of weathering and erosion and most of them only showed concepts that the students could visibly see. For example after examining the pre concept sketches, it was seen that students had the most misconceptions about how ice changes the Earth's surface. Out of the 25 concept sketches, 19 of the sketches either showed how ice can cause the ground to freeze, cause snow or icebergs to form, or did not mention ice at all. These are all visible concepts that students would be able to see on the Earth's surface. Figure 3 shows a picture of a student's pre concept sketch that showed the common conceptions the students had before the unit of instruction began.

Figure 3

Student's Pre Concept Sketch. This pre concept sketch illustrates some of the common conceptions students had in their pre concept sketches.

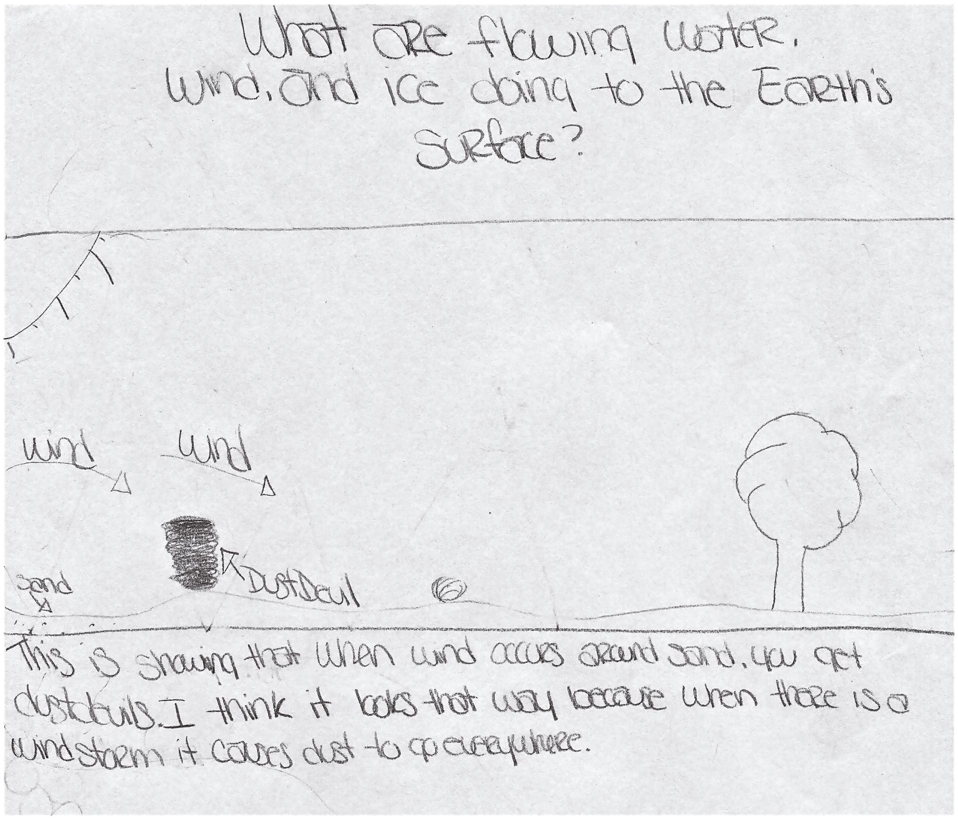


The next most common misconception was seen with how water can affect the Earth's surface. Thirteen of the twenty-five pre concept sketches discussed how water can cause the surface to be muddy, help the plants grow, add to the rivers, oceans, and lakes, or did not discuss how water affects the Earth's surface at all.

One of the more correct preconceptions, which were found on 60 percent of the students' pre concept sketches, was the idea that wind moves sediments, showing students had some conceptions of the affects of wind on Earth's surface. One student said, "When wind occurs around sand, you get dust devils. I think it looks that way because when there is a windstorm it causes dust to go everywhere." Figure 4 shows how the student drew and wrote about wind.

Figure 4

Student's Pre Concept Sketch on Wind. This figure illustrates one student's concept on how wind affects the Earth's surface.

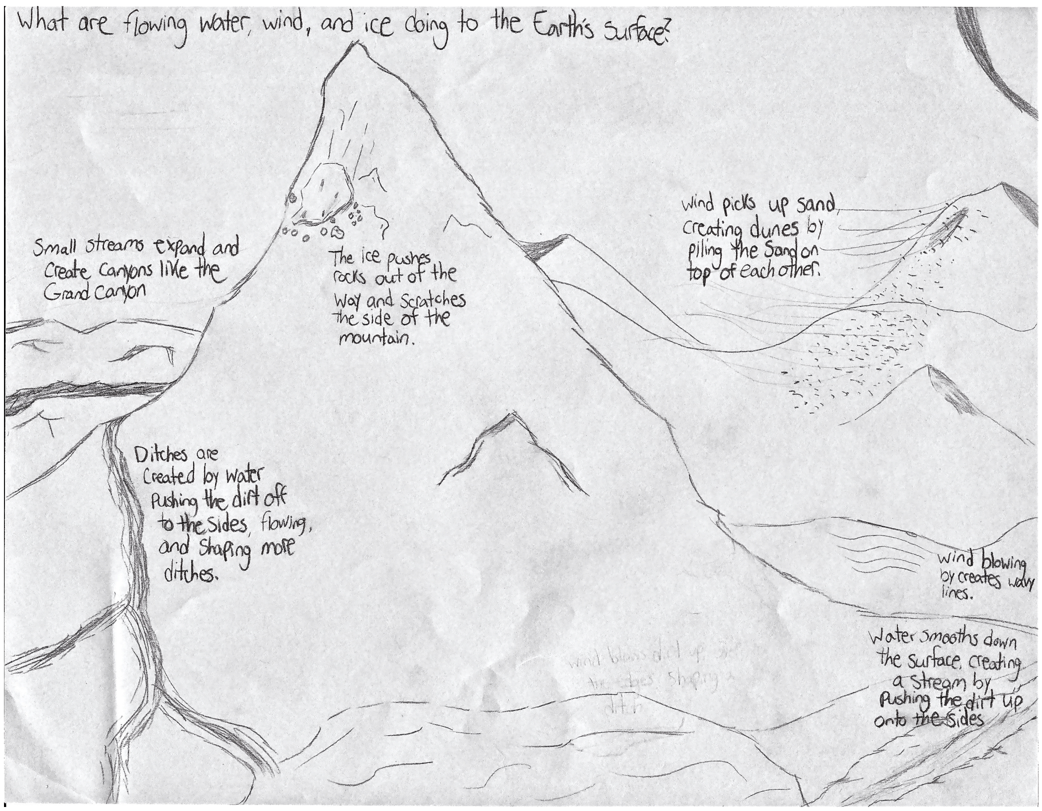


When the post concept sketches were examined it was seen that many students' conceptions of weathering and erosion were correctly modified. Of the 19 students who had major conceptual errors and misunderstandings on their pre concept sketch according to the rubric, seven of them increased to no conceptual errors and 11 of them increased to minor conceptual errors on their post concept sketches. Five of the students who had minor conceptual errors on their pre sketches increased to no conceptual errors.

The post concept sketches illustrated several concepts that students hadn't discussed or drawn in the pre concept sketches. The students' post concept sketches showed more of an understanding of non-visible phenomena than their pre concept sketches had shown. For example, one of the concepts that had only been discussed in two of the pre concept sketches was how ice shapes the Earth's surface. Sixty percent of the post concept sketches illustrated how glaciers or ice change the surface by carving streams, valleys, and changing the shape of mountains. Figure 5 shows an example of a student's post concept sketch that illustrates many of the correct conceptions of weathering and erosion.

Figure 5

Student's Post Concept Sketch. This figure is an example of a post concept sketch that shows many concepts that were not seen in pre concept sketches.

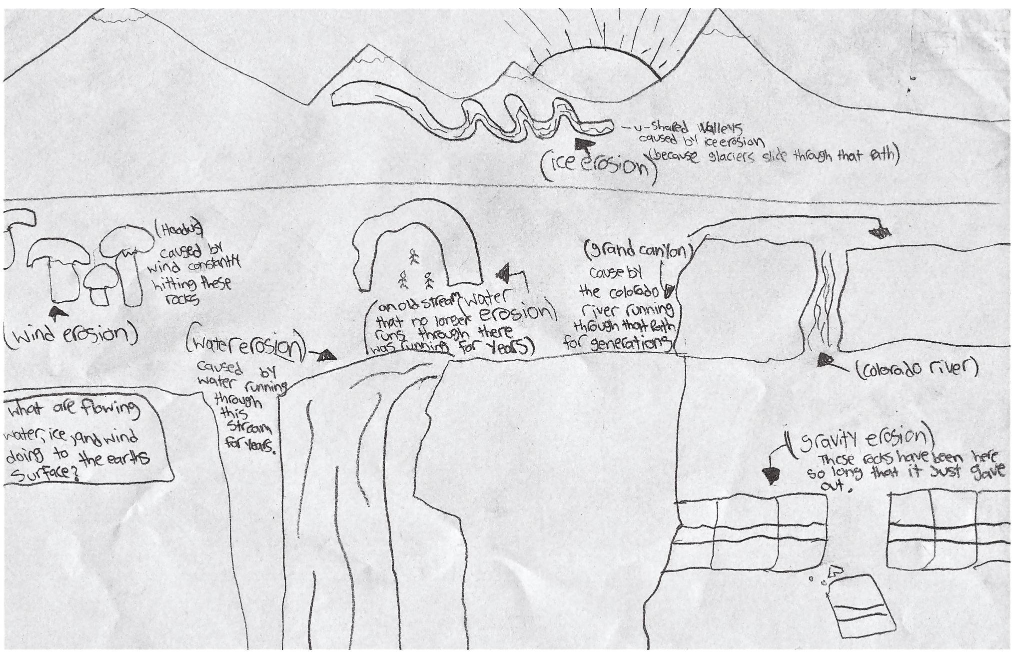


The most common conception that was discussed in all of the post concept sketches and was only seen in four of the pre concept sketches was how flowing water causes erosion. Most of the concept sketches showed how water forms streams that carve out the Earth's surface and some illustrated how different landforms like canyons can form from water erosion. Other post concept sketches showed how students understood that water could also move sediments.

Another conception that was seen in seven of the twenty-five post concept sketches was the idea that these processes happen over time. In pre concept sketches none of the students had referred to how these processes take time. For example in one of the post concept sketches one student drew a picture of a hole in a rock and described the picture by saying “an old stream that no longer runs through there was running for years.” That same student drew a picture of water falling over a ledge and said “caused by water running through this stream for years.” Figure 6 shows what this student drew and how they discussed weathering and erosion happening over time.

Figure 6

Student’s Post Concept Sketch on time. This figure illustrates one student’s idea of weathering and erosion changing the Earth’s surface over time.



By examining the pre concept sketches and post concept sketches the evaluator was able to see how students’ conceptions changed after the unit of instruction was taught. Most importantly it was apparent that students’ conceptions increased from their pre concept sketches to their post concept sketches and that they had new understandings of weathering and erosion.

Specifically, students had a better understanding of how ice and water changes the surface by carving streams, valleys, and changing the shape of mountains, and that these processes happen over long periods of time.

Chapter 5

DISCUSSION

For our society to become literate in science, teachers need to begin teaching students the correct conceptual concepts to help them to be able to communicate these ideas to others. As functioning citizens in society they need to be able to make informed decisions about their actions and how they affect the Earth. Students struggle to understand many science concepts at a conceptual level because they are being taught at a more factual level. Conceptual change research has been a large part of science education for many decades. This is due, in part, to the explanation of knowing that conceptual change provides to teachers a way to get at students misconceptions and help modify these misconceptions to the correct scientific conception. If teachers could use more of the conceptual change framework within their instruction they would be able to get away from teaching students just the facts and help them to understand science at a deeper conceptual level.

The purpose of this study was to see if using the conceptual change framework would improve students' understandings of weathering and erosion. Specifically the question that was examined in this study was: Does instruction, which is within a conceptual change framework, improve students' understanding of weathering and erosion? If so, how?

For the first part of the question, the analysis of the data showed the instruction within the conceptual change framework did improve students' understanding of weathering and erosion. These findings are supported by past studies that researched conceptual change frameworks and data that was collected by this study. As found in this study, students' pre and post total concept sketch scores were significant at the .05 level, as shown in Table 4. This means that students' understanding of the concepts of weathering and erosion did increase from before the unit of instruction to after they had received the instruction using the conceptual change framework. There are several reasons why students' conceptions increased after the unit of instruction was taught to the students.

Students' conceptions increased because through the conceptual change framework the students' initial preconceptions were challenged when they were shown alternative conceptions through experiments and discussions. If students are able to look at what their preconceptions are and then have these conceptions challenged they can work through their ideas to come to the correct conception. Tsai and Chang (2005) also had similar findings in their study. By using the conceptual change framework, they were able to challenge students' preconceptions with an alternative concept that allowed the students to modify their conceptions.

In this study many students' had preconceptions that ice can cause the ground to freeze or can cause snow or icebergs to form. After students were introduced to the idea of how glaciers can carve streams, valleys, and shape mountains they were able to modify their conceptions. Students were then able to illustrate and explain how ice changes the Earth's surface on their concept sketches.

Another reason this study showed that students' conceptions increased was because throughout this study students were encouraged to discuss their preconceptions and discuss what happened after they did their experiments. This is important in conceptual change because the discussion allows for students to think about what they understood before, than challenge each other's conceptions and their own conceptions through discussion. Students can then restructure their understanding of their concepts as they talk out loud about their conceptions.

Eryilmaz (2002) also used the conceptual change framework and found that by allowing students to have conceptual discussions, where they were able to discuss their conceptions and challenge each other's conceptions, they were able to modify their conceptions. Vosniadou (1994) research explains how it is important for students to discuss, analyze, and defend their conceptions and mental models to help them restructure their conceptual understanding.

Students conceptions were also modified due to the fact that they were able to have hands-on activities and experiments that allowed them to collect data and observations. The hands-on experiments allowed the students to compare their conceptions to the correct scientific conceptions and this allowed them to then modify their preconceptions. Research done by Bell and Trundle (2008) supports this conclusion. In their study they found that when pre-service teachers compared their preconceptions of the moon phases to the scientific conceptions that were shown during a simulation, the pre service teachers were able to increase their understanding of the correct scientific conceptions.

Specifically examining students' concept sketches supported the second part of the question that asks how the conceptual change framework improved students' conceptions of weathering and erosion. By looking at the pre concept sketches it was apparent that students were deficient in their understanding of how ice and water can weather and erode the Earth's surface. Students' deficiency can probably be attributed to seeing a lack of ice and water erosion in their everyday lives. Since geology is a visual science (Reynolds et. al, 2005) students do not see how ice and water affect the Earth's surface. At the end of the instruction using the conceptual change framework, students were able to draw and describe how ice and water can change the Earth's surface.

Students were able to draw and describe what ice and water do to the Earth's surface on their post concept sketches because they were able to visually see how ice and water affect the Earth's surface through the hands-on experiments they did in the unit of instruction. Reynolds et al (2005), saw the same results. When students were able to construct 3D models of different geological structures and manipulate them, it helped them understand different geological phenomena.

The conceptual change framework has students use hands-on experiments that they can manipulate and collect data on. In order for conceptual change to occur, students need to see that the new conception is intelligible through representations. The students then figure out how to fit these representations into their new conceptions (Posner et al, 1982). From the experiments in this study, students were able to see how agents of erosion like ice and water change the Earth's surface. By seeing the new representation they were able to modify their conceptions and these modifications were represented in their post concept sketches. In the case of this study, the students were able to draw and describe how water and ice affected the Earth's surface because they had seen the affects in the new representations in the hands-on experiments.

Lubarkin and Brick (2002) did a study to find which model: static, animation or interactive models, help students to visualize different geological concepts. They found that interactive models were the most effective because they allowed students to manipulate the models and physically see how they worked. The more students were able to see 3D models and were able to manipulate interactive models the more they can build their spatial skills and visualization. They are then able to understand larger geologic concepts like weathering and erosion and how these visually change the Earth's surface. Students were able to represent these concepts better on their post concept sketches because they did interactive models and were visually able to see how water and ice change the Earth's surface.

Not all students' conceptions changed in the same way. After the unit of instruction using the conceptual change framework, seven of the twenty-five students were able to explain how weathering and erosion happen over a long period of time. The concept that weathering and erosion happen over long periods of time is an important part of understanding how the Earth's surface has changed. These students had more of a robust understanding then other students and were able to illustrate this in their post concept sketches. Others may have not discussed time in their concept sketches because they didn't know how to illustrate that in their concept sketch or they hadn't modified that part of their conceptual understanding of weathering and erosion. The fact that students didn't discuss time in their concept sketch is an example of how the conceptual change framework didn't help some students' hold new conceptions. This could be due to the fact that their previous conceptions were so deeply embedded that they were unable to modify them.

Trundle, Atwood, and Christopher (2007) did a study where they had similar results. These researchers found that although pre service teachers held the correct conceptions of the moon phases initially, over time they reverted back to their incorrect preconceptions. The researchers believed these students reverted back to their preconceptions because they had not realized their inconsistencies between their preconceptions and the correct scientific conceptions at the end of the unit of instruction. The weathering and erosion study is not a longitudinal study as the moon phase study was, however it may still explain why the conceptual change framework doesn't always modify conceptions completely. In this study, the students may have not realized what they knew before the unit of instruction and how their conceptions had changed at the end of the unit, which is why some of their concept sketches may have not been as detailed as others. If students had been more aware of their preconceptions they may have realized detail they needed to add to their post concept sketches that they had not included in their pre concept sketches.

Implications

The findings of this study suggest many implications for the use of the conceptual change framework in geosciences instruction. To address misconceptions in the science classroom, the conceptual change framework is an effective instructional strategy that science teachers should be using in their classrooms.

This study confirmed the importance of using the conceptual change framework to modify students' misconceptions. Through the framework teachers can modify misconception by having students present their preconceptions and then challenge those preconceptions with the correct scientific conception. Teachers can do this by showing the concept is plausible and possible through hands-on experiments, models, and discussions that the students have. Students can then work through their preconceptions to modify to the scientific accepted conception.

Past studies of conceptual change have also expressed the importance of discussion and allowing students to defend and support their conceptions. This study also supports that this is an effective strategy in a science classroom. The more teachers can allow students to discuss their ideas and defend them, the more students can think through their conceptions and come to a deeper understanding of scientific conceptions.

Researchers in the geosciences show that visualization is important to help students modify their conceptions of geosciences. This study supports that visualization is important. Teachers should be using interactive models that students can manipulate to visualize the concept.

To help students understand science at a more conceptual level it is important for teachers to begin looking at what students' misconceptions are and working to change those by showing them the correct conceptions. By allowing students to work through their misconceptions to the scientific accepted conception through discussion and visualizations with interactive models students will come to understand science at a deeper conceptual level.

Future Research

The findings of this study align with previous research done on using the conceptual change framework, which shows this framework does help modify students' conceptions. Future research in conceptual change should focus on different geological concepts, a longitudinal study, and on instructional strategies.

Science researchers have shown the importance of the conceptual change framework in instruction to help change students conceptions. This study focused on whether the conceptual change framework can improve students' understanding of weathering and erosion, but research needs to be continued to see if there is another more effective way to change students' misconceptions. Another study could be done to see whether conceptual change framework or another instructional strategy changes students' conceptions to the scientific accepted conception better.

Some studies in conceptual change research have shown that after instruction using the conceptual change framework some students lose the correct conception over time. The study done by Trundle et al., (2007) found that some pre-service teachers' conceptions of the moon phases remained the same six months after instruction, but some pre-service teachers went back to their preconceptions. More research of how students' conceptions change over time would help to see if the conceptual change framework helps change students conceptions at a deeper level where they are able to keep these scientific accepted conception and not revert back to their preconceptions.

The limited research in the geosciences in general shows the need for more research in this discipline of science. Not only do we need to research the geosciences more but we also need to look at how students learn geosciences and see if we can find more effective ways to teach students geosciences. While this study focused specifically on weathering and erosion, research should continue in the geosciences by using the conceptual change framework to see if the conceptual change framework can help modify students' misconceptions of other geoscience concepts.

Limitations

There were many limitations in this action research project. One of the limitations was the assessment tool. Concept sketches are an effective way to find students' visual understanding of how weathering and erosion change the Earth's surface, however for this study there were some parts that would need to be changed to make the concept sketches more effective at evaluating students' understanding.

The first part of the concept sketch that limited the ability to show the students understanding is that students struggled to be able to draw a picture of the Earth's surface. Many of the students understood what the prompt was asking them but they struggled in how to draw their conceptions in a picture. This is expected since research shows many students struggle to draw their understanding of the Earth's surface visually (Reynolds et al., 2005). This study was able to collect data from the concept sketches, but if students' had been able to show more of their understanding in their drawings, the results could have showed an even deeper understanding of weathering and erosion.

Another limitation with the concept sketch is, even though students had practiced making a concept sketch once in the classroom before this study, concept sketches were not implemented from the beginning of the school year. It would have helped the students to practice more with other concepts and to have been doing concept sketches from the beginning of the year.

It was sometimes difficult to determine what the students were illustrating and describing in their sketches, which is another limitation. One way the instructor could have improved her understanding of what the students were illustrating and describing in their sketches was by conducting interviews. The interviews would have allowed the instructor to understand the reason why students drew the pictures the way they did. If interviews were conducted then the instructor would not have to assume what the students drew and why they drew it. The interviews would have given the instructor a deeper understanding of what the students' misconceptions were and where these misconceptions may have come from.

The rubric that was used to score the concept sketches was a good starting point for assessing the students' concept sketches, however it would have been beneficial if the rubric had explicitly stated what content should be included in each concept sketch, especially in the content area section of the rubric. For example it would have helped if the rubric stated specifically the landforms that can be created from wind, water, and ice and then the scorer would have known to look for those in the students' concept sketches.

The vagueness of the rubric made the scoring of the concept sketches very subjective. If the rubric had been more detailed the scorer would have been able to be more objective, which would have allowed for more reliable scores. Along with a more detailed rubric, outside scorers would have helped increase the inter-rater reliability of students' scores on their concept sketches.

Due to the uncertainty of the rubric this also may have affected the validity of the statistical findings. Some ways to improve the validity of the rubric would be to change the scale so students would score 1-3 points instead of 1-10 points. Another way to improve the validity of the rubric would be to have example concept sketches that could serve as a scoring guide.

The end of the school year and student motivation was also a limitation. The lessons took place in the final quarter of the school year after the state test had been administered. Even though the school year was not finished, once the test was administered many of the students' attitudes and motivation decreased.

This factor may have contributed to the fact that students didn't include a lot of detail in their concept sketches and lack of motivation to think critically. The instructor did her best to continue instruction and motivate students to continue to work, but students were not as motivated and focused as they were in the beginning of the school year.

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APPENDIX A

WEATHERING AND EROSION UNIT

Lesson Plans for Weathering and Erosion Conceptual Change Unit

Pre conceptual drawing: Students will be given the prompt "What are flowing water, wind, and ice doing to the Earth's Land surface." And they will have to draw a conceptual drawing using this prompt. They will also use words and phrases to label what is going on.

Lesson 1: Why do weathering and erosion happen?

Predict -The question that will be asked is can rocks be broken and how
- Students will write a response to this.
- With their groups they will try to come up with a consensus this answer.
- Groups will share out and the class will discuss their ideas whether they think rocks can be broken and how.

Observe:
- Start this lesson by showing students of pictures of rocks that have been broken down and different example of rotting rocks and examples of fresh rocks so they can make the comparison.
    - Ask students the difference between the rotten rocks and the fresh rocks? Ask them to make inferences about what happened.
    - Once again have a class discussion on what they think happened.

- Students will then do an experiment to see if they can break rocks down.
    - They will do three things to see if they can break down granite, sugar cubes, and white limestone.
    - They will try to break it with their hands by rubbing the rocks together and in water and they will record their results.
    - Students will discuss what these results show them about how rocks can be broken.

Explain: Why rocks weather and erode?
- Students should see that rocks that are originally formed beneath the surface by geological processes, and when they are brought form their original environment to their new environment they are no longer stable.
    - Rocks can be broken down in many different methods.
    - Class discussion will begin to come up with a consensus on why does weathering and erosion happen.
    - They will do this by looking back over their data and their observations they made about the rotten and fresh rock to explain why weathering and erosion occur.

Lesson 2: In what places does erosion occur in the natural environment, and what are some of the agents that cause erosion?

Predict: The question that will be asked is in what places does erosion occur in the natural environment, and what are some of the agents that cause erosion?

- Students will write a response to this.
- Students will also think about any experiences they have had before that they may have seen on outside landscape.
- With their groups they will try to come up with a consensus this answer.
- Groups will share out and the class will discuss their ideas on in what places does erosion occur in the natural environment, and what are some of the agents that cause erosion.

Observe:
Water erosion

- The first lab students will do is they will examine water erosion through a stream table. Students will run water through the system, and observe the processes of erosion and deposition.
- Students will study different variables of weathering and erosion by changing the slope of the land, and the rate of the flow.
- They will design the experiment they will test to see what happens and record the results of water erosion of a stream.

Wind Erosion

- Students will also set up an experiment to determine the factors that affect wind erosion of different surface materials.
- Students will have a pan of sand and water, sand, clay and water, clay, and sand and gravel.
- Students will then test with a blow dryer at different angles (10 degrees and 45 degrees) and different distances (10cm and 20cm) what wind can do to the surface of different materials.
- Students will record results and make observations of how wind causes erosion.

Ice erosion

- The final type of erosion the students will look at is ice erosion. Students will observe how ice can erode a valley.
- Students will measure the width and the depth of the channel to see how the glacier affects the stream.
- Using a stream table they will make a river channel and measure the width and depth.
- Then they will take the glacier and place it in the river channel at the top of the steam. Push the glacier along the river channel until they reach the bottom.
- Students will also record their observations of the materials that the glacier leaves behind and the new formations that are made.

Explain:
In what places does erosion occur in the natural environment, and what are some of the agents that cause erosion?

- Students should see that wind, ice, and water all cause erosion. There are many factors that cause them to do different things to the surface.
- Groups will come up with a consensus on where weathering and erosion occur and how these factors change the Earth's surface.

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Lesson 3: What are the results of erosion and weathering that we can see around us?

Predict: The question that will be asked is what are the results of weathering and erosion give us?

- Students will write a response to this.
- With their groups they will try to come up with a consensus this answer.
- Groups will share out and the class will discuss their ideas on what weathering and erosion give us.

Observe:

Pictures of erosion

- Students will examine different pictures of mountains that have changed over time because of erosion.
- Students will also look at several different pictures of land features that have formed from erosion.

Observations from experiments

- Students will also use observations from their experiments and what those experiments with weathering and erosion give us.

Explain

What are the results of weathering and erosion?

-Students will gather all the data they have collected to explain what weathering and erosion give us.

-They will then explain how this can affect our Earth's surface and change it.

-Students will work in groups to come up with a group consensus on what weathering and erosion give us.

Post Conceptual Drawings: Students will be given the prompt "What are flowing water, wind, and ice doing to the Earth's surface" again, and they will have to draw a conceptual drawing using this prompt. They will also use words and phrases to label what is going on.