Using Conceptual Change Texts to Address Misconceptions in the Middle School Science Classroom

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Abstract

The aim of this study is to create conceptual change texts for use in the middle school Earth Science curriculum. This project was informed by the current research on student misconceptions, the conceptual change model, and conceptual change texts. A review of the literature demonstrated that student misconceptions are prevalent in most science classrooms and that the conceptual change model is the most effective model for addressing misconceptions. The research also found that conceptual change texts are an excellent application of the conceptual change model and can be used in any science classroom. The project associated with this study produced seven conceptual change texts that cover seven different middle school Earth Science topics.

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Chapter I: Introduction

Rationale

Students enter our classrooms not as blank slates but as individuals with previous encounters with scientific concepts and ideas about how the world works (Smith, 1993). Unfortunately, our students' prior knowledge is often faulty or incomplete and results in misconceptions about the scientific concepts we cover in our curriculum. Because students are comfortable with their misconceptions, it is very difficult to dispel their inaccurate thinking and replace it with scientifically accurate understandings. Research has shown that unless student misconceptions are specifically and individually addressed, their misconceptions are likely to persist throughout their academic careers and possibly into adulthood (Hashweh, 1986).

Conceptual Change Texts are scientific texts that are specifically designed to address and remediate student-held misconceptions. They differ from traditional textbooks because they cause students to reflect on their thinking and realize possible flaws in their mental models (Cetingul & Geban, 2011). Conceptual change text styles may vary from author to author but the overall format remains the same. The reader is first asked a question or asked to make a prediction about a scientific concept. Secondly, the reader is presented with commonly held misconceptions about the concept. When the reader sees similarity in his or her thinking, cognitive dissonance takes place and the need for correction is realized (Durmus & Bayraktar, 2010). Thirdly, the reader is given a correct explanation of the concept. Finally, the reader is asked to answer questions that solidify understanding and demonstrate accurate remediation of their prior misconceptions (Ozkan & Selcuk, 2013).

Conceptual change texts have been found to be effective for correcting student misconceptions across all of the major scientific fields. Several studies have found conceptual change texts to be more effective than standard instruction for correcting misconceptions in science topics such as but not limited to: particles and matter (Beerenwinkel, Parchman, & Grasel, 2011, Durmus & Bayraktar, 2010), air pressure (Akbas & Gencturk, 2011), sound (Ozkan & Selcuk, 2013), acids and bases (Cetingul & Geban, 2011, Demircioglu, 2009), cellular respiration (Al khawaldeh & Al Olaimat, 2010), nature of science (Cepni & Cil, 2010), chemical bonding (Pabuccu & Geban, 2012), human circulatory system (Sungur et al., 2001), solutions (Uzuntiryaki & Geban, 2005), and ecology (Ozkan, Tekkaya, & Geban, 2004). These studies demonstrated that Conceptual Change Texts are effective at: helping students identify and remediate their own misconceptions, providing teachers with formative assessments about misconceptions that exist within their classroom, and finally helping students to retain correct understanding of scientific concepts long-term.

No one educational tool is without some downfalls and this is also true of conceptual change texts. Concerns have been raised about the accessibility, reliability, and effectiveness of conceptual change texts. Students with significant reading and writing disabilities may have difficulty accessing and comprehending the texts (Guzzetti, 1995). Modified versions that aid in comprehension should be provided for these students. The reliability of conceptual change texts comes under question because students may change their answers to questions in the text based on class discussions (Cepni & Cil, 2010). This would distort their true understanding of the scientific concepts and therefore reduce reliability of the results. It is important that students are encouraged to simply do their best and not change their answers based on the thoughts of their peers. Teachers should explain to students that the purpose of the conceptual change text is to identify their thinking and improve upon it, not simply getting the correct answers. A third critique of conceptual change texts is that they are not one hundred percent effective in remediating misconceptions, most studies find that a small percentage of students retain their initial misconceptions despite reading the texts (Sungur et al., 2001). Despite this small percentage, conceptual change texts are shown to have a high success rate with remediating misconceptions and are an extremely effective tool for science teachers in any classroom.

The goal of this project is to research effective methods for remediating science misconceptions. The second part of this goal is to use the findings of the research to create materials that teachers can use to identify and address the science misconceptions in their classrooms. A thorough review of the literature found that the principles of the conceptual change model are essential for dealing with science misconceptions. Research also showed that conceptual change texts are effective tools for implementing the conceptual change model across all of the scientific fields. Creating conceptual change texts for teachers to use in their classrooms will therefore be the emphasis of the second half of this project.

Significance of the Project

Traditional science instruction that relies primarily on the presentation of scientific concepts without the consideration of the student's conceptions can be rather ineffective. This project seeks to create materials that can be used by teachers in their middle school science classrooms that examine the thoughts of each student and transitions these thoughts to correct scientific knowledge. The conceptual change texts will serve as formative assessments that inform the teacher of the misconceptions within their classroom and afford them the chance to adapt instruction. The texts also directly refute false concepts held by students by asking them questions and then specifically showing them their mistakes. These texts will provide differentiation for both ability and learning style. Each text will include a modified version designed for students with low reading levels. In addition, each conceptual change text includes a choice of extension activities that feature different modalities of learning (artistic, written, hands-on, etc.). Finally, this project is significant because despite the large amount of research done about conceptual change texts, there are not many conceptual change texts available as resources. This project will make conceptual change texts available for use by any middle school science teacher.

Overview of Chapters

This paper consists of three chapters. This chapter serves as an introduction to the topic of student misconceptions in the science classroom and how conceptual change texts can be used to address these misconceptions.

Chapter I explains how this paper is significant to the educational community and supplies the reader with the definitions of the essential research terms related to student misconceptions.

Chapter II starts out with a chapter overview that summarizes the literature review for this project. The full literature review is included and focuses on the topics of student misconceptions and conceptual change texts. Then a short explanation of how the research covered by the literature review helped to inform the project portion of this paper is included.

Chapter III is the heart of this paper and includes the actual conceptual change texts created for the use of middle school Earth Science teachers to help address student misconceptions and increase understanding of the Earth Science content.

Definition of Terms

CONCEPTUAL CHANGE MODEL (CCM): Model of science instruction created by Edward Posner in 1982 based on identifying and addressing student held misconceptions. It is a student based model that guides the learner through activities that directly challenge their personal misconceptions.

CONCEPTUAL CHANGE TEXTS: Instructional texts that present students with situations that challenge their previously held beliefs.

SCIENCE MISCONCEPTION: A mental model created by students with the purpose of understanding scientific concepts that differ with the accepted beliefs held by scientists (Prokop & Fancovicova, 2006) Referred to by the research in a variety of different ways including preconceptions, alternative conceptions, alternative beliefs, alternative frameworks, private concepts, and naïve theories (Smith, 1993).

SOCIAL CONSTRUCTIVISM: The use of peer interaction as a learning strategy that allows to students to express their beliefs and at the same time compare their beliefs to those held by others in the classroom.

Chapter II: Literature Review

Overview

This chapter includes a review of the literature about student misconceptions in science, the conceptual change model, and conceptual change texts. The literature review gives the reader background knowledge about misconceptions and then examines studies that aim to identify and address student misconceptions. The studies predominately used the conceptual change model to help students overcome misconceptions about science topics and found the model to be highly effective. The studies also suggested that conceptual change texts are an effective media for implementing the conceptual change model. The literature review was then amended to include research on the use of conceptual change texts to address science misconceptions. Several studies found conceptual change texts to be very effective. A brief description of how the literature review informed the project portion of this paper is included at the close of this chapter.

Introduction

It is obvious that one of the main goals of standards based science education is for students to gain an accurate understanding of scientific concepts covered in the classroom. What is not so obvious is how students actually perceive these oftentimes abstract scientific concepts. Very rarely do students hold completely accurate views of material discussed in the science classroom (Smith, DiSessa, & Roschelle, 1993). In their efforts to relay vast amounts of scientific information in limited amounts of time, teachers frequently ignore student perceptions of material and focus strictly on the presentation of scientifically accurate information. Numerous studies have shown that despite receiving research-based, high quality instruction on scientific concepts, students are not likely to correct their misconceptions unless these misconceptions are specifically confronted (Hashweh, 1986). Based on a review of the literature dealing with misconceptions, proper identification and instruction related to student misconceptions leads to enhanced student engagement and performance.

In order to evaluate what constitutes effective instructional strategies for identifying and addressing student misconceptions in the classroom, this paper will start with an overview of the nature of student misconceptions and then discuss the methods used by studies on the Conceptual Change Model. Because proper identification of student misconceptions is an integral part of the Conceptual Change Model, additional studies strictly on identification of misconceptions will also be discussed. An examination of the studies included in this paper will yield a highlight list of effective practices to be used by teachers for successful remediation of misconceptions in the science classroom. The use of conceptual change texts encompasses these effective practices and will therefore also be covered by this paper. The application, effectiveness, and downfalls of conceptual change texts will be discussed.

The Nature of Misconceptions

In addition to understanding the terminology associated with misconceptions, it is important to consider how misconceptions are formed and the way in which they affect student learning. Current research heavily contradicts the traditional "tabula rasa" view of student understanding. Because our world is filled with science, a simple walk outside or the bouncing of a basketball creates a multitude of mental models about the way science works for our students (Salierno, Edelson, & Sherin, 2005). Students enter the classroom not as "blank slates" but as young scientists with preconceived notions about how the world works that are frequently incorrect or incomplete (Smith, 1993). The nature of these misconceptions is described by current research as: student-generated, influenced by social interactions, similar throughout the student population, persistent, and not easily changed (Eaton, Anderson, & Smith, 1983). These misconceptions are so difficult to change because students oftentimes feel more comfortable with their initial beliefs and are not willing to contemplate the scientific explanations that cause significant cognitive dissonance (Stepans, Beisenwgener, & Dyche, 1986). Even if a student that holds a misconception is willing to struggle through the cognitive dissonance, they must first be able to correct their misconception prior to forming a correct mental model. Thomas O’Brien (2010) uses the analogy of constructing a house to describe this situation. Just like you cannot build a solid framework for a house on a weak foundation, you can’t construct new meaning from background knowledge that is flawed. Science misconceptions are formed whenever a student interacts with the world and can present as significant road blocks to correct understandings of scientific concepts.

The Conceptual Change Model (CCM)

Now that this paper has established what student misconceptions are and how significantly they can detract from learning, it is appropriate to examine some research that shows how to effectively identify and address student misconceptions. The most effective and current research dealing with student misconceptions involves the Conceptual Change Model. The model, created by Posner in 1982, strives to achieve four conditions necessary for conceptual change. “These conditions are: (1) students must become dissatisfied with their existent conceptions; (2) the new conception must be intelligible for the student; (3) the new conception must be logical and acceptable for the student; and (4) the new conception must have a potential for explanations in new fields (Atasoy et al., 2009).” The following four studies in science education utilize the CCM and aim to fulfill the four conditions listed above. An examination of their methods will yield insight on the use of the CCM in the everyday science classroom.

In 2005, Uzuntyriaki and Geban conducted a study to compare the effectiveness of the Conceptual Change Model with that of traditional instruction in teaching about chemistry solution concepts. The authors' purpose for the study was driven by the prevalence of student misconceptions about solutions. Because solutes are not readily visible when dissolved, the mechanisms of solutions are mostly hidden and therefore abstract (Abraham et al., 1994). Students oftentimes approach the topic of solutions with faulty background knowledge, such as believing that solutes simply "disappear" upon being dissolved and do not add to the overall mass of the solution (Prieto et al., 1989). To gauge the effectiveness of the CCM on remediating these misconceptions about solutions, the study utilized a sample of 64 eighth grade students in a general science course in Turkey. The population was split into two equal groups of 32 students. The experimental group received instruction utilizing the CCM and concept mapping techniques, while the control group received traditional instruction. The same teacher taught both groups for duration of four weeks.

The study began with a 20 question multiple-choice Solution Concept Test. All 64 students were required to take the test as it detected possible misconceptions held about solutions. The questions were based on commonly held student misconceptions about chemical solutions. The first half of the assessment tested for correct knowledge where the second half explored the reasoning for student choices on questions 1-10. The student scores on this test were compiled and the initial misconceptions of the students in the study were established. The instruction for the two groups was distinctly different. The control group received traditional instruction, which consisted primarily of lecture supplemented by the use of traditional textbooks and worksheets. The instruction received by the experimental group was primarily student-centered and included conceptual change texts, whole class discussions, and the construction of concept maps. After completing the 4 weeks of instruction, the entire population was given a post-test on solution concepts. Both the experimental and control group showed improvement on their understanding of solution concepts but the experimental group who received instruction based on the CCM showed significantly greater improvement.

Uzuntyriaki and Geban's study serves as evidence of the potential that CCM based instruction can have in the classroom. Their use of conceptual change text served to make students aware of misconceptions about chemical solutions but also directly refuted their plausibility. The effectiveness of conceptual change texts is obvious when compared to that of traditional textbooks. Traditional texts simply present information where conceptual texts present students with information that directly conflicts with their current beliefs (Hynd, 2001). This conflict that conceptual change texts provide is essential in motivating students to improve their conceptual models. In addition to having students read the texts, this study utilized social constructivism to ensure proper understanding of the text. The teacher frequently paused to stimulate whole class discussion on what was being covered by the text. This discussion allowed for students to voice their misconceptions and also ensured that all students comprehended the reading, regardless of their reading ability (Guzzetti, 2000). One weak point of this study occurred in the area of identifying misconceptions. The authors used a multiple-choice instrument alone to detect misconceptions about chemical solutions. This limited approach allows for very incomplete expression of student ideas about scientific concepts and may not uncover all misconceptions. This limited approach to detecting misconceptions is common in most studies that utilize the CCM and is most likely due to time constraints.

The next study also features a very similar use of the CCM in chemistry but focuses on the topic of chemical equilibrium. A great deal of research has been conducted on student perceptions of chemical equilibrium. Due to its abstract nature and the prerequisite knowledge of mathematics required to understand it, student perceptions of chemical equilibrium are commonly found to be incorrect (Hackling & Garnett, 1985). These findings are troublesome, considering chemical equilibrium is a fundamental concept required for even the most basic of chemistry classes. In order to address this issue, Atasoy, Akkus, and Kadayifici performed a study utilizing the CCM in 2009. Their goal was to examine the effectiveness of the CCM in remediating student misconceptions related to chemical equilibrium versus that of traditional instruction. The study was conducted in Turkey and included a sample population of 85 male and female students enrolled in a college-level general chemistry course.

The entire sample was tested for misconceptions prior to instruction utilizing a two-tiered multiple-choice test very similar to the assessment used in the previous study by Uzuntyriaki and Geban. The authors divided the sample into a control group that received traditional chemistry instruction featuring lectures and an experimental group that received CCM based instruction. The procedure for the experimental group began with a reading from a conceptual change text that presented a description of a chemical reaction and several plausible explanations of how the reaction worked. The text provided the correct explanation and addressed why the other explanations were false. Next, the students participated in a Predict-Observe-Explain activity that featured a similar reaction to the one in the conceptual change text. Prior to physically performing the reaction, the students made predictions of what would happen. These predictions revealed any possible misconceptions the students possessed. These misconceptions were challenged by observations made during the reaction. Finally, students had to come up with explanations for why the chemical reaction took place the way it did. Students received teacher guidance in constructing a concept map of their explanation to further clarify their understanding of the equilibrium concepts observed during the reaction. The procedure was completed by having the students apply and extend their knowledge to other types of reactions commonly seen in the real world. Both the control and experimental groups concluded their participation in the study with taking a post-test on equilibrium concepts. The test showed that both groups improved their knowledge about chemical equilibrium but the students who received CCM based instruction showed significantly better correction of previously held misconceptions.

This study by Atasoy, Akkus, and Kadayfici provides further evidence that the CCM is a successful approach for remediating misconceptions in the science classroom. Although, this study followed the same basic model of utilizing conceptual change texts to identify and alleviate misconceptions as Uzuntyriaki and Geban, some key differences are apparent. When the authors of this study utilized conceptual change texts, they did not conduct classroom discussions. This lack of social constructivism failed to provide students with an opportunity to share their misconceptions and also failed to provide clarity on the readings. Although this lack of social constructivism is definitely a weakness, the study also contained many strong points. One of these strong points included the use of the Predict-Observe-Explain activity. This activity allowed for further identification and evaluation of student misconceptions about chemical equilibrium and also added the element of kinesthetic activity to the study. The POE reaction was particularly effective because the type of reaction chosen was selected based on student misconceptions detected in the study's pre-test. This calculated approach to pinpointing and refuting student misconceptions is highly effective (Hashweh, 1986). The authors' additional activity of having students create concept maps about their knowledge of chemical equilibrium is another strongpoint of this study. Student concept maps help students to organize their thoughts surrounding a concept and provide visual evidence of conceptual change (Novak, 1991).

In order to explore the effectiveness of the CCM in addressing student misconceptions in the area of genetics, Mbajiorgu, Ezechi, and Idoko conducted a study with Nigerian adolescents in 2006. Motivation for the study came from the commonly held belief that genetics is one of the most abstract and difficult concepts for students of biology (Bahar, Johnstone &Hansell 1999). Because genes are expressed physically in human traits, microscopically in chromosomes, and symbolically in punnet squares, students are often overwhelmed by the requirement to use multiple levels of thought simultaneously (Johnstone 1991). To add to the difficulty, cultural beliefs can heavily influence student preconceptions about the importance and processes of genetics. With all these variables taken into account, the authors wanted to see how use of the CCM would improve student conceptions of genetics compared to that of traditional instruction. To do so, the study utilized a sample population of 282, 17-18 year old students, at 4 different schools in Southeastern Nigeria.

In an effort to obtain a firm understanding of where the misconceptions of the Nigerian students in their study were coming from, the authors began their study with a thorough investigation of the local culture. All of the students within the sample population were members of the Igbo Tribe, a traditional cultural group from Southeastern Nigeria. The authors discovered that this tribe's views of genetics were very limited and were dictated by their religious beliefs. Genetic illnesses were thought to be caused by mystical forces and the gender of children was believed to be determined solely by the mother. Based on these cultural ideas and values, the authors developed three fictitious stories with characters that had genetic diseases that were present in the Igbo Tribe. These stories and a series of questions that accompanied them were presented to the sample population as an instrument to identify their misconceptions about genetics. The students' misconceptions were analyzed and used to design a CCM based unit. During the unit, the students were informed of their misconceptions and forced to confront them. With the help of their teacher, the students re-read the three fictitious stories from the pre-assessment and constructed genetic cross diagrams of the characters with genetic disorders. After re-examining the stories and their genetic cross diagrams, the students were given the opportunity to re-evaluate their original misconceptions. The unit culminated with an achievement test that measured the participants' knowledge of genetic disorders. The results of the achievement tests were compared with the students' original misconceptions and significant concept improvement was observed.

This study of Nigerian youth and their knowledge of genetics stood apart from the rest of the articles covered in this paper due to its focus on the socio-cultural background of its participants. The authors' consideration of socio-cultural conditions and their impact on student misconceptions is unmatched by most studies done on the CCM. Although most studies rely entirely on identifying student misconceptions with a simple pre-test, Mbajiorgu, Ezechi, and Idoko conducted an in depth study on Igbo culture that revealed a great deal about the origin of their students' misconceptions. Background knowledge is the source for student misconceptions about science and this background knowledge is directly influenced by a student's cultural experiences (Baker & Taylor, 1995). It is therefore worth the time for all teachers to obtain a thorough knowledge of their students' cultural backgrounds in order to prepare for probable misconceptions in the classroom. This study further set itself apart from the others by creating conceptual change texts aimed directly at the socio-cultural experiences of its students. The purpose of conceptual change texts is to address specific misconceptions held by students and there is no better way of achieving this than creating the texts with specific students and their misconceptions in mind. Although creating resources from scratch may not be practical in some situations due to time and financial constraints, it is an effective practice that should be utilized whenever possible in the classroom.

The final CCM study explored by this paper was a study conducted by Steer, Knight, Owens, and McConnell in 2005. Steer et al. aimed to examine the effectiveness of the CCM in improving student conceptual understanding of earth's interior structure and plate boundaries. The sample population in this study consisted of 97 college students enrolled in the general education course entitled "Earth Science", at a large urban university. The sample was 52% male, 48% female, and 11% of the total sample identified themselves as a member of an ethnic minority.

The methods employed by Steer included several phases. Students were first assigned a pre-class reading on the structure of earth's interior. In class, the students were divided into four person groups and given the task of drawing the major layers of earth on a circle. After the group drawings, the professor presented a lecture on the earth's interior and the groups were allowed to discuss the accuracy of their initial drawings. The groups then applied knowledge gained during the lecture to build a scale model of earth's interior with markers, string, and a tape measure. Upon completion of the student model construction, the groups were given expert USGS models for comparison. The groups were separated and students individually repeated the initial earth structure drawing task from the beginning of the study. Finally, the students were given a written task that asked them to describe their understanding of earth's structure and how their new knowledge might relate to other topics such as plate tectonics. The initial and final drawings were collected and analyzed for each student. A rubric was developed based on frequently occurring misconceptions and all the drawings were scored separately by two instructors. The scores were evaluated for inter-rater reliability and showed an overall trend of concept improvement. The CCM was demonstrated to be an effective method for identifying and addressing student misconceptions.

This study is very similar in structure to that of the previous CCM studies covered by this paper in that it forced students to identify and confront misconceptions held about a scientific concept. Despite the similarities with the other CCM studies, the work done by Steer et al. has some unique qualities worth discussing. Unlike the previous works, Steer et al. did not use conceptual change texts. Participants in the study were assigned a pre-reading on earth's interior structure from a traditional science textbook. It is unclear why Steer et al. chose to use a traditional text when the literacy research has proven conceptual change texts to be the most effective texts for remediating student misconceptions (Alverman & Hague, 1989). Although this study's use of text is in need of improvement, it does include several commendable qualities. Steer et al. did a great job in utilizing multiple modalities of learning to assist students in improving their misconceptions about earth's interior structure. The participants in the study were required to read, draw, discuss, build models, and write all in an effort to realize and improve their personal conceptions of earth's interior structure. This multi-modal approach ensured that all students learned, regardless of learning style. "No single instrument is likely to effectively assess all aspects of understanding a topic (Sibley, 2005)." In addition to touching on multiple learning styles, the study's multi-tiered nature offered several opportunities for students to re-evaluate their conceptions. Research has continuously shown that misconceptions occur at all stages of the learning process and can be very resistant to change. Multiple re-examinations of student misconceptions are required to combat their resiliency (Smith et al., 1993). The multi-tiered approach for addressing misconceptions used in this study should definitely be emulated in the everyday science classroom.

Alternative Methods for Identification of Student Misconceptions

Thus far, this paper has provided an analysis of the methods used by different studies that utilize the CCM in identifying and addressing student misconceptions. Although these studies provide several good examples of how to remediate misconceptions in the classroom, their methods used for the initial identification of student misconceptions lack in variety. Proper identification of student misconceptions is the first and most important step in remediating these flawed mental models (Baker and Piburn, 1997). It is therefore necessary to utilize a range of instruments to ensure a proper investigation of the misconceptions held by students (Sibley, 2005). This section of the paper will examine four studies specifically in the area of identification of student misconceptions to supplement the identification methods of the previous four studies.

The topic of discovering student misconceptions about the concept of geologic time was explored in a study by Libarkin, Kurdziel, and Anderson (2007). In the study, the authors attempted to expand upon the existing research about geologic time misconceptions and survey specific misconceptions held by college students. The driving force to collect this research was the ultimate goal of creating curriculum specifically designed to address the common misconceptions associated with geologic time. Based on previous research, the authors hypothesized that students struggle most with absolute ages of geologic events and relating the relative ages of geologic events to the relative ages of rock strata. The sample included 63 college students enrolled in introductory level science courses at four different colleges spread across the east coast and Midwest United States. The majority of the sample consisted of non-science majors and the level of scientific knowledge held by the students varied greatly.

Interviews were conducted on a subset of students (n=15) in the sample, while the rest of the students participated in an open-ended questionnaire. The interviews and questionnaires tested the same material but the interviews allowed for verbal explanation of answers when trouble was encountered with the written responses. The open-ended questions had the students explain their views of what different periods of geologic time looked like and then required the students to construct a drawing of the geologic timeline. The students were asked to include several geologic events and their associated absolute ages, some of these events included the beginning of time, the appearance of life, and the appearance of dinosaurs. The surveys were collected and analyzed based on the spacing of the geologic events on the student drawn timelines. All of the individual student drawings were plotted on a ternary diagram, which illustrated specific trends within the data.

The results of the study showed that most students realized that the earth is quite old. The majority of students referred to the earth's age in billions of years, some referred to it in millions, and very few placed the earth's age in the thousands of years old. The students also demonstrated a fairly accurate view of the relative ordering of the earth's major geologic events (appearance of life, extinction of dinosaurs, etc.). The major student misconceptions lied in the spacing of time between the geologic events. A large portion of the drawings showed the appearance of life occurring very early on in the earth's history and didn't allow enough time between the appearances of different species to account for the processes of evolution. Based on their findings, the authors conclude that significant misconceptions exist about the time lapses between major geologic events. Because a solid knowledge of geologic time is required for understanding many other geologic concepts such as plate tectonics, erosion, metamorphism, and stratigraphy, the authors recommend that geologic time be placed very early on in any geology curriculum. Confronting and correcting the common misconceptions of geologic time early on in the curriculum would result in better student understanding of subsequent topics.

From a teacher's perspective, the study by Libarkin illustrates the effectiveness of questionnaires and student drawings in identifying student misconceptions within the classroom. The task of having the students draw timelines of geologic events was strengthened by scaffolding the students with a list of major geologic events. Although assessments aimed at uncovering student misconceptions should not plant knowledge in the minds of students, they should be explicit in their directions and expectations. Giving students a list of events gave students the proper amount of guidance required to construct their timeline drawings. Research has shown that instruments used to discover misconceptions must not be ambiguous in order to accurately assess student knowledge (Panagiotaki, Nobes, & Potton, 2009). The interviews utilized in this study were beneficial in allowing the students to express their knowledge about geologic time to the researchers but would most likely prove impractical for use in the science classroom. Although teachers would love to have one-on-one conferences with their students in order to discover misconceptions, time restraints would generally not allow for such a practice. The methods used to discover student misconceptions by Libarkin provide some effective tools to classroom teachers but by no means provide a complete toolbox.

The next study to be discussed was conducted by Haim Eshach in 2010. This article also explores the process of identifying student misconceptions but expands upon the methods used by Libarkin through including a wider range of assessment techniques. The purpose of the study was to evaluate the effectiveness of their newly created assessment tool in identifying student misconceptions related to Newton's 3rd Law. The sample included in this study consisted of two separate groups: high school students and pre-service physics teachers. The teacher group consisted of 26 college students from several Israeli universities. All of these pre-service teachers were highly trained in the sciences and were in the final stages of receiving their science teacher certificates. The high school group consisted of 27 11th grade students who all attended the same public school in Northern Israel.

The researchers used the acronym CIP to refer to their assessment tool as it required participants of the study to **C**reate and **I**nterpret their own **P**hotographs. Subjects were grouped in pairs and instructed to act as science textbook designers. Their objective was to either take or find a photograph that represented Newton's 3rd Law and could be included in a physics textbook. They were then asked to verbally explain just how their photograph depicted Newton's 3rd Law. Using inductive analysis, an experienced physics teacher and a cognitive science student examined the photographs and associated explanations. They identified the common misconceptions held amongst both groups and established six different categories. The misconceptions ranged from complete failure to depict Newton's 3rd Law to explanations that were mostly factual but failed to utilize correct terminology. Surprisingly, the highly knowledgeable pre-service teacher group expressed very similar frequencies of misconceptions about the physics concepts as the high school group did. The results indicated that the CIP method is an effective method for identifying misconceptions.

This study should not only be viewed as a successful experiment in education research but also as a blueprint for everyday misconception identification within the classroom. Although Libarkin's study successfully identified student misconceptions, Eshach's CIP method went beyond the simple survey method and incorporated several effective educational practices. By allowing students to create their own photographs using technology such as Google images or digital cameras, it increased student engagement and required more authentic application of Newton's 3rd Law. Eshach's decision to incorporate group work into the CIP allowed for social constructivism related to important physics concepts. The discussion between students while creating their representations served as additional opportunities to express and analyze possible misconceptions. One failure of this study was that 25% of the participants completely failed to represent Newton's 3rd Law of Motion. This occurrence was not likely a result of student knowledge but rather lack of specificity in the directions. Although the freedom of the CIP method is one this study's greatest strengths, it also proved to be one of its weaknesses. The ambiguity of the CIP method would benefit from the addition of some scaffolding like that seen in Libarkin's study. With the addition of some the elements from the next study, the CIP would prove to be an effective method of misconception identification in any science classroom.

In comparison with the previous two articles, a study performed by Sibley in 2005 was both explicit in its directions and utilized student creativity to successfully identify student misconceptions. Sibley's study sought to identify student misconceptions related to convergent plate boundaries. The study surveyed over 600 students from five different sections of a general education geology course at Michigan State University.

During the implementation of the study, students were given an open book homework assignment to draw and label the critical aspects of a convergent plate boundary. During the following class, students were allowed to discuss their drawings with other students prior to taking a quiz. The quiz simply required the participants to repeat the steps of the convergent plate drawing homework but this time they were not allowed to view their notes nor conference with their classmates. A rubric was constructed for what constituted a correct representation of a convergent plate boundary and the student quiz drawings were analyzed according to the rubric. The majority of the student drawings fell into two main misconception categories. "Misconception #1 depicts mountains sitting on rigid plates. The mountains have no roots and do not show thickening of the lithosphere below the surface. Misconception #2 depicts mountains as the result of upward tilting of slightly plastic ridges overlying a rigid substrate (Sibley, 2005)." The authors utilized these common misconceptions to create drawings that depicted the flawed models. These incorrect drawings were given to the students and the students were asked to identify any possible errors. The majority of the students in the study were unable to detect the errors which confirmed the resilient nature of misconceptions. Sibley's methods proved effective in uncovering the common student misconceptions surrounding convergent plate boundaries.

Although this study was not as creative as Esach's work with Newton's 3rd Law, it did engage students by allowing them to draw their understandings of convergent plate boundaries and then discuss them with their classmates. This combination of drawing and social constructivism allowed for an in-depth look at student thinking and any possible misconceptions. Sibley's work also paralleled that of Libarkin's in that its participants did not show any confusion about the tasks they were asked to complete. This is important because instruments designed to uncover student misconceptions that are ambiguous do not accurately relay the mental models students hold regarding scientific concepts ((Panagiotaki, Nobes, & Potton, 2009). Sibley's study provided the necessary directions and scaffolding for its participants to successfully complete its required activities.

The final article related to identification of student misconceptions to be discussed by this paper is a study conducted by Ben-zvi-Assarf and Orion in 2005, on the water cycle. Even though every human being has experienced the water cycle firsthand, its hidden processes such as groundwater infiltration and evaporation are oftentimes overlooked or misunderstood by students. Understanding the water cycle requires knowledge of hidden processes and an understanding of cyclic systems which both require some higher-level thinking. The complex nature of the water cycle leads to a great deal of student misconceptions about the topic (Agelidou et al., 2001). Ben-zvi-Assarf and Orion's study sought to identify the specific misconceptions held by junior high school students about the water cycle. Their study included a sample population of 1,000 junior high school students (7^{th}-9^{th} grade) from 6 different urban Israeli schools.

The study began with a likert-type questionnaire that sampled the participants' knowledge of 4 main areas related to the water cycle including: (1) significance of the water cycle to humans, (2) cyclic thinking, (3) volume of water on earth, and (4) prior experience with the water cycle. Next, the students were assigned a drawing task in which they were asked to draw a model of the water cycle. To aid them in their drawings, a list of water cycle components and processes to be included was provided to the students. These drawings were analyzed and categorized based on the types of misconceptions present. After the drawing activity, the students participated in a word association activity. "The students were asked to write down all the concepts regarding the water cycle with which they were familiar (Ben-zvi-Assarf & Orion, 2005). The study was completed with an interview of a subsample of the participant population including 40 students. During the interview, the students were asked to read their answers aloud and explain their drawings of the water cycle.

Similar to Libarkin and Sibley, the work done by Ben-zvi-Assarf and Orion does a good job of including explicit directions and the proper amount of scaffolding to ensure students understood what was expected of them. The directions and word lists attached to the water cycle drawing task gave the participants proper guidance in expressing their mental models. No confusion among the students was detected in the analysis of their drawings and questionnaires. This study on the water cycle rivals that of Esach's and Sibley's work in the area of variety of assessment techniques. Ben-zvi-Assarf and Orion utilized a combination of questionnaires, drawings, word associations, and interviews which allowed them to obtain a well-rounded survey of student conceptions of the water cycle. Although their methods were varied, Ben-zvi-Assarf and Orion's work would benefit from the addition of some group work and some written work. If students were allowed to conference about their drawings with their classmates, like in studies produced by Sibley and Eshach, students would gain further opportunity to voice and clarify their mental models. In addition, the student drawings may have demonstrated further evidence of student understanding if students were required to describe their drawings in writing. This use of written explanation of student drawings was shown to be quite effective in a similar study about groundwater misconceptions by Daniel P. Shepardson (2005). Overall, Ben-zvi-Assarf and Orion demonstrated an effective model of student misconception identification with their study.

Upon a thorough review of the literature related to student misconceptions in science, it can be concluded that student misconceptions are prevalent in the classroom and present as significant barriers to learning. Students enter the classroom with preconceived notions about scientific concepts based on their interactions with the world around them. They are comfortable with and confident in these personally constructed concepts and are therefore resistant to changing them for those accepted by the scientific community. Due the reluctance of students to amend their misconceptions, a targeted and intensive approach must be taken to effectively remediate them. The articles examined by this paper serve as evidence that research-based methods aimed at identifying and addressing specific misconceptions can be highly successful.

In an effort to identify how to best remediate science misconceptions in the classroom, this paper focused on evaluating the methods of several studies that did just that. The first four articles dealt with the Conceptual Change Model, which both identifies and addresses misconceptions. Because proper identification of misconceptions is such an integral part of the CCM, the second set of studies served to supplement the CCM articles with additional methods for identifying misconceptions. Upon a thorough examination of the methods used by each study, some overarching themes arose regarding successful identification and instruction related to student misconceptions:

- Students should be allowed to express their ideas about scientific concepts in a variety of ways (i.e., drawing, model-building, writing, discussions, questionnaires, etc.) in order to let them fully relay their understanding (Prokop, 2006).
- Instruments designed to identify misconceptions must be explicit in nature and not cause further confusion. The directions for all tasks must be specific and the necessary scaffolding must be provided to assist students through the desired activities (Panagiotaki, 2009).
- Students should be given multiple opportunities to reevaluate their ideas about scientific concepts throughout the learning cycle. The resiliency of misconceptions requires constant analysis and adjustment of thinking in order for corrections to take place (Steer, 2005).
- Conceptual change texts that take into account the reading level, interests, and socio-cultural background of the student population in the classroom should be used (Mbajiorgu, 2006).

- The instructional process should include some form of social constructivism to allow students opportunities to verbalize, compare/contrast, and clarify their mental models about scientific concepts (Eshach, 2009).
- Proper research should be conducted on common misconceptions specific to the scientific concept to be covered prior to instruction. This research allows for preparation of necessary explanations and materials required to combat misconceptions (Stepans, 2003).

When sound educational practices such as these are enlisted in the classroom, student misconceptions are identified and remediated effectively. Student engagement and performance are enhanced dramatically because students are given the opportunity to see the flaws in their mental models and correct them accordingly. I propose that all teachers become familiar with the effective methods for identifying and addressing student misconceptions and use them on a consistent basis in their classrooms.

What is a conceptual change text?

According to the review of the literature on effective implementation of the conceptual change method, conceptual change texts are an effective tool for remediating science misconceptions. According to Hynd and Alverman, conceptual change texts are texts that specifically confront student held misconceptions through presenting readers with common misconceptions and also the correct scientific explanation of a concept (as cited in, Durmus & Bayraktar, 2010). Conceptual change texts are different from traditional textbooks because they target the reader's specific misconceptions and force the reader to confront them (Cetingul & Geban, 2011). Conceptual change text styles may vary from author to author but the overall format remains the same. The reader is first asked a question or asked to make a prediction about a scientific concept. Secondly, the reader is presented with commonly held misconceptions about the concept. When the reader sees similarity in his or her thinking, cognitive dissonance takes place and the need for correction is realized (Durmus & Bayraktar, 2010). Thirdly, the reader is given a correct explanation of the concept. Finally, the reader is asked to answer questions that solidify understanding and demonstrate accurate remediation of their prior misconceptions (Ozkan & Selcuk, 2013). This process of the conceptual change text successfully fulfills Posner's requirements for conceptual change: creates dissatisfaction with the original misconception and provides the reader with an explanation that is intelligible, plausible, and fruitful (Posner et al, 1982).

Implementation of Conceptual Change Texts

Conceptual change texts can be used in any science classroom from elementary school to college courses (Ozkan & Selcuk, 2013). Students can utilize these texts both at home and in the classroom but it is suggested that they be used in the classroom under the direction of a teacher. The research suggests that it is most effective to allow students to read each section silently and then to pause for class discussion after each section (Cetingul & Geban, 2011). During discussion students can express their thoughts and clarify their own thinking through social constructivism (Sungur, Tekkaya, & Geban, 2001). Another benefit of pausing at each section is that it allows the teacher to provide clarification and summarize key points for struggling readers. Some authors say it is best to hand out the different sections of the conceptual change texts one section at a time. This is because some students go ahead and read explanations prior to formulating their own thoughts about the associated scientific concept. Other authors say it is fine to just remind students not to read ahead. At the end of the text, students are asked to answer a series of questions to indicate if they have developed an accurate understanding of the scientific concept. Teachers should collect and analyze the questions to determine where their students are struggling and adjust instruction accordingly. Conceptual change texts are not meant to replace other forms of instruction such as demonstrations, laboratory activities, computer simulations, etc (Cetingul & Geban, 2011). The conceptual change texts should be used in conjunction with these other practices and are meant to cause students to analyze their scientific thinking for possible errors.

Benefits of Conceptual Change Texts

Conceptual change texts have been found to be effective for correcting student misconceptions across all of the major scientific fields. Several studies have found conceptual change texts to be more effective than standard instruction for correcting misconceptions in science topics such as but not limited to: particles and matter (Beerenwinkel, Parchman, & Grasel, 2011, Durmus & Bayraktar, 2010), air pressure (Akbas & Gencturk, 2011), sound (Ozkan & Selcuk, 2013), acids and bases (Cetingul & Geban, 2011, Demircioglu, 2009), cellular respiration (Al khawaldeh & Al Olaimat, 2010), nature of science (Cepni & Cil, 2010), chemical bonding (Pabuccu & Geban, 2012), human circulatory system (Sungur et al., 2001), solutions (Uzuntiryaki & Geban, 2005), and ecology (Ozkan, Tekkaya, & Geban, 2004). These studies were found to be effective in three main ways. First, the conceptual change texts successfully identified for both the teachers and students what misconceptions existed. This set the stage for students to begin to correct their thinking but also demonstrated to teachers how they needed to adjust their instruction. Secondly, the texts provided students with accurate and plausible explanations that replaced their previous misconceptions. Thirdly, research conducted weeks after the initial studies were conducted showed that experimental groups who utilized conceptual change texts exhibited better retention of the scientific concepts (Durmus & Bayraktar, 2010).

This finding makes logical sense as previous research on misconceptions shows that most students return to their initial misconceptions about a science topic unless their misconceptions are directly refuted. The studies mentioned above are evidence that simply providing students with an accurate explanation of a scientific concept is not enough. Conceptual change texts are a very necessary tool for remediation of student-held misconceptions.

Addressing the Possible Downfalls of Conceptual Change Texts

No one educational tool is without some downfalls and this is also true of conceptual change texts. One possible shortcoming of conceptual change texts is the issue of accessibility for students who struggle in the areas of reading and writing (Guzzetti, 1995). Conceptual change texts require students to both read passages and respond in written format which can be quite challenging for students who read below grade level or have writing deficits. To address this issue, it is advised that teachers guide students through the individual sections of the conceptual change texts and stop to paraphrase and discuss the readings with the entire class. This practice is beneficial for all students in the classroom as it allows for discussion and clarification. It is also suggested that conceptual change texts include pictures that help to engage students and help to explain the reading.

Another potential downfall of conceptual change texts is the possibility that students' answers to the questions can be influenced by their peers during class discussions. Discussions that take place at specific points of the conceptual change texts are supposed to provide clarification and social constructivism but sometimes lead to students changing their answers to conform to that of higher achieving students within the class for fear of being wrong (Cepni & Cil, 2010). This defeats the purpose of the conceptual change texts as they depend on honest reflection. These occurrences can be remediated by providing students with a solid explanation of the purpose of a conceptual change text. Students should be encouraged to be honest and reassured that their initial misconceptions are not failures but opportunities for growth.

A third critique of conceptual change texts is that they are not one hundred percent effective in remediating misconceptions, most studies find that a small percentage of students retain their initial misconceptions despite reading the texts (Sungur et al., 2001). This is not surprising as the research describes misconceptions as "student-generated, influenced by social interactions, similar throughout the student population, persistent, and not easily changed (Eaton, Anderson, & Smith, 1983)." Taking into account the difficulty of overcoming misconceptions, conceptual change texts should be considered rather effective. So effective that Guzzetti (2000, p.95) stated that "the most effective way we know of changing students' alternative conceptions is by reading and discussing refutational expository text."

Implications

The above literature review firmly establishes that conceptual change texts are an effective method for remediating student misconceptions about scientific concepts. It also yields several characteristics that these conceptual change texts must have to be effective. These themes or characteristics include: multiple modalities, explicit directions/scaffolding, multiple opportunities for reflection/analysis, social constructivism, research on specific misconceptions. Based on the findings of the literature review, the conceptual change texts produced by this project include all of these characteristics. The conceptual change texts include multiple modalities of learning by including discussion, text, videos, hands-on experiments, and artistic creativity. The texts include section-by-section scaffolding through the conceptual change process with specific instructions that intentionally assist students towards better understandings of the science concepts. Social constructivism is utilized through partner reading activities, discussions, and group experiments. Finally, all the conceptual change texts produced by this project are supported by academic research on misconceptions. Teachers are given a research-based explanation of why students struggle with each scientific concept and some common misconceptions to look out for among their students.

Chapter III: Project Design

Chapter Overview

This chapter features the conceptual change texts inspired by the literature review from chapter 2. Each conceptual change text covers one topic or concept from the New York State Intermediate Level Science Curriculum. A formal lesson plan precedes each text and serves to provide teachers with instructions on how to use the texts in their classrooms. The lesson plans also include research about why students struggle with the associated concept and common misconceptions students in their classroom are likely to possess. The conceptual change texts themselves come in two versions. Version I is the standard worksheet and Version II is modified to assist students who struggle with reading. Each conceptual change is followed by a rubric to help teachers assess student conceptions of the scientific concepts.

Why this Project is Unique

This project is unique because it provides teachers with ready-to-use conceptual change texts. A large amount of research has been conducted about conceptual change texts but there are limited conceptual change texts available to teachers. The texts produced by this project are especially unique because they are grounded in research and provide teachers with an understanding of why students may possess misconceptions about a particular science concept. The texts serve as comprehensive resources that provide the necessary questions, texts, activities, demonstrations, videos, and rubrics required to address student misconceptions. A quality conceptual change text requires a great deal of time and energy to produce and the texts provided by this project aim to take that workload off of the teacher and provide students with high quality instruction.

Project Components

I. **The Reasons for the Seasons**
   a. Lesson Plan
   b. Version I Worksheet
   c. Version II Worksheet
   d. Rubrics

II. **The Water Cycle**
   a. Lesson Plan
   b. Version I Worksheet
   c. Version II Worksheet
   d. Rubrics

III. **Earth's Structure**
   a. Lesson Plan
   b. Version I Worksheet
   c. Version II Worksheet
   d. Rubrics

IV. **Moon Phases**
   a. Lesson Plan
   b. Version I Worksheet
   c. Version II Worksheet
   d. Rubrics

V. **Rock Cycle**
   a. Lesson Plan
   b. Version I Worksheet
   c. Version II Worksheet
   d. Rubrics

VI. **Air Pressure**
   a. Lesson Plan
   b. Version I Worksheet
   c. Version II Worksheet
   d. Rubrics

VII. **Earthquakes**
   a. Lesson Plan
   b. Version I Worksheet
   c. Version II Worksheet
   d. Rubrics

I. The Reasons for the Seasons

NYS Standards:

Standard 4: The Physical Setting.

Key Idea 1 - The Earth and celestial phenomena can be described by principles of relative motion and perspective.

1.1i The tilt of Earth's axis of rotation and the revolution of Earth around the Sun cause seasons on Earth. The length of daylight varies depending on latitude and season.

Next Generation Science Standards:

MS-ESS1-1 Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of the seasons.

Background Research:

The reasons for the seasons is quite possibly one of the most popular scientific concepts associated with misconceptions. It was made even more popular with the release of the documentary film "A Private Universe" in which Harvard graduates were asked to explain some basic scientific concepts. The film demonstrated that even the brightest minds of our nation have misconceptions about everyday scientific concepts, the reasons for the seasons being one of the most apparent (Metz, 2011). It is no wonder that if even Harvard graduates struggle to understand the concept of seasons that our general population of students struggles too.

Research shows that students struggle with the concept of the reasons for the seasons because it requires students to have a solid foundational knowledge of several different concepts. Students need a thorough understanding of:

- The Earth's rotation and the Sun's apparent path through the sky.
  (Students must understand that when the sun is higher in the sky, it has a longer path which results in more sunlight. More hours of sunlight result in higher temperatures.)

- The true shape of the Earth's orbit around the sun.
  (Students must understand that Earth's orbit is only slightly elliptical and does not cause the Earth to be significantly further away from the Sun at any point.)

- Angle of insolation/solar intensity/temperature change.
  (Students must understand that when the sun is higher in the sky, it's rays are more direct and therefore more intense. More intense sunlight results in higher temperatures.

Not only do students need a solid understanding of the above concepts but they must also be able to apply the understandings simultaneously to grasp the entire seasons concept.

In addition to foundational knowledge, students must have sufficient visual-spatial skills in order to visualize both the earth-based and space-based perspectives simultaneously. Students have to be able to picture the Earth rotating while simultaneously revolving around the Sun at a constant tilt of 23.5 degrees. At the same time they must consider the effects of these motions have from the Earth's perspective to grasp why the seasons are changing.

The multiple demands of accurate foundational knowledge, simultaneous application of this knowledge, and the need for sufficient visual-spatial skills combine to make the reasons for the seasons a very difficult concept for students to understand. This difficulty often results in students possessing significant misconceptions about the reasons for the seasons. Although there are many student misconceptions about why we have seasons, listed below are a few of the most common that teachers should look for in their classrooms:

- The Sun is further away from the Earth in winter and closer to the Sun in summer (Baxter, 1989).

- We have seasons because large amounts thick clouds block the sun from heating up the earth (Baxter, 1989).

- Seasons are caused by the Sun moving to different sides of the earth. Summer follows the Sun (Baxter, 1989).

- The earth's tilt changes, which causes the amount of sunlight hitting different parts of the earth's surface to change. This then causes the seasons to change in response (Sneider, 2011).

Objectives:

Students will:

- Identify their personal conceptions of the reasons for the seasons.
- Compare their personal conceptions to the scientifically accurate explanation of why we have seasons.
- Evaluate the effectiveness of the presented explanation and modify their previously held conceptions if necessary.
- Explain the reasons for the seasons.

Materials:

- "Reasons for the Seasons" conceptual change text worksheet (Version I&II)
- Access to internet for video clips in worksheet
- Flashlight
- Globe
- Tape

Lesson Summary:

This lesson utilizes a conceptual change text to help students remediate their misconceptions associated with the reasons for the seasons. There are two versions of the text (Version I&II). Version II is modified to assist students with difficulties in the areas of reading and writing.

Section 1 asks students to explain the reasons for the seasons and complete a diagram that demonstrates the seasons. Prior to students answering this section, the teacher should explain to the students that they should not be afraid to get the answer wrong. The goal of this section is simply to recognize their current thoughts about the reasons for the seasons so they can improve upon them. The students should do this section individually, as misconceptions might not be detected if students are influenced by their peers.

Section 2 presents students with some common misconceptions surrounding the reasons for the seasons. This section should either be read by the teacher aloud to the students or students should be given the option to read with a partner. Partner reading will allow struggling readers to have the support of a classmate. Stronger readers should also be allowed to read ahead if they choose. Students should close this section by discussing with their partners how their initial answers compared to the misconceptions.

Section 3 presents students with the correct explanation of the reasons for the seasons.The teacher should either read this section with the entire class or give students the option to read in their partner groups. The teacher should also summarize the main concepts within the section and provide clarification through facilitating a class discussion.

Section 4 includes 2 videos and a series of questions that scaffold them in writing down their new conception of the reasons for the seasons. The teacher should play one or both of the videos and then have the students answer the questions. Students should work independently on this section as the goal is to get an accurate assessment of their knowledge.

Section 5 features a hands-on group activity in which they create a kinesthetic model of the changing seasons. It is suggested that this section be used as an extension activity. This way, students who struggle and need more time can spend more time on the reading and writing sections and not feel pressured for time. It also provides the other students with some enrichment and an alternate mode of displaying their new knowledge.

Modifications/Differentiation:

This lesson is designed for student groups of various ability levels. In particular, it has been modified to assist students who struggle with reading and writing. The lesson worksheet comes in two versions, Version I and Version II. Version II is to be given to students who struggle with reading and writing and includes the following modifications:

- Bolded and Underlined key terms.
- Shortened readings with simpler language and structure.
- Word Banks
- Additional diagrams
- Multiple Choice Questions

This lesson includes elements of differentiation by giving students choice in utilizing partner or independent work. It also differentiates by providing an extension activity for students who finish early (Section 5).

Rationale:

This lesson utilizes a conceptual change text to serve as formative assessment of student understanding of the reasons for the seasons. As indicated by the above research, students typically have many misconceptions about the reasons for the seasons. The conceptual change text in this lesson provides students the opportunity to critically analyze their conceptions and then provides scaffolding to assist them in correcting any misconceptions they may have. The student responses to the questions are to be used as a formative assessment tool by the teacher as well. By reading the student responses, teachers can determine what misconceptions about the reasons for the seasons exist in their classroom and adjust their instruction accordingly.

References

Baxter, J. (1989). Children's Understanding of Familiar Astronomical Events. *Int. J. Sci. Educ., 11*, 502.

Metz, S. (2011). Private Worlds. *Science Teacher*, *78*(4), 6.

Sneider, C., and Bar, V. (2011). Learning about Seasons: A Guide for Teachers and Curriculum Developers," *Astronomy Education Review*, 10, 010103-1, 10.3847/AER2010035

Version I
Name: ______________________________ Period: ___________

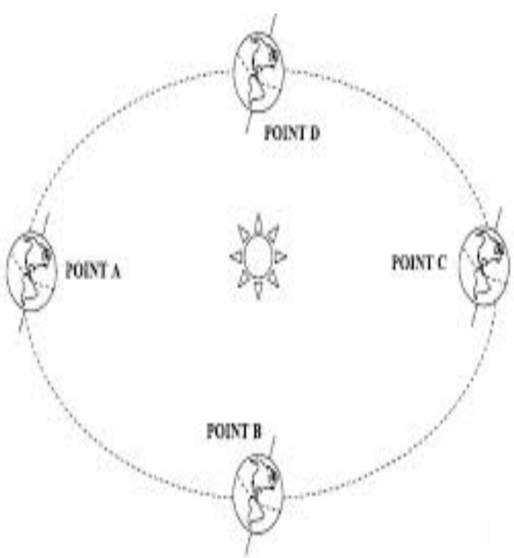
Check Your Misconceptions: The Reasons for the Seasons

SECTION 1: What do you think?

In New York State we have four different seasons. Winter comes first and has the shortest days (fewest hours of daylight) with cold temperatures. Then we have spring where days start to get longer and temperatures are mild. Next comes summer where days are the longest (most hours of sunlight) and temperatures are the highest. Finally, fall arrives and days begin to shorten and temperatures drop again. This cycle continues to give us our four seasons every year.

As you can see, there are strong connections between sunlight, temperature, and earth's seasons.

Below is a diagram of the earth traveling around the sun. Your task is to label the season that New York State is experiencing for each of the four locations. Then answer the question that follows.



A. _____________ B. _____________ C. ______________ D. ______________

What do you think causes New York State to have four different seasons?

How well do you think you understand the reasons for the seasons? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

SECTION 2: Common Mistakes

Many students incorrectly think that...

MISCONCEPTIONS	
X	Changes in seasons are caused by changes in the distance between the earth and the sun. When the earth is closest to the sun it is warmer, and therefore it is summer. When the earth is farthest away from the sun it is colder, and therefore it is winter (CS Monitor, 2013).
X	The earth's tilt changes, which causes the amount of sunlight hitting different parts of the earth's surface to change. This then causes the seasons to change in response (Sneider, 2011).
X	We have seasons because large amounts thick clouds block the sun from heating up the earth (Baxter, 1989).
X	Seasons are caused by the Sun moving to different sides of the earth. Summer follows the Sun (Baxter, 1989).

Compare your answer to the incorrect ideas above. What are some similarities and/or differences between them and your answer from Section 1?

* Discuss with your partner the similarities and differences you found.

In what ways has your thinking about the reasons for the seasons changed during this lesson?

How well do you think you understand the reasons for the seasons? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding) ______________

SECTION 3: The Correct Answer

The reason we experience the four seasons in New York State is mostly due to the constant tilt of the earth's axis. The earth's axis or the pivotal point, at which the earth spins, is always tilted at an angle of 23.5 degrees. As the earth revolves or travels around the sun, the tilt remains parallel to itself. In other words, the earth rotates and revolves around the sun but the tilt angle remains the same.

As the earth travels around the sun, New York is pointed towards the sun at some points and away from the sun at other points. When New York is pointed towards the sun, the sun has a longer path through our sky. This longer path results in more hours of sunlight. In addition to more hours of sunlight, the angle of the sun's rays is also more direct when New York is pointed towards the sun. More direct solar rays result in more intense sunlight. The combination of more hours of sunlight and more intense sunlight result in higher temperatures for New York during the summer.

When New York is pointed away from the sun, it receives fewer hours of sunlight and less direct solar rays. Therefore New York experiences colder temperatures at these points of the earth's orbit around the sun. Spring and Fall experience milder temperatures because the amount and intensity of sunlight New York receives is less extreme.

Specific points on the earth's path or calendar dates are used as markers for the beginning of a new season. In New York State, the spring season starts on *March 21st*, which is called the *vernal equinox*. During an equinox the sun is directly over the equator, which results in equal hours of day and night. On June 21st the seasons change from spring to summer, which is called the summer solstice. This is the longest day of the year in New York because it is the day at which the northern hemisphere is the most angled towards the sun. The end of summer and the beginning of fall occurs on September 21st, this day is called the autumnal equinox and again results in equal hours of day and night. Finally the cycle is completed with the beginning of winter on December 21st, which is called the winter solstice. This day is the shortest day of the year in New York because the northern hemisphere is pointed the furthest away from the sun.

SECTION 4: A little more explanation.

In order to further your understanding, watch these two videos and then answer the questions that follow.

Videos:
Earth's Tilt 1: The Reason for the Seasons
http://www.youtube.com/watch?v=Pgq0LThW7QA
Bill Nye - Seasons

http://www.youtube.com/watch?v=yQ34-2cuzfY

Answer the following questions. Refer to the reading in Section 3 for help.

1) At what angle is the Earth's axis tilted?

____

2) Describe the tilt of the Earth as it revolves around the Sun.

____

____

3) What is the Earth tilted towards during the summer in New York?

____

3) Name two factors from the reading that cause higher temperatures in New York during the summer.

____

Considering the new information that you have learned, answer the following question for the second time.

Explain the reasons for the seasons?

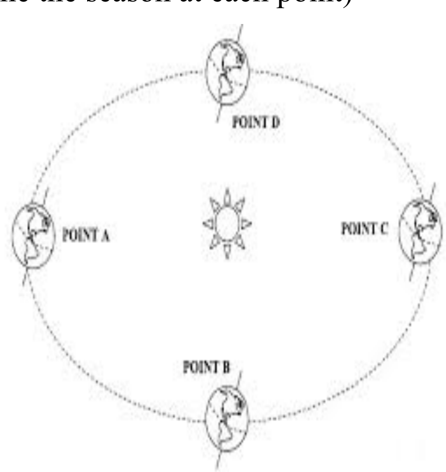
____

____

____

____

Complete the diagram for a second time. Make any necessary corrections from before.
(Name the season at each point)



A. ______________ B. ______________ C. _______________ D. _______________

In what ways has your thinking about the reasons for the seasons changed during this lesson?

____

____

____

How well do you think you understand the reasons for the seasons? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 5: Extension activity (Hands-on!)

For further experience with "The Reason for the Seasons" try this hands-on activity. Break into small groups (2-4 students) and use a flashlight, a globe, and some tape to demonstrate the change of the seasons. Some key words to use and demonstrate include:

-tilt	-spring, summer, fall, winter
-axis	-sun
-rotate	-earth
-revolve	-daylight
-orbit	-direct/indirect

References:

American Association for the Advancement of Science (AAAS). 2014. *The Four Seasons*. Retrieved from http://sciencenetlinks.com/lessons/the-four-seasons/

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Nye, B., McKenna, J., Gottlieb, E. Bill Nye Seasons. Retrieved from http://www.youtube.com/watch?v=yQ34-2cuzfY

Sneider, C., and Bar, V. (2011). Learning about Seasons: A Guide for Teachers and Curriculum Developers. *Astronomy Education Review*, 10, 010103-1, 10.3847/AER2010035

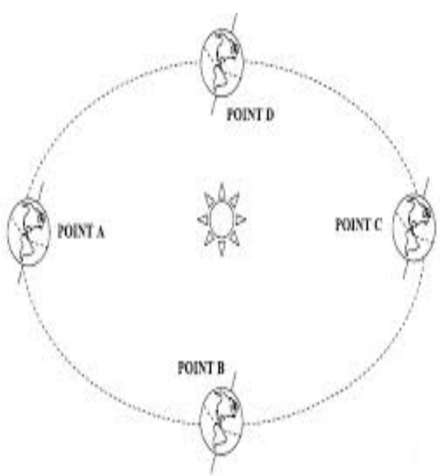
Version II
Name: ______________________________ Period: ___________

Check Your Misconceptions: The Reasons for the Seasons

SECTION 1: What do you think?

In New York State we have four different seasons. **Winter** comes first and has the shortest days (fewest hours of daylight) with cold temperatures. Then we have **spring** where days start to get longer and temperatures are mild. Next comes **summer** where days are the longest (most hours of sunlight) and temperatures are the highest. Finally, **fall** arrives and days begin to shorten and temperatures drop again. This cycle continues to give us our four seasons every year.
As you can see, there are strong connections between **sunlight, temperature, and earth's seasons**.

Below is a diagram of the earth traveling around the sun. Your task is to label the season that New York State is experiencing for each of the four locations.



A. ____________ B. _____________ C. ______________ D. ______________

Word Bank:

Fall	Winter	Spring	Summer

What do you think causes New York State to have four different seasons?

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How well do you think you understand the reasons for the seasons? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 2: Common Mistakes

Read this section with your reading partner.

Many students incorrectly think that...

MISCONCEPTIONS	
X	Changes in seasons are caused by changes in the distance between the earth and the sun. When the earth is closest to the sun it is warmer, and therefore it is summer. When the earth is farthest away from the sun it is colder, and therefore it is winter (CS Monitor, 2013).
X	The earth's tilt changes, which causes the amount of sunlight hitting different parts of the earth's surface to change. This then causes the seasons to change in response (Sneider, 2011).
X	We have seasons because large amounts thick clouds block the sun from heating up the earth (Baxter, 1989).
X	Seasons are caused by the Sun moving to different sides of the earth. Summer follows the Sun (Baxter, 1989).

Compare your answer to the incorrect ideas above. What are some similarities and/or differences between them and your answer from Section 1.

* Discuss with your partner the similarities and differences you found.

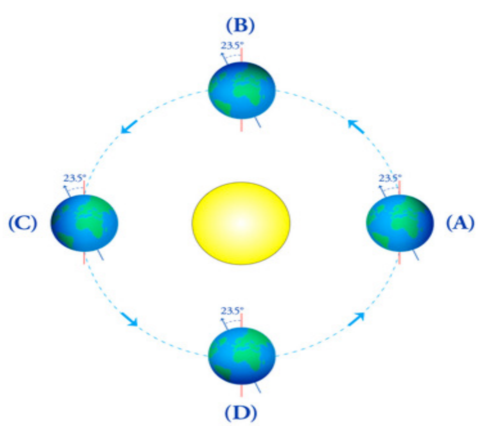
In what ways has your thinking about the reasons for the seasons changed during this lesson?

How well do you think you understand the reasons for the seasons? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

SECTION 3: The Correct Answer

Read this section with your reading partner

The reason we experience the four seasons in New York State is mostly due to the **constant tilt** of the earth's axis. The earth's axis or the pivotal point, at which the earth spins, is always tilted at an angle of **23.5 degrees**. As the earth **revolves** or travels around the sun, the tilt remains parallel to itself. In other words, the earth rotates and revolves around the sun but the tilt angle remains the same.



As the earth travels around the sun, New York is pointed towards the sun at some points and away from the sun at other points. When New York is pointed towards the sun, the sun has a longer path through our sky. This longer path results in **more hours of sunlight**.

In addition to more hours of sunlight, the angle of the sun's rays is also more direct when New York is pointed towards the sun. **More direct solar rays** result in more intense sunlight. The combination of more hours of sunlight and more intense sunlight result in higher temperatures for New York during the summer.

When New York is pointed away from the sun, it receives fewer hours of sunlight and less direct solar rays. Therefore New York experiences colder temperatures at these points of the earth's orbit around the sun. Spring and summer experience milder temperatures because the amount and intensity of sunlight New York receives is less extreme.

SECTION 4: A little more explanation.

In order to further your understanding, watch these two videos and then answer the questions that follow.

Videos:
Earth's Tilt 1: The Reason for the Seasons
http://www.youtube.com/watch?v=Pgq0LThW7QA
Bill Nye - Seasons
http://www.youtube.com/watch?v=yQ34-2cuzfY

Answer the following questions. Refer to the reading in Section 3 for help.

1) At what angle is the earth's axis tilted?
    a. 45 degrees
    b. 15 degrees
    c. 360 degrees
    d. 23.5 degrees

2) As the earth travels around the sun, the tilt of the Earth's axis…
    a. remains the same
    b. increases in the summer
    c. decreases in the summer

3) During the summer, New York is tilted…
    a. towards the Sun
    b. away from the Sun

4) Circle **two** factors that cause higher temperatures in the summer.
    a. There are more hours of daylight
    b. There are fewer clouds to block the Sun.
    c. The Earth is closer to the Sun.

d. The sunlight is more direct in the summer.

Considering the new information that you have learned answer the next question again.

Explain the reasons for the seasons?

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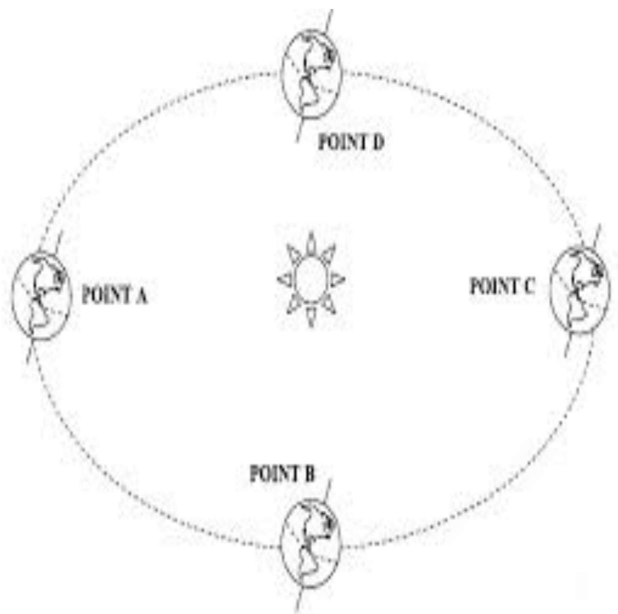
Complete the diagram for a second time. Make any necessary corrections from before.
(Name the season at each point)



A. _____________ B. _____________ C. ______________ D. ______________

Fall	Winter	Spring	Summer

In what ways has your thinking about the reasons for the seasons changed during this lesson?

How well do you think you understand the reasons for the seasons? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

Complete this section only if time allows.

SECTION 5: Extension activity (Hands-on!)

For further experience with "The Reason for the Seasons" try this hands-on activity. Break into small groups (2-4 students) and use a flashlight, a globe, and some tape to demonstrate the change of the seasons. Some key words to use and demonstrate include:

-tilt	-spring, summer, fall, winter
-axis	-sun
-rotate	-earth
-revolve	-daylight
-orbit	-direct/indirect

References:

American Association for the Advancement of Science (AAAS). 2014. *The Four Seasons*. Retrieved from http://sciencenetlinks.com/lessons/the-four-seasons/

MIT + K12 videos. 2014. Earth's Tilt 1: The Reason for the Seasons. Retrieved from http://www.youtube.com/watch?v=Pgq0LThW7QA

Nye, B., McKenna, J., Gottlieb, E. Bill Nye Seasons. Retrieved from http://www.youtube.com/watch?v=yQ34-2cuzfY

Sneider, C., and Bar, V. (2011). Learning about Seasons: A Guide for Teachers and Curriculum Developers. *Astronomy Education Review*, 10, 010103-1, 10.3847/AER2010035

Reasons for the Seasons Rubric #1

Score	4	3	2	1
Axial Tilt	Student describes the tilt of the Earth as a constant 23.5 degrees.	Student describes the Earth's axis as tilted but does not include the accurate angle of 23.5 degrees. The student also states that the tilt is constant.	Student describes the Earth as tilted but does not accurately state the angle of tilt. Student does not state that the tilt is constant.	Student does not describe the Earth's axis as tilted.
Revolution	Student explains that the Earth revolves around the Sun with its axis remaining parallel to itself and results in the hemispheres being pointed more towards the sun at different times.	Student explains that the Earth revolves around the Sun which results in different parts of the Earth being pointed more towards the Sun at different times.	Student states that the Earth revolves around the Sun.	Student does not state that the Earth revolves around the Sun or incorrectly states that the Sun revolves around the Earth.
Hours of Sunlight	Student expresses that the amount of hours of Sunlight the Earth receives from the Sun is affected by the tilt of the Earth ***and*** the position of Earth in its orbit around the Sun. More hours of sunlight results in higher temperatures and fewer hours results in lower temperatures.	Student expresses that the amount of hours of Sunlight the Earth receives from the Sun is affected by the tilt of the Earth ***or*** the position of Earth in its orbit around the Sun. More hours of sunlight results in higher temperatures and fewer hours results in lower temperatures.	Student expresses that the amount of hours of Sunlight the Earth receives from the Sun is affected by the tilt of the Earth ***or*** the position of Earth in its orbit around the Sun. Student does not state how hours of sunlight affects temperature.	Student does not make mention of either the cause or the affect of hours of sunlight received from the Sun.
Intensity of Sunlight	Student expresses that the angle of the Sun's rays is affected by the tilt of the Earth ***and*** the position of Earth in its orbit around the Sun. More direct solar rays result in more intense sunlight and higher temperatures. (The opposite is also true.)	Student expresses that the angle of the Sun's rays is affected by the tilt of the Earth ***or*** the position of Earth in its orbit around the Sun. More direct solar rays result in more intense sunlight and higher temperatures. (The opposite is also true.)	Student expresses that the angle of the Sun's rays is affected by the tilt of the Earth ***or*** the position of Earth in its orbit around the Sun. ***OR*** More direct solar rays result in more intense sunlight and higher temperatures. (The opposite is also true.)	Student does not make mention of either the cause or the affect of the angle of the Sun's rays/Intensity of Sunlight.

Score : _________ out of 16

Reasons for the Seasons Rubric #2

Score	4	3	2	1
Axial Tilt	Student describes the tilt of the Earth as a constant 23.5 degrees.	Student describes the Earth's axis as tilted but does not include the accurate angle of 23.5 degrees. The student also states that the tilt is constant.	Student describes the Earth as tilted but does not accurately state the angle of tilt. Student does not state that the tilt is constant.	Student does not describe the Earth's axis as tilted.
Revolution	Student explains that the Earth revolves around the Sun with its axis remaining parallel to itself and results in the hemispheres being pointed more towards the sun at different times.	Student explains that the Earth revolves around the Sun which results in different parts of the Earth being pointed more towards the Sun at different times.	Student states that the Earth revolves around the Sun.	Student does not state that the Earth revolves around the Sun or incorrectly states that the Sun revolves around the Earth.
Hours of Sunlight	Student expresses that the amount of hours of Sunlight the Earth receives from the Sun is affected by the tilt of the Earth ***and*** the position of Earth in its orbit around the Sun. More hours of sunlight results in higher temperatures and fewer hours results in lower temperatures.	Student expresses that the amount of hours of Sunlight the Earth receives from the Sun is affected by the tilt of the Earth ***or*** the position of Earth in its orbit around the Sun. More hours of sunlight results in higher temperatures and fewer hours results in lower temperatures.	Student expresses that the amount of hours of Sunlight the Earth receives from the Sun is affected by the tilt of the Earth ***or*** the position of Earth in its orbit around the Sun. Student does not state how hours of sunlight affects temperature.	Student does not make mention of either the cause or the affect of hours of sunlight received from the Sun.
Intensity of Sunlight	Student expresses that the angle of the Sun's rays is affected by the tilt of the Earth ***and*** the position of Earth in its orbit around the Sun. More direct solar rays result in more intense sunlight and higher temperatures. (The opposite is also true.)	Student expresses that the angle of the Sun's rays is affected by the tilt of the Earth ***or*** the position of Earth in its orbit around the Sun. More direct solar rays result in more intense sunlight and higher temperatures. (The opposite is also true.)	Student expresses that the angle of the Sun's rays is affected by the tilt of the Earth ***or*** the position of Earth in its orbit around the Sun. ***OR*** More direct solar rays result in more intense sunlight and higher temperatures. (The opposite is also true.)	Student does not make mention of either the cause or the affect of the angle of the Sun's rays/Intensity of Sunlight.

Score : __________ out of 16

Change in Score: __________

II. Water Cycle

NYS Science Standards:

STANDARD 4: The Physical Setting
Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.
2.1j Water circulates through the atmosphere, lithosphere, and hydrosphere in what is known as the water cycle.

Next Generation Science Standards:

ESS2.C: The Roles of Water in Earth's Surface Processes
Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4)

Background Research:

Proper student understanding of the water cycle is of great importance to our society. Knowing about where are water resources come from and how to manage our water supply is only possible if our society has a solid grasp of the water cycle. Most students have a general understanding of the water cycle but unfortunately many misconceptions exist preventing complete understanding of this essential natural cycle.

Research performed by Kali in 2003, indicates that proper understanding of the water cycle requires that students be familiar with the relationships that exist between all of Earth's spheres. Students must comprehend: the relationship between the Hydrosphere and Geosphere (infiltration, groundwater, erosion), the relationship between the Hydrosphere and the Atmosphere (evaporation and condensation), and the relationship between the Hydosphere, Biosphere, and Atmosphere (transpiration) (As cited in Ben-zvi-Assarf & Orion, 2005).

It is believed that the cause for many of the misconceptions surrounding the water cycle stem from an incomplete systemic understanding of the above mentioned relationships. Students often understand some but not all of the relationships. In other situations, students understand all of the individual relationships but cannot connect them to form a complete understanding of the water cycle. Some authors attribute this difficulty to improper instruction related to the water cycle while others attribute it to lack of cognitive readiness of most adolescents (Ben-zvi-Assarf & Orion, 2005).

In addition to the need for a systemic understanding of multiple Earth spheres, students struggle with understanding of the water cycle because many of its components are not readily visible. Students often struggle with the concept of groundwater because they do not directly witness infiltration and underground movements of water. Even students, who are made aware of the underground portion of the water cycle, still use their observations of the above ground hydrosphere to form their mental models (Marques & Thompson, 1997). Their mental models are simply an underground version of the hydrosphere. Lack of direct observation of groundwater processes make this component of the water cycle prone to causing misconceptions.

The systemic and abstract nature of the water cycle makes it a difficult concept for students to understand completely. The fragmented and sometimes inaccurate conceptions students hold lead to the generation of misconceptions. Although there are many student misconceptions regarding the water cycle, listed below are a few of the most common that teachers should look out for in their classrooms:

- Water above the ground and water in the ground are parts of two separate systems and do not interact (Ben-zvi-Assarf & Orion, 2005).

- Groundwater is static and does not move or flow (Ben-zvi-Assarf & Orion, 2005).

- Groundwater does not exist within rocks. It is in open spaces or beneath rocks. Groundwater is found in underground lakes (Ben-zvi-Assarf & Orion, 2005).

- Human activities are not part of or don't influence the water cycle (Ben-zvi-Assarf & Orion, 2005).

- Groundwater only exists in climates that have a large amount of rain (Ben-zvi-Assarf & Orion, 2005).

- Water evaporates only from the ocean or lakes. (Henriques, 2002)

Objectives:

Students will:

- Identify their personal conceptions of the water cycle.
- Compare their personal conceptions to the scientifically accurate explanation of the water cycle.
- Evaluate the effectiveness of the presented explanation and modify their previously held conceptions if necessary.
- Draw and explain the water cycle.
- Apply their knowledge of the water cycle during a hands-on activity.

Materials:

- Water Cycle Conceptual Change Text (Version I &II)
- Internet Access
- 500 ml glass beaker
- Plastic wrap
- Rubber band
- 250 ml hot water
- 4 ice cubes
- Safety goggles
- Beaker Tongs
- Clear 2-liter soda bottle
- Gravel
- Sand
- Water
- Coffee filter
- Drinking Straws
- Plastic bulb pipette

Lesson Summary:

This lesson utilizes a conceptual change text to help students remediate their misconceptions associated with the water cycle. There are two versions of the text (Version I&II). Version II is modified to assist students with difficulties in the areas of reading and writing.

Section 1 asks students to draw a diagram of the water cycle and then to describe the path that water takes through the water cycle in writing. Students are given several key terms associated with the water cycle to use in their diagram and written explanation. Prior to students answering this section, the teacher should explain to the students that they should not be afraid to get the answer wrong. The goal of this section is simply to recognize their current thoughts about the water cycle so they can improve upon them. The students should do this section individually, as misconceptions might not be detected if students are influenced by their peers.

Section 2 presents students with some common misconceptions surrounding the water cycle. This section should either be read by the teacher aloud to the students or students should be given the option to read with a partner. Partner reading will allow struggling readers to have the support of a classmate. Stronger readers should also be allowed to read ahead if they choose. Students should close this section by discussing with their partners how their initial answers compared to the misconceptions. The teacher should culminate this section by facilitating a class discussion about the misconceptions and provide any necessary clarification.

Section 3 presents students with the correct description of the water cycle. The section begins with a short video about the water cycle that serves to provide students with some background knowledge before the reading. Next comes the reading about the water cycle, the teacher should either read this section with the entire class or give students the option to read in their partner groups. The teacher should also summarize the main concepts within the section and provide clarification through facilitating a class discussion.

Section 4 requires to students to revisit their initial conceptions by redrawing the water cycle according to what they have learned during the lesson. They are also asked to rewrite their description of the water cycle. This reflection on their initial conceptions will cause them to further analyze any misconceptions they may have had and help to consolidate a new more accurate understanding of the water cycle. Section 4 closes with a few questions that ask them to state explicitly how their thinking has changed in regards to the water cycle and how confident they are in their understanding of the topic.

Section 5 includes three activities that serve as extension opportunities about the water cycle. These extension activities help students further their understanding of the water cycle by utilizing different modalities of learning and make the learning more relevant to their lives. This section provides differentiation by allowing students to choose what activities they will perform. It also provides differentiation for students of varying ability levels. Students who finish earlier will complete 2 out of the 3 activities while students who take longer to read and write in the earlier sections will only be required to complete one of the activities from this section.

Modifications/Differentiation:

This lesson is designed for student groups of various ability levels. In particular, it has been modified to assist students who struggle with reading and writing. The lesson worksheet comes in two versions, Version I and Version II. Version II is to be given to students who struggle with reading and writing and includes the following modifications:

- Bolded and Underlined key terms.
- Shortened readings with simpler language and structure.
- Word Banks
- Additional diagrams

This lesson includes elements of differentiation by giving students choice in utilizing partner or independent work. It also differentiates by providing a extension activities of varying lengths (Section 5).

Rationale:

This lesson utilizes a conceptual change text to serve as formative assessment of student understanding of the water cycle. As indicated by the above research, students typically possess misconceptions about the water cycle due to its systems perspective and abstract nature. The conceptual change text in this lesson provides students the opportunity to critically analyze their conceptions and then provides scaffolding to assist them in correcting any misconceptions they may have. The student responses to the questions are to be used as a formative assessment tool by the teacher as well. By reading the student responses, teachers can determine what misconceptions about the water cycle exist in their classroom and adjust their instruction accordingly.

References

Ben-zvi-Assarf, O., & Orion, N. (2005). A Study of Junior High Students' Perceptions of the Water Cycle. *Journal of Geoscience Education*, *53*(4), 366-373.

Henriques, L. (2002). Children's Ideas About Weather: A Review of the Literature. *California State University, Long Beach*, *102*(5), 206.

Marques, L., & Thompson, D. (1997). Misconceptions and conceptual changes concerning continental drift and plate tectonics among. *Research In Science & Technological Education*, *15*(2), 195.

Version I
Name: ______________________________ Period: ___________

Check Your Misconceptions: ***<u>The Water Cycle</u>***

SECTION 1: What do you think?

Planet Earth is known as the "Water Planet." Over 70% of the earth's surface is covered by water. However, 97% of that water is salt water, which is not easily consumable by humans. Of the remaining 3% that is freshwater, only a small portion is not frozen in ice caps and glaciers. We are left with a relatively small amount that can be used for our daily life functions. Water is necessary for drinking, cleaning, farming, transportation, recreation, and much more. You name it; water is probably involved some how.

Because water is so important, we should know all about it so we can make sure we will always have enough. Luckily, water is a renewable resource that is continuously cycled through the environment. A constant supply of water is available to us as long as we take care of it. In order to take care of our water resources we must understand how the Water Cycle works.

Let's take a moment to look at what we think we know about the Water Cycle. Draw a diagram of the paths water takes through the water cycle in the box below. Use as many of the following terms that you are familiar with to label what is happening in your diagram:

- **Condensation**
- **Runoff**
- **Infiltration**
- **Groundwater**
- **Transpiration**
- **Precipitation**
- **Evaporation**

Draw the Water Cycle in the box

Using as many terms as you can from above, describe how water is cycled through your diagram.

How well do you think you understand the water cycle? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

SECTION 2: Common Mistakes

Many students incorrectly think that...

MISCONCEPTIONS	
X	Water above the ground and water in the ground are parts of two separate systems and do not interact.
X	Groundwater is static and does not move or flow.
X	Groundwater does not exist within rocks. It is in open spaces or beneath rocks. Groundwater is found in underground lakes.
X	Human activities are not part of or don't influence the water cycle.
X	Groundwater only exists in climates that have a large amount of rain.
X	Water evaporates only from the ocean or lakes. (Henriques, 2002)

Compare your diagram and ideas about the Water Cycle to the incorrect ideas above. What are some similarities and/or differences between them and your thoughts about the Water Cycle?

*Discuss with your partner the similarities and differences you found.

In what ways has your thinking about the water cycle changed during this lesson?

How well do you think you understand the water cycle? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 3: The Correct Answer

Build your background knowledge of water cycle before the reading by watching this video.
https://www.youtube.com/watch?v=al-do-HGuIk

There is a fixed amount of water on planet Earth. Luckily it is constantly cycled and replenished by the Water Cycle. The ultimate driving force of the cycle is the energy provided by the Sun. Energy from the Sun evaporates water from rivers, lakes, oceans, and any other form of water on the Earth's surface. Water is also evaporated from plants through a process called transpiration.

Water vapor rises into the atmosphere and eventually condenses on tiny dust particles. When enough condensation occurs, a cloud is formed. When the droplets within the cloud become large enough, they fall to the earth as precipitation.

Precipitation, or rain, falls all over the earth's surface. Some rain falls directly onto water sources such as lakes or oceans but the rest falls on land. A portion of the rain that falls on land does not penetrate the surface and runs down hill towards a river, lake, or ocean. This water that runs across the land surface is called runoff.

The other portion of the precipitation that falls on Earth's surface actually makes its way into the ground through a process called infiltration. This water fills the pore spaces within rock layers below the surface and is called groundwater. Although groundwater is within the rock, it is constantly moving and remains part of the Water Cycle. Groundwater can eventually mix with rivers, lakes, and oceans or be pumped to the surface by man-made wells.

Humans have a significant impact on the natural flow of the water cycle. For example, large amounts of groundwater are extracted for drinking, farming, and industry by man-made wells. If humans pump water out of the ground faster than it is replaced by rainfall, it causes the water table to drop. The water table is uppermost level of underground rock saturated by groundwater. When this level drops, it becomes harder to pump and only deeper wells can produce water.

Another way humans impact the Water Cycle is through run-off pollution. Improper disposal of chemicals and leaks from automobiles pollute the earth's surface. When it rains, runoff pushes pollutants into our rivers, lakes, and oceans resulting in contamination of our water supply.

Answer the following questions about the above reading.

1) The ___________ provides the energy for the Water Cycle.

2) Water enters the atmosphere from rivers, lakes, and oceans through a process called ___________________.

3) The evaporation of water from plants is called ________________.

4) _____________ is the transformation of water vapor to water and results in the formation of clouds.

5) Water droplets return to the earth through a process called____________.

6) Rain that does not penetrate the earth's surface and flows over the land is called ____________.

7) Water fills the pore spaces of underground rock layers through the process of _______________.

8) Although groundwater can be deep below the Earth's surface, it is still part of the _______________.

9) Humans can deplete groundwater resources through the over use of man-made _____________.

10) Pollution can make its way into our water supply by ______________ water that travels over the earth's surface and mixes with harmful chemicals.

SECTION 4: Reflect and Reconsider

Now that you have learned more about the Water Cycle, redraw your diagram of the paths water takes through the Water Cycle. Use as many of the following terms in your diagram as you can.

- Condensation
- Infiltration
- Precipitation
- Runoff
- Groundwater
- Evaporation
- Transpiration

Draw the Water Cycle in the box

Using as many terms as you can from above, describe how water is cycled through your diagram.

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In what ways has your thinking about the water cycle changed during this lesson?

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How well do you think you understand the water cycle? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 5: Extension Activity

This section includes three hands-on activities that demonstrate key components of the Water Cycle. You are to choose any two to complete with a partner.

Activity #1 – Persuasive Poster

Create a poster to hang in the hallway at school that educates students about the issue of water resources. Describe some of the sources of water pollution and how our water supply can become contaminated. Discuss some ways that we can conserve our water. Include information and images that persuade people to take good care our water resources. Use the following websites to help you with your research.
http://water.epa.gov/polwaste/nps/kids/index.cfm
http://www.watereducation.utah.gov/conservation/default.asp
http://www.ducksters.com/science/environment/water_pollution.php
http://www.water-pollution.org.uk/

Activity #2 – Modeling Condensation

Perform the following experiment and draw a picture of what happens. Then write a short summary describing what happens during the experiment. Include the following terms in your description: Temperature, Water Vapor, Condensation, and Liquid Water.

Step 1. Collect the following materials.

- 500 ml glass beaker
- Plastic wrap
- Rubber band
- 250 ml hot water
- 4 ice cubes
- Safety goggles
- Beaker Tongs

Step 2. Put on safety glasses and pour hot water into beaker. Use beaker tongs when handling beaker. Cover beaker with plastic wrap and fasten plastic wrap with a rubber band. Place 3 to 4 ice cubes on top of plastic wrap and observe for a few minutes.

Step 3. Draw the experiment setup and what happened during your observation time.

Step 4. Write a brief description of what happened using the terms (temperature, water vapor, liquid water, and condensation).

Activity #3 – Create your own Groundwater Model

Materials

- Clear 2-liter soda bottle
- Gravel
- Sand
- Water
- Coffee filter
- Drinking Straws
- Plastic bulb pipette

Use the following materials to create your own groundwater model. Include a functioning well that can pump clean water out of the ground. Write a brief description of your model stating what the materials you used represent in real life.

References

http://www.nbclearn.com/water

Version II
Name: ______________________________ Period: ___________

Check Your Misconceptions: ***The Water Cycle***

  

SECTION 1: What do you think?

Planet Earth is known as the "Water Planet." Over 70% of the earth's surface is covered by water. However, 97% of that water is salt water, which is not easily consumable by humans. Of the remaining 3% that is freshwater, only a small portion is not frozen in ice caps and glaciers. We are left with a relatively small amount that can be used for our daily life functions. Water is necessary for drinking, cleaning, farming, transportation, recreation, and much more. You name it; water is probably involved some how.

Because water is so important, we should know all about it so we can make sure we will always have enough. Luckily, water is a renewable resource that is continuously cycled through the environment. A constant supply of water is available to us as long as we take care of it. In order to take care of our water resources we must understand how the Water Cycle works.

Let's take a moment to look at what we think we know about the Water Cycle. Draw a diagram of the paths water takes through the water cycle in the box below. Use as many of the following terms that you are familiar with to label what is happening in your diagram:

- Condensation
- Runoff
- Infiltration
- Groundwater
- Transpiration
- Precipitation
- Evaporation

Draw the Water Cycle in the box.

Using as many terms as you can from above, describe how water is cycled through your diagram.

How well do you think you understand the water cycle? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

SECTION 2: Common Mistakes

****Read this section with your reading partner.**

Many students incorrectly think that...

MISCONCEPTIONS	
X	Water above the ground and water in the ground are parts of two separate systems and do not interact.
X	Groundwater is static and does not move or flow.
X	Groundwater does not exist within rocks. It is in open spaces or beneath rocks. Groundwater is found in underground lakes.
X	Human activities are not part of or don't influence the water cycle.
X	Groundwater only exists in climates that have a large amount of rain.
X	Water evaporates only from the ocean or lakes. (Henriques, 2002)

Compare your diagram and ideas about the Water Cycle to the incorrect ideas above. What are some similarities and/or differences between them and your thoughts about the Water Cycle?

*Discuss with your partner the similarities and differences you found.

In what ways has your thinking about the water cycle changed during this lesson?

____

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How well do you think you understand the water cycle? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 3: The Correct Answer

Build your background knowledge of water cycle before the reading by watching this video.
https://www.youtube.com/watch?v=al-do-HGuIk

****Read the next section with your reading partner. Tip: Read the questions for each section before you read the paragraph to help give you a purpose.**

There is a fixed amount of water on planet Earth. Luckily it is constantly cycled and replenished by the Water Cycle. The ultimate driving force of the cycle is the energy provided by the Sun. Energy from the Sun **evaporates** water from rivers, lakes, oceans, and any other form of water on the Earth's surface. Water is also evaporated from plants through a process called **transpiration**.

1) The _____________ provides the energy for the Water Cycle.

2) Water enters the atmosphere from rivers, lakes, and oceans through a process called _____________________.

3) The evaporation of water from plants is called _____________________.

Word Bank:	transpiration	sun	evaporation

Water vapor rises into the atmosphere and eventually **condenses** on tiny dust particles. When enough condensation occurs, a cloud is formed. When the droplets within the cloud become large enough, they fall to the earth as **precipitation**.

4) _____________________ is the transformation of water vapor to water and results in the formation of clouds.

Word Bank:	precipitation	condensation	evaporation

Precipitation, or rain, falls all over the earth's surface. Some rain falls directly onto water sources such as lakes or oceans but the rest falls on land. A portion of the rain that falls on land does not penetrate the surface and runs down hill towards a river, lake, or ocean. This water that runs across the land surface is called **runoff**.

5) Water droplets return to the earth through a process called _____________________.

6) Rain that does not penetrate the earth's surface and flows over the land is called _________________.

Word Bank:	runoff	infiltration	precipitation

The other portion of the **precipitation** that falls on Earth's surface actually makes its way into the ground through a process called **infiltration**. This water fills the pore spaces within rock layers below the surface and is called **groundwater**. Although groundwater is within the rock, it is constantly moving and remains part of the water cycle. Groundwater can eventually mix with rivers, lakes, and oceans or be pumped to the surface by man-made wells.

7) Water enters the ground to eventually fill the pore spaces of rock layers through the process of _______________.

8) Although groundwater can be deep below the Earth's surface, it is still part of the ________________.

Word Bank:	water cycle	infiltration	precipitation

Humans have a significant impact on the natural flow of the water cycle. For example, large amounts of groundwater are extracted for drinking, farming, and industry by man-made wells. If humans pump water out of the ground faster than it is replaced by rainfall, it causes the water table to drop. The water table is uppermost level of underground rock saturated by groundwater. When this level drops, it becomes harder to pump and only deeper wells can produce water.

9) Humans can deplete groundwater resources through the over use of man-made ______________.

Word Bank:	dams	wells	reservoirs

Another way humans impact the Water Cycle is through run-off pollution. Improper disposal of chemicals and leaks from automobiles pollute the earth's surface. When it rains, runoff pushes **<u>pollutants</u>** into our rivers, lakes, and oceans resulting in contamination of our water supply.

10) Pollution can make its way into our water supply by ______________ water that travels over the earth's surface and mixes with harmful chemicals.

Word Bank:	stream	river	runoff

SECTION 4: Reflect and Reconsider

Now that you have learned more about the water cycle, redraw your diagram of the paths water takes through the water cycle. Use as many of the following terms in your diagram as you can.

- Condensation
- Infiltration
- Precipitation
- Runoff
- Groundwater
- Evaporation
- Transpiration

Draw the Water Cycle in the box.

Using as many terms as you can from above, describe how water is cycled through your diagram.

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In what ways has your thinking about the water cycle changed during this lesson?

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How well do you think you understand the water cycle? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 5: Extension Activity

This section includes three hands-on activities that demonstrate key components of the Water Cycle. You are to choose one to complete with a partner.

Activity #1 – Persuasive Poster

Create a poster to hang in the hallway at school that educates students about the issue of water resources. Describe some of the sources of water pollution and how our water supply can become contaminated. Discuss some ways that we can conserve our water. Include information and images that persuade people to take good care our water resources. Use the following websites to help you with your research.

http://water.epa.gov/polwaste/nps/kids/index.cfm
http://www.watereducation.utah.gov/conservation/default.asp
http://www.ducksters.com/science/environment/water_pollution.php
http://www.water-pollution.org.uk/

Activity #2 – Modeling Condensation

Perform the following experiment and draw a picture of what happens. Then write a short summary describing what happens during the experiment. Include the following terms in your description: Temperature, Water Vapor, Condensation, and Liquid Water.

Step 1. Collect the following materials.

- 500 ml glass beaker
- Plastic wrap
- Rubber band
- 250 ml hot water
- 4 ice cubes
- Safety goggles
- Beaker Tongs

Step 2. Put on safety glasses and pour hot water into beaker. Use beaker tongs when handling beaker. Cover beaker with plastic wrap and fasten plastic wrap with a rubber band. Place 3 to 4 ice cubes on top of plastic wrap and observe for a few minutes.

Step 3. Draw the experiment setup and what happened during your observation time.

Step 4. Write a brief description of what happened using the terms (temperature, water vapor, liquid water, and condensation).

Activity #3 – Create your own Groundwater Model

Materials

- Clear 2-liter soda bottle
- Gravel
- Sand
- Water
- Coffee filter
- Drinking Straws
- Plastic bulb pipette

Use the following materials to create your own groundwater model. Include a functioning well that can pump clean water out of the ground. Write a brief description of your model stating what the materials you used represent in real life.

References

http://www.nbclearn.com/water

Rubric for Water Cycle Diagram #1

Score	4	3	2	1
Elements of the Water Cycle	All of the parts of the Water Cycle are included in the diagram and are in the proper locations.	At least 5 out of the 7 parts of the Water Cycle are included in the diagram and are in the proper locations.	At least 3 out of the 7 parts of the Water Cycle are included in the diagram and are in the proper locations.	Less than 3 out of the 7 parts of the Water Cycle are in included in the diagram are in the proper locations.
Connectedness of the Water Cycle	A clear path is shown that properly connects the parts of the water cycle. The connections clearly show that the Water Cycle is a continuous and repeating cycle.	The majority of the water cycle is shown to be connected properly. The connections demonstrate that the Water Cycle is a continuous and repeating cycle.	Some connections between the parts of the Water Cycle are shown and the diagram demonstrates a continuous and repeating cycle.	A few connections between the parts of the Water Cycle may be shown but the diagram does not depict a continuous and repeating cycle.

Total Score: ________out of 8

Rubric for Water Cycle Diagram #1

Score	4	3	2	1
Elements of the Water Cycle	All of the parts of the Water Cycle are included in the diagram and are in the proper locations.	At least 5 out of the 7 parts of the Water Cycle are included in the diagram and are in the proper locations.	At least 3 out of the 7 parts of the Water Cycle are included in the diagram and are in the proper locations.	Less than 3 out of the 7 parts of the Water Cycle are in included in the diagram are in the proper locations.
Connectedness of the Water Cycle	A clear path is shown that properly connects the parts of the water cycle. The connections clearly show that the Water Cycle is a continuous and repeating cycle.	The majority of the water cycle is shown to be connected properly. The connections demonstrate that the Water Cycle is a continuous and repeating cycle.	Some connections between the parts of the Water Cycle are shown and the diagram demonstrates a continuous and repeating cycle.	A few connections between the parts of the Water Cycle may be shown but the diagram does not depict a continuous and repeating cycle.

Total Score: ________out of 8
Change in Score _______

III. Earth's Internal Structure – Earth's Layers

NYS Science Standards:

STANDARD 4: The Physical Setting

Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

2.2b Analysis of earthquake wave data (vibrational disturbances) leads to the conclusion that there are layers within Earth. These layers—the crust, mantle, outer core, and inner core—have distinct properties.

Background Research:

Research conducted at the elementary, middle, secondary, and college levels of education reveal that students hold misconceptions about Earth's structure at all academic levels. The misconceptions held at the elementary level include more fictional and mystical accounts of Earth's structure but significant misconceptions regarding the thickness and composition of Earth's layers still exist throughout the college levels. The existence of these misconceptions is concerning because a solid understanding of Earth's structure is a necessary foundation for understanding other important Earth Science concepts such as tectonic plate movements, earthquakes, and volcanoes. A solid understanding of why students possess these naïve concepts and what these misconceptions are is therefore rather important.

One reason that students possess misconceptions regarding Earth's structure is that the topic is rather complex and abstract. Although most students are exposed to many diagrams depicting earth's internal structure, they can't see it firsthand. The true size of the Earth is difficult for students to understand and there is no possible way they could see a true cross-sectional view of it firsthand. Oftentimes, students must create their mental models of Earth based solely on diagrams.

Students also struggle with the concept of Earth's structure because they are not typically given the appropriate resources and time to develop an accurate mental model. According to Clement (2000), students must create models based on their own thinking and then be exposed to accurate models for comparison. Students must then be given several opportunities to discuss these models with others in order to refine and retain them for any significant long-term understanding. Traditional science instruction does not take into account the thinking of individual students and typically does not give them several opportunities to discuss and refine their mental models of Earth's internal structure.

Younger students often struggle with comprehending the internal structure of Earth due to inaccurate depictions of it in fictional books and movies. Oftentimes students have no exposure to the scientific explanation of Earth's structure until later in their elementary school years. Their only exposure to the topic may be through fictional books and movies that hold inaccurate depictions of the composition, structure, and size of Earth's interior. These naïve mental models that students bring with them into the science classroom are very hard to dispel.

The complex and abstract nature of Earth's internal structure combined with a lack of proper science instruction makes the topic very difficult for students to understand. Further complications are added by naïve conceptions of Earth's structure influenced by fictional books and movies that inaccurately portray the internal composition, structure, and thickness of Earth's layers. All of these factors combined result in the generation of many misconceptions regarding Earth's structure. Listed below are a few of the most common student misconceptions that teachers should look out for in their classrooms:

- The center of the Earth is liquid, containing either water or lava (Capps, 2013).

- The interior of the Earth is filled with soil and scattered rocks like you find at Earth's surface (Capps, 2013).

- The Earth's crust or outer layer is equally as thick as the mantle and core (Steer, 2005)

- Earth's layers are horizontal and not concentric (Steer, 2005).

- The Earth's interior is not layered. It is one, solid, uniform rock structure (Capps, 2013).

Objectives:

Students will:

- Identify their personal conceptions of the interior structure of the earth.
- Compare their personal conceptions to the scientifically accurate explanation of Earth's structure.
- Evaluate the effectiveness of the presented explanation and modify their previously held conceptions if necessary.
- Draw and explain the interior structure of the Earth.
- Apply their knowledge of Earth's structure during a hands-on activity.

Materials:

- "Inside Earth" Conceptual Change Text (Version I & II)
- Internet Access
- Hard-boiled eggs
- Toothpicks
- Knife
- Video cameras
- Construction paper
- Colored pencils/markers

Lesson Summary:

This lesson utilizes a conceptual change text to help students remediate their misconceptions associated with Earth's internal structure. There are two versions of the text (Version I&II). Version II is modified to assist students with difficulties in the areas of reading and writing.

Section 1 asks students to draw a cross-section diagram of the Earth and then to describe their diagram in writing. The students are given some prompts such as "What is the Earth composed of?" and "How is the interior of the Earth organized?" Prior to students answering this section, the teacher should explain to the students that they should not be afraid to get the answer wrong. The goal of this section is simply to recognize their current thoughts about the structure of Earth's interior so they can improve upon them. The students should do this section individually, as misconceptions might not be detected if students are influenced by their peers.

Section 2 presents students with some common misconceptions surrounding the Earth's interior. The teacher should either read this section aloud to the students or students should be given the option to read with a partner. Partner reading will allow struggling readers to have the support of a classmate. Stronger readers should also be allowed to read ahead if they choose. Students should close this section by discussing with their partners how their initial answers compared to the misconceptions. The teacher should culminate this section by facilitating a class discussion about the misconceptions and provide any necessary clarification.

Section 3 presents students with the correct description of the Earth's interior. The section begins with a short video about Earth's layers that serves to provide students with some background knowledge before the reading. Next comes the reading about Earth's internal structure, the teacher should either read this section with the entire class or give students the option to read in their partner groups. The teacher should also summarize the main concepts within the section and provide clarification through facilitating a class discussion.

Section 4 requires to students to revisit their initial conceptions by redrawing a cross-section diagram of the Earth according to what they have learned during the lesson. They are also asked to rewrite their description of the diagram. This reflection on their initial conceptions will cause them to further analyze any misconceptions they may have had and help to consolidate a new more accurate understanding of Earth's internal structure. Section 4 closes with a few questions that ask them to state explicitly how their thinking has changed in regards to Earth's layers and how confident they are in their understanding of the topic.

Section 5 includes three activities that serve as extension opportunities about Earth's structure. These extension activities help students further their understanding by utilizing different modalities of learning and make the learning more relevant to their lives. This section provides differentiation by allowing students to choose what activities they will perform. It also provides differentiation for students of varying ability levels. Students who finish earlier will complete 2 out of the 3 activities while students who take longer to read and write in the earlier sections will only be required to complete one of the activities from this section.

Modifications/Differentiation:

This lesson is designed for student groups of various ability levels. In particular, it has been modified to assist students who struggle with reading and writing. The lesson worksheet comes in two versions, Version I and Version II. Version II is to be given to students who struggle with reading and writing and includes the following modifications:

- Bolded and Underlined key terms.
- Shortened readings with simpler language and structure.
- Word Banks
- Additional diagrams

This lesson includes elements of differentiation by giving students choice in utilizing partner or independent work. It also differentiates by providing a extension activities of varying lengths (Section 5).

Rationale:

This lesson utilizes a conceptual change text to serve as formative assessment of student understanding of Earth's internal structure. As indicated by the above research, students typically possess misconceptions about the Earth's internal structure due to its complex and abstract nature along with the influence of inaccurate depictions of the Earth's internal structure in fictional books and movies. The conceptual change text in this lesson provides students the opportunity to critically analyze their conceptions and then provides scaffolding to assist them in correcting any misconceptions they may have. The student responses to the questions are to be used as a formative assessment tool by the teacher as well. By reading the student responses, teachers can determine what misconceptions about the Earth's internal structure exist in their classroom and adjust their instruction accordingly.

References:

Capps, D.K., McAllister, M., & Boone, J. (2013). Alternative Conceptions Concerning the Earth's Interior Exhibited by Honduran Students. *Journal of Geoscience Education*, *61*, 231-239.

Steer, D.N., Knight, C.C., Owens, K.D., and McConnell, D.A. 2005. Challenging Students Ideas About Earth's Interior Structure Using a Model-based, Conceptual Change Approach in a Large Class Setting. *Journal of Geoscience Education*, *53*, 415-421.

Version I
Name: ______________________________ Period: ___________

Check Your Misconceptions: ***Inside Earth***

SECTION 1: What do you think?

For many years, people thought the Earth was flat. The Earth is so large that it is hard to notice any curvature when you are standing on its surface. However, people began to notice that as ships sailed far enough away, they disappeared over the horizon. Years later, Aristotle, a Greek philosopher, noticed that the Earth leaves a curved shadow on the Moon during a lunar eclipse. This curved surface indicates that the Earth is a sphere. These discoveries provided us with significant evidence about the exterior shape of our planet but did not give us any information about the internal structure of Earth.

For the next few centuries, people wondered about what the inside of the Earth looked like. What is it composed of? Is it solid or liquid? Is it uniform or are there layers? Eventually, scientists developed instruments to measure energy waves given off by earthquakes. By analyzing the velocities of different types of waves, they were able to gain information about the density and structure of the Earth's interior.

Before we get further into the story of Earth's interior structure, let's take a moment to look at what you think you know about Earth's interior. Draw a cross-section diagram of Earth in the box below. Label your diagram to the best of your ability including the individual structures and materials that make up Earth's interior. Remember a cross-section diagram of Earth is a picture of what Earth would look like if you cut it in half and looked at the cut surface.

Explain what the inside of the Earth looks like. What is it made of? How it is organized?

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How well do you think you understand the water cycle? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 2: Common Mistakes

Many students incorrectly think that...

MISCONCEPTIONS	
X	The center of the Earth is liquid and contains either water or lava (Capps, 2013).
X	The interior of the Earth is filled with soil and scattered rocks like you find at Earth's surface (Capps, 2013).
X	The Earth's crust or outer layer is equally as thick as the mantle and core (Steer, 2005).
X	Earth's layers are horizontal and not concentric (Steer, 2005).
X	The Earth's interior is not layered. It is one, solid, uniform rock structure (Capps, 2013).

Compare your diagram and ideas about Earth's interior to the incorrect ideas above. What are some similarities and/or differences between the misconceptions and your thoughts about Earth's interior?

____

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*Discuss with your partner the similarities and differences you found.

In what ways has your thinking about the water cycle changed during this lesson?

____

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How well do you think you understand the water cycle? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

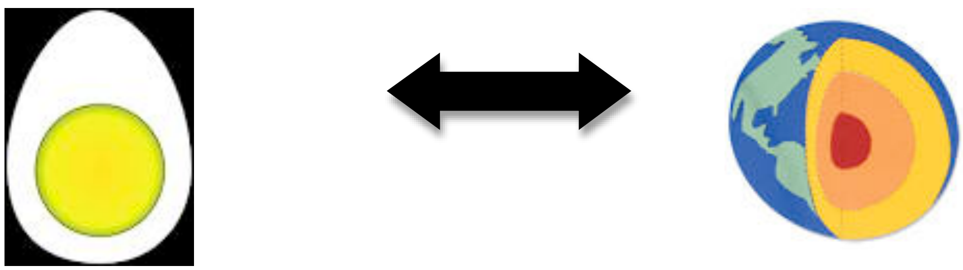
____

SECTION 3: The Correct Answer

Build your background knowledge of Earth's internal structure before the reading by watching this video.

https://www.youtube.com/watch?v=3MFr2cC3erk

When learning about the interior structure of the Earth, it is helpful to picture a hard-boiled egg. Imagine if you took a hard boiled and cut it in half with the shell still on it. The cross-sectional view of the egg would make a pretty good model of Earth's interior.



The shell of the egg represents the Earth's crust. Just like the shell is thin and rigid, so is the Earth's crust. Compared to the other layers of Earth, the crust is extremely thin and not very dense. The thickness of the crust varies depending whether you are on the continents or the oceanic crust but it ranges from 5km to 70 km in depth. The crust is made up solid rock material and is the only layer that has temperatures and pressures that can sustain life. We know the most about this layer because it is the only layer we can explore directly.

The egg white represents the Earth's mantle. Similar to the egg white and the shell, the Mantle is located underneath the crust. The mantle is a layer of hot dense rock that ranges from 1,800 km to 2,900 km in thickness. The upper mantle is considered part of the lithosphere, which also includes the Earth's crust. The upper most part of the mantle consists of flowing magma. Earth's plates move slowly across this molten layer. The yolk of the egg represents the Earth's core. The core contains the highest temperatures and pressures found on earth. The core primarily consists of iron, which is a very dense metal. The outer core is approximately 2,250 km thick and is composed of flowing liquid iron. The inner core is about 1,300 km thick and made of solid iron.

In summary, the Earth is composed of four distinct layers. Starting at the surface and extending to the Earth's core, these layers include: the crust, the mantle, the outer core, and the inner core. These layers each have unique temperatures, pressures, densities, and chemical compositions. The farther you travel towards the center of the Earth, the greater the temperature, pressure, and density becomes. No human has directly observed Earth's layers but evidence for Earth's layered structure is provided by earthquake wave measurements.

Answer the following questions about the above reading.

1) Earth's internal structure is layered is similar to the inside of an ____________.

2) The outer most and least dense layer of the earth is called the _________________.

3) The ______________ is a mostly solid layer except for its upper most portion, which is a molten surface on which the Earth's plates move.

4) The _______________ is a liquid layer composed mostly of iron.

5) The inner core is ______________ iron and is located at the center of our Earth.

6) As you travel deeper into the Earth, the temperature, pressure, and density __________________.

SECTION 4: Reflect and Reconsider

Now that you have learned more about Earth's internal structure, redraw your cross-section diagram of the Earth. Label your diagram with the following terms.

- **Inner Core**
- **Outer Core**
- **Crust**
- **Mantle**

Draw a cross-section of Earth in the box

Describe your cross-section diagram of the Earth. Include a discussion about temperatures, pressures, and densities of Earth's layers.

In what ways has your thinking about the Earth's internal structure changed during this lesson?

How well do you think you understand the structure of Earth's interior? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 5: Extension Activity

This section includes three hands-on activities that demonstrate key components of the Earth's structure. You are to choose any two to complete with a partner.

Activity #1- Hard Boiled Egg model of the Earth:

1) Cut a hard-boiled egg in half with the shell still on it.
2) Make small paper flags labeled: crust, mantle, outer core, and inner core.
3) Tape the flags to toothpicks.
4) Stick the toothpicks into the egg in the places that represent the corresponding Earth's layers.

Activity #2- Traveling to the Center of the Earth:

Write a short fictional story about traveling to the center of the Earth in a specially designed vehicle that can drill into the earth and withstand its intense temperatures and pressures. Describe what the journey would look and feel like as you pass through each layer of the Earth. (Keep in mind that this is a fictional story. Humans are not capable of traveling to the center of the Earth at this time.)

Activity #3- Layers of the Earth News Report:

Use your phone or class video recorder to create a news report about the layers of the earth. Make a diagram or some sort of visual to help your audience understand the layers of the Earth. Give your viewers a detailed description of each layer.

Version II
Name: ______________________________ Period: ___________

Check Your Misconceptions: ***Inside Earth***

SECTION 1: What do you think?

***Reading Tip: Preview the Vocabulary**

Curvature –	**the bend or curve of a surface, like the rounded surface of a ball**
Horizon –	**the curved line that forms the boundary between earth and sky**
Lunar Eclipse –	**the blocking of the Sun's rays by the Earth**
Sphere –	**a solid, 3-D, circular figure like a basketball**
Density –	**how compact or tightly packed something is**

For many years, people thought the Earth was flat. The Earth is so large that it is hard to notice any **curvature** when you are standing on its surface. However, people began to notice that as ships sailed far enough away, they disappeared over the **horizon**. Years later, Aristotle, a Greek philosopher, noticed that the Earth leaves a **curved shadow** on the Moon during a **lunar eclipse**. This curved surface indicates that the Earth is a **sphere**. These discoveries provided us with significant evidence about the exterior shape of our planet but did not give us any information about the internal structure of Earth.

For the next few centuries, people wondered about what the inside of the Earth looked like. What is it composed of? Is it solid or liquid? Is it uniform or are there layers? Eventually, scientists developed instruments to measure **energy waves** given off by earthquakes. By analyzing the velocities of different types of waves, they were able to gain information about the **density and structure** of the Earth's interior.

Before we get further into the story of **Earth's interior structure**, let's take a moment to look at what you think you know about Earth's interior.

1) Draw a **cross-section diagram** of Earth in the box below. Remember a cross-section diagram of Earth is a picture of what Earth would look like if you cut it in half and looked at the cut surface.

2) **Label your diagram** to the best of your ability including the individual structures and materials that make up Earth's interior.

Explain what the inside of the Earth looks like. What is it made of? How it is organized?

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How well do you think you understand the water cycle? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 2: Common Mistakes

Many students incorrectly think that...

MISCONCEPTIONS	
X	The center of the Earth is liquid and contains either water or lava (Capps, 2013).
X	The interior of the Earth is filled with soil and scattered rocks like you find at Earth's surface (Capps, 2013).
X	The Earth's crust or outer layer is equally as thick as the mantle and core (Steer, 2005).
X	Earth's layers are horizontal and not concentric (Steer, 2005).
X	The Earth's interior is not layered. It is one, solid, uniform rock structure (Capps, 2013).

Compare your diagram and ideas about Earth's interior to the incorrect ideas above. What are some similarities and/or differences between the misconceptions and your thoughts about Earth's interior?

*Discuss with your partner the similarities and differences you found.

In what ways has your thinking about the water cycle changed during this lesson?

How well do you think you understand the water cycle? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

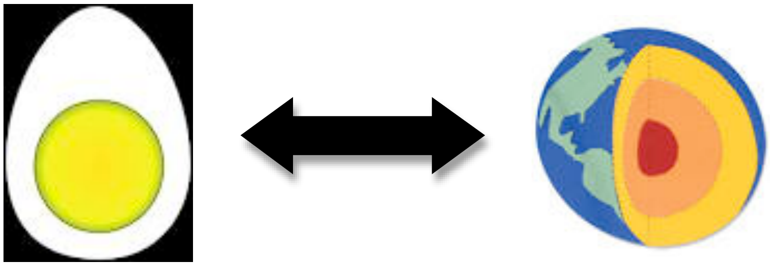
SECTION 3: The Correct Answer

Build your background knowledge of Earth's internal structure before the reading by watching this video.

https://www.youtube.com/watch?v=3MFr2cC3erk

*__Read the passage below about the Earth's interior. Complete the outline to the right as you read to help you keep track of all the information.__

When learning about the **interior structure of the Earth**, it is helpful to picture a hard-boiled egg. Imagine if you took a hard boiled and cut it in half with the shell still on it. The cross-sectional view of the egg would make a pretty good model of Earth's interior.



The shell of the egg represents the **Earth's crust**. Just like the shell is thin and rigid, so is the Earth's crust. Compared to the other layers of Earth, the crust is extremely thin and not very dense. The thickness of the crust varies depending whether you are on the continents or the oceanic crust but it ranges from 5km to 70 km in depth. The crust is made up solid rock material and is the only layer that has temperatures and pressures that can sustain life. We know the most about this layer because it is the only layer we can explore directly.

The egg white represents the **Earth's mantle**. Similar to the egg white and the shell, the Mantle is located underneath the crust. The mantle is a layer of hot dense rock that ranges from 1,800 km to 2,900 km in thickness. The upper mantle is considered part of the **lithosphere**, which also includes the Earth's crust. The upper most part of the mantle consists of flowing magma. Earth's plates move slowly across this molten layer.

The yolk of the egg represents the Earth's core. The core contains the highest temperatures and pressures found on earth. The core primarily consists of iron, which is a very dense metal. The **outer core** is approximately 2,250 km thick and is composed of flowing liquid iron. The **inner core** is about 1,300 km thick and made of solid iron.

In summary, the Earth is composed of four distinct layers. Starting at the surface and extending to the Earth's core, these layers include: the crust, the mantle, the outer core, and the inner core. These layers each have unique temperatures, pressures, densities, and chemical compositions. **The farther you travel towards the center of the Earth, the greater the temperature, pressure, and density becomes.** No human has directly observed Earth's layers but evidence for Earth's layered structure is provided by earthquake wave measurements.

Paragraph 1

Main Idea:

Paragraph 2

Main Idea:

Detail 1:

Detail 2:

Paragraph 3

Main Idea:

Detail 1

Detail 2

Paragraph 4

Main Idea

Detail 1:

Detail 2:

Paragraph 5

Summary:

***Answer the following questions about the above reading using the word bank.**

Word Bank

Outer Core	**Increase**	**Egg**
Crust	**Solid**	**Mantle**

1) Earth's internal structure is layered is similar to the inside of an ____________.
2) The outer most and least dense layer of the earth is called the _________________.
3) The ______________ is a mostly solid layer except for its upper most portion, which is a molten surface on which the Earth's plates move.
4) The _______________ is a liquid layer composed mostly of iron.
5) The inner core is ______________ iron and is located at the center of our Earth.
6) As you travel deeper into the Earth, the temperature, pressure, and density __________________.

SECTION 4: Reflect and Reconsider

Now that you have learned more about Earth's internal structure, redraw your cross-section diagram of the Earth. Label your diagram with the following terms.

- Inner Core **- Outer Core**
- Crust **- Mantle**

Draw a cross-section of Earth in the box

Describe your cross-section diagram of the Earth. Include a discussion about temperatures, pressures, and densities of Earth's layers.

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In what ways has your thinking about the Earth's internal structure changed during this lesson?

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How well do you think you understand the structure of Earth's interior? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 5: Extension Activity

This section includes three hands-on activities that demonstrate key components of the Earth's structure. You are to choose **one** to complete with a partner.

Activity #1- Hard Boiled Egg model of the Earth:

5) Cut a hard-boiled egg in half with the shell still on it.
6) Make small paper flags labeled: crust, mantle, outer core, and inner core.
7) Tape the flags to toothpicks.
8) Stick the toothpicks into the egg in the places that represent the corresponding Earth's layers.

Activity #2- Traveling to the Center of the Earth:

Write a short fictional story about traveling to the center of the Earth in a specially designed vehicle that can drill into the earth and withstand its intense temperatures and pressures. Describe what the journey would look and feel like as you pass through each layer of the Earth. (Keep in mind that this is a fictional story. Humans are not capable of traveling to the center of the Earth at this time.)

Activity #3- Layers of the Earth News Report:

Use your phone or class video recorder to create a news report about the layers of the earth. Make a diagram or some sort of visual to help your audience understand the layers of the Earth. Give your viewers a detailed description of each layer.

Earth's Interior Structure Diagram #1

Score	4	3	2	1
Structure	Diagram shows 4 distinct concentric layers.	Diagram shows concentric layers.	Diagram demonstrates some form of layering.	The Earth's interior is not shown to be layered.
Proportionality	The layers are in correct proportion to each other with the Earth's crust significantly thinner than the other layers.	The layers are in close proportion to each other. The Earth's crust is shown to be somewhat thinner than the other layers.	The layers may be shown to be the same thickness.	The layers are completely out of proportion or there are no layers at all.
Materials	The crust is shown to be solid rock. The mantle has a thin upper region of magma but is primarily solid rock. The outer core is liquid Iron and the inner core is shown to be solid Iron.	3 out of the 4 layers are labeled with the correct materials.	2 out of the 4 layers are labeled with the correct materials.	Less than 2 of the 4 layers are labeled with the correct materials.
Terminology	The diagram correctly labels the crust, mantle, outer core, and inner core.	3 out of the 4 layers labeled with the correct term.	2 out of the 4 layers are labeled with the correct term.	Less than 2 out of the 4 layers are labeled with the correct term.

Score: ___________ out of 16

Earth's Interior Structure Diagram #2

Score	4	3	2	1
Structure	Diagram shows 4 distinct concentric layers.	Diagram shows concentric layers.	Diagram demonstrates some form of layering.	The Earth's interior is not shown to be layered.
Proportionality	The layers are in correct proportion to each other with the Earth's crust significantly thinner than the other layers.	The layers are in close proportion to each other. The Earth's crust is shown to be somewhat thinner than the other layers.	The layers may be shown to be the same thickness.	The layers are completely out of proportion or there are no layers at all.
Materials	The crust is shown to be solid rock. The mantle has a thin upper region of magma but is primarily solid rock. The outer core is liquid Iron and the inner core is shown to be solid Iron.	3 out of the 4 layers are labeled with the correct materials.	2 out of the 4 layers are labeled with the correct materials.	Less than 2 of the 4 layers are labeled with the correct materials.
Terminology	The diagram correctly labels the crust, mantle, outer core, and inner core.	3 out of the 4 layers labeled with the correct term.	2 out of the 4 layers are labeled with the correct term.	Less than 2 out of the 4 layers are labeled with the correct term.

Score: ___________ out of 16

Change in Score: __________

IV. Moon's Phases

NYS Standards

Standard 4: The Physical Setting

Key Idea 1- The Earth and celestial phenomena can be described by principles of relative motion and perspective.

1.1g Moons are seen by reflected light. Our Moon orbits Earth, while Earth orbits the Sun. The Moon's phases as observed from Earth are the result of seeing different portions of the lighted area of the Moon's surface. The phases repeat in a cyclic pattern in about one month.

Background Research:

The phases of the moon ranks as highly as the changing of the seasons on the list of the most common astronomy topics that people hold misconceptions about. Both children and adults are clearly shown by research to have false conceptions about the phases of the moon. A study conducted by Schoon, that involved 1,213 students from elementary school through college, found that 64.3% of the participants possessed misconceptions about the phases of the moon (As cited by Trundle, Atwood, & Christopher, 2007). In a similar study about astronomy misconceptions, Barrier found that only 4% of her population sampled could correctly describe and explain the phases of the moon. Furthermore, the American Association for the Advancement of Science stated that most adults do not understand the phases of the moon and most teaching conducted about the topic produces very little true understanding (As cited in Trundle, Atwood, & Christopher, 2002).

There are multiple reasons why people fail to properly understand the phases of the moon. One major reason is that astronomical concepts are unique from our daily experiences here on Earth. Astronomy deals with very large planetary bodies that are extremely far away. The field of astronomy is therefore very abstract to all of us here on Earth. To understand the phases of the moon, one must possess relatively strong spatial reasoning skills (Barrier, 2010). Many educators argue that not all students are cognitively developed enough to be understand the phases of the moon before the middle school age (Trundle, 2007). This early introduction to a concept that students are not prepared for cognitively, may lead to the development of many misconceptions.

Another reason why students frequently possess misconceptions regarding the moon's phases is related to inaccurate depictions of the concept in media. Cartoons, movies, and books not intended for educational use often depict the moon inaccurately. Most see these forms of media harmless but a child's exposure to faulty scientific principles in the media are actually a significant cause of many science misconceptions. Children's books in particular, have been noted to include many inaccurate depictions of the moon's phases. A study conducted by Trundle and Troland in 2005, actually surveyed 79 books, many of which contained misconceptions about the moon's phases. One book displayed the Gibbous moon as a lunar eclipse, reinforcing the most common of all moon phase misconceptions. The eclipse model has been shown repeatedly by research to be the most commonly held misconception about moon phases by both children and adults. Another inaccurate depiction found in the book survey included the incorrect sequencing of the phases. Most frequently the moon phases are shown in reverse of the natural order. Finally, some books show the moon phases as the physical moon changing shape instead of different portions of the illuminated moon becoming visible by the Earth. Stars are placed where the dark part of the moon should be, making it seem as if the moon is not always a spherical shape (Trundle & Troland, 2005).

The abstract nature of the moon phase concept combined with inaccurate representations of it in media combine to produce a large amount of misconceptions. Although there are many student misconceptions about the moon's phases, listed below are a few of the most common that teachers should look for in their classrooms:

The moon phases are the result of:

1) Earth's shadow on moon (Barrier, 2010).
2) Earth's rotation on its axis (Trundle, 2002)
3) Moon's position relative to different geographic locations on Earth (Trundle, 2002)
4) Clouds (Trundle, 2002)

Objectives:

Students will:

- Identify their personal conceptions of what causes the Moon's phases to occur.
- Compare their personal conceptions to the scientifically accurate explanation of what causes the Moon's phases.
- Evaluate the effectiveness of the presented explanation and modify their previously held conceptions about the Moon's phases if necessary.
- Explain what causes the Moon's phases to occur.
- Create a video, model, or poem illustrating the cause of the Moon's phases.

Materials:

- "The Phases of the Moon" worksheet version I & II
- Internet Access
- Video Camera
- Pencils
- Styrofoam balls
- Lamp (with shade removed)
- Oreos
- Paper plates
- Digital camera/camera phone

Lesson Summary:

This lesson utilizes a conceptual change text to help students remediate their misconceptions associated with the phases of the Moon. There are two versions of the text (Version I&II). Version II is modified to assist students with difficulties in the areas of reading and writing by providing them with tips and assistance on comprehension of the text. Assistance is provided through the use of bolded/underlined key terms, vocabulary previews, word banks, note-taking/outlining assistance, partner reading, and reduced workload to more time to focus on key concepts.

Section I begins with a short reading passage about the moon. This section serves to build background knowledge and introduce the topic. Teachers should either read this section aloud to the class or the students should be given the option to read with a partner. Students are then asked write down what they think causes the Moon's phases. Prior to students answering this section, the teacher should explain to the students that they should not be afraid to get the answer wrong. The goal of this section is simply to recognize their current thoughts about the cause of the Moon's phases so they can improve upon them. The students should do this section individually, as misconceptions might not be detected if students are influenced by their peers. The section closes by having them rate their understanding of the topic on a 1-10 scale.

Section 2 presents students with some common misconceptions surrounding the cause of the Moon's phases. The teacher should either read this section aloud to the class or students should be given the option to read with a partner. Partner reading will allow struggling readers to have the support of a classmate. Stronger readers should also be allowed to read ahead if they choose. Students should discuss with their partners how their initial answers compared to the misconceptions. The teacher should culminate this section by facilitating a class discussion about the misconceptions and provide any necessary clarification. Students are asked to compare their conceptions with the misconceptions and record any similarities. They are then asked how their thinking has changed so far during the lesson and to rate their understanding of the topic on 1-10 scale.

Section 3 presents students with the correct explanation of what causes the phases of the Moon. The section begins with a short video about the phases of the Moon that serves to provide students with some more background knowledge before the reading. The video is followed by a reading passage about the Moon's phases, the teacher should either read this section with the entire class or give students the option to read in their partner groups. The teacher should also summarize the main concepts within the section and provide clarification through facilitating a class discussion. The section closes with a series of questions about the reading, which also serves to scaffold their response to the question about the cause of the Moon's phases. Students are again asked to note how their thinking has changed during the lesson and to rate their understanding on a 1-10 scale.

Section 4 requires students to revisit their initial conceptions and rewrite their answer to the initial question about the cause of the Moon's phases according to what they have learned during the lesson. This reflection on their initial conceptions will cause them to further analyze any misconceptions they may have had and help to consolidate a new more accurate understanding of the cause of the Moon's phases. Section 4 closes with a few questions that ask them to state explicitly how their thinking has changed in regards to the cause of the Moon's phases and how confident they are in their understanding of the topic. They are asked a final time to rate their understanding of the topic on a 1-10 scale.

Section 5 includes three activities that serve as extension opportunities about the phases of the Moon. These extension activities help students further their understanding by utilizing different modalities of learning and make the learning more relevant to their lives. This section provides differentiation by allowing students to choose what activities they will perform. It also provides differentiation for students of varying ability levels. Students who finish earlier will complete 2 out of the 3 activities while students who take longer to read and write in the earlier sections will only be required to complete one of the activities from this section.

Modifications/Differentiation:

This lesson is designed for student groups of various ability levels. In particular, it has been modified to assist students who struggle with reading and writing. The lesson worksheet comes in two versions, Version I and Version II. Version II is to be given to students who struggle with reading and writing and includes the following modifications:

- Bolded and Underlined key terms.
- Vocabulary previews
- Word Banks
- Note-taking/Outlining assistance
- Partner Reading
- Reduced workload to allow focus on key concepts

This lesson includes elements of differentiation by giving students choice in utilizing partner or independent work. It also differentiates by providing an extension activities of varying lengths (Section 5).

Rationale:

This lesson utilizes a conceptual change text to serve as formative assessment of student understanding of the cause of the Moon's phases. As indicated by the above research, students typically possess misconceptions about the cause of the Moon's phases due to astronomy's abstract distances and planetary motions, and the inaccurate portrayal of the Moon in children's books. The conceptual change text in this lesson allows students the opportunity to critically analyze their conceptions and then provides scaffolding to assist them in correcting any misconceptions they may have. The student responses to the questions are to be used as a formative assessment tool by the teacher as well. By reading the student responses, teachers can determine what misconceptions about the Earth's internal structure exist in their classroom and adjust their instruction accordingly.

References

Barrier, R. M. (2010). Astronomical Misconceptions. *Physics Teacher*, *48*(5), 319-321. doi:10.1119/1.3393064

Trundle, K. C., Atwood, R. K., & Christopher, J. E. (2002). Preservice elementary teachers' conceptions of moon phases before and after instruction. *Journal Of Research In Science Teaching*, *39*(7), 633-658. doi:10.1002/tea.10039

Trundle, K. C., & Troland, T. H. (2005). The Moon in Children's Literature. *Science & Children*, *43*(2), 40-43.

Trundle, K. C., Atwood, R. K., & Christopher, J. E. (2007). Fourth-grade Elementary Students' Conceptions of Standards-based Lunar Concepts. *International Journal Of Science Education*, *29*(5), 595-616. doi:10.1080/09500690600779932

Version I
Name: ______________________________ Period: ___________

Check Your Misconceptions: The Phases of the Moon

SECTION 1: What do you think?

The Moon is the Earth's only satellite and has been influencing human culture for thousands of years. Not only has the Moon influenced art and mythology but it is also the basis for the lunar calendar. The Moon's predictable orbit around the Earth provided early civilization with a way of keeping track of the months of the year. Humans continued to observe the Moon from over 100,000 miles away for generations, until 1969, when the United States first put a man on the Moon. Several Moon landings have allowed us to gather all sorts of firsthand research about the Moon's craters, gravity, composition, etc. Despite all the knowledge we have about the Moon, most people do not understand many basic moon concepts. For example, the cause of the Moon's phases.

During each month, the Moon's appearance changes in a consistent pattern. Sometimes the Moon is large and bright, while at other times of the month, it appears small or completely dark. Take a moment and think about what causes this cycle to occur.

What causes the phases of the Moon to change? Or in other words, why does the Moon look different at different times throughout the month?

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How well do you think you understand the cause of the Moon's phases? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 2: Common Mistakes

Many students incorrectly think that the phases of the Moon are caused by...

MISCONCEPTIONS	
X	The Earth's shadow on the moon.
X	The Earth's rotation on its axis.
X	The Moon's position relative to different geographic locations on Earth.
X	Clouds

Compare your ideas about the cause of the Moon's phases to the incorrect ideas above. What are some similarities and/or differences between the misconceptions and your thoughts about the phases of the Moon?

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*Discuss with your partner the similarities and differences you found.
In what ways has your thinking about the cause of the Moon's phases changed during this lesson?

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How well do you think you understand the cause of the Moon's phases? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 3: The Correct Answer

Build your background knowledge of the Moon's phases before the reading by watching this video.

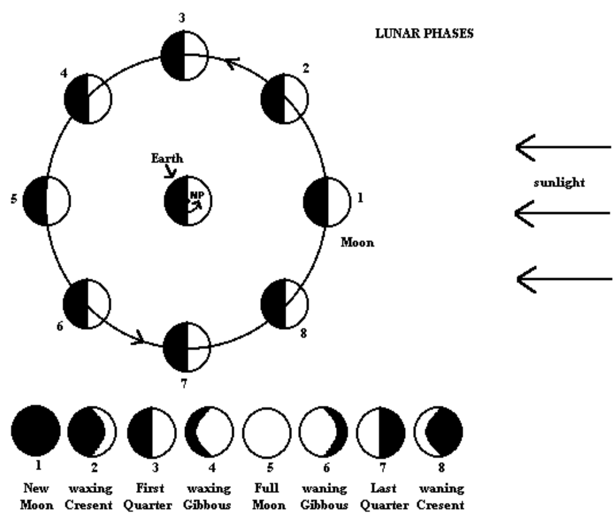
https://www.youtube.com/watch?v=wz01pTvuMa0

The Phases of the Moon

To understand what causes the phases of the moon to occur, one must understand the motions of the Earth and the Moon. The Moon orbits the Earth while the earth orbits around the Sun. The Sun and Moon therefore both travel around the Sun. The Moon takes roughly one month or 27 1/3 days to complete a trip around the Earth. During this time, the relative positions of the Sun, Earth, and Moon are constantly changing. This constant change in position is a major factor why we see the different phases of the Moon.

Light from the Sun is constantly shining on both the Earth and the Moon. Some of this light is absorbed but another portion of the light is reflected. The Moon does not create its own light. We are able to see the Moon because it reflects some of the Sun's light in our direction. Based on where the Moon is in its orbit around the Earth, we see different portions of the lit Moon. The changing amount of sunlight we see reflected by the Moon, makes it appear as though the Moon is changing shape. We call these different appearances of the Moon, the phases of the Moon.

The phases of the Moon fall into two main categories, waxing and waning. Waxing refers to the phases where the visible part of the Moon is increasing. The Moon's first phase is the New Moon. During a New Moon, the lit portion of the Moon is not visible to Earth and it may appear that there is no Moon at all. As the Moon begins to travel on its counter-clockwise path around the Earth, less than half the Moon is visible. This is called the waxing crescent phase. When the Moon is one quarter of its way around the Earth, it is in the first quarter phase. At this point, half of the moon is visible from Earth. The visible portion of the Moon continues to grow during its waxing gibbous phase until the Moon reaches its halfway point on its path around the Earth. At the halfway point, the Moon is fully lit and is referred to as a full Moon.



The remaining phases of the Moon are considered the waning phases. During this time, the visible portion of the Moon is decreasing. As the Moon passes the halfway point on its path around the Earth, it is in the waning gibbous phase. During this time, more than half of the moon is lit. When the Moon is three quarters of its way around the Earth, it is referred to as a last quarter moon and half of the moon is visible to Earth. The visible portion of the Moon continues to decrease during the waning crescent phase until the Moon appears completely dark and the cycle begins again with a new Moon.

In summary, the relative motions of the Earth and the Moon cause the phases of the Moon. The Moon does not create light but reflects it from the Sun. As the Moon travels on its path around the Earth, different portions of the Moon are visible. These different visible portions are categorized into eight distinct phases. The Moon is not actually changing shape and the phases are not a result of the Earth blocking sunlight from hitting the moon. The Moon continuously orbits the Earth resulting in a constant monthly rotation of the Moon's phases.

Answer the following questions about the above reading.

1) The Moon __________ the Earth on a 27 1/3 day cycle.

2) The relative positions of the Earth, Moon, and Sun are constantly _____________.

3) The Moon does not create light but __________ it from the Sun.

4) The visible portion of the Moon increases during the ____________ phases and decreases during the ______________ phases.

5) The first of the Moon's phases is called the ___________ Moon.

6) A _________ Moon occurs when the Moon is at its half way point on its orbit around the Earth.

7) Different portions of the Moon are ___________ at different points on the Moon's path around the Earth.

SECTION 4: Reflect and Reconsider

Now that you have learned more about the Moon's phases, answers the following question again.

What causes the phases of the Moon to change? Or in other words, why does the Moon look different at different times throughout the month?

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In what ways has your thinking about the cause of the Moon's phases changed during this lesson?

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How well do you think you understand the cause of the Moon's phases? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 5: Extension Activity

This section includes three hands-on activities about earthquakes. You are to choose **two** to complete with a partner.

Kinesthetic Moon Phase Activity

1) Use the following materials to re-enact the video you watched above:
-pencil
-styrofoam ball
-lamp with light shade removed
-video recorder
2) Record your demonstration of the Moon's phases on video.
3) Include a verbal description of each phase and what causes these phases to occur.

Oreo Moon Phases

Use a paper plate and 8 Oreos to create a model of the Moon's phases. Be sure to label each phase. Represent the Earth and the Sun in your model. You may want to take a photo of your creation so you can finish by eating the Moon's phases!

Moon Poem

Create a poem from the perspective of the "Man in the Moon." Explain the changing phases of the Moon and include a creative description of all 8 phases.

Version II
Name: ______________________________ Period: ___________

Check Your Misconceptions: The Phases of the Moon

SECTION 1: What do you think?

*Reading Tip: Preview the Vocabulary

satellite-	a body that revolves around a planet, a moon
mythology-	a set of stories, traditions, or beliefs
lunar calendar-	a monthly calendar based on the moon's phases
crater-	a hole or depression on the Moon's surface caused by the impact of a meteorite

The Moon is the Earth's only **satellite** and has been influencing human culture for thousands of years. Not only has the Moon influenced art and **mythology** but it is also the basis for the **lunar calendar**. The Moon's predictable orbit around the Earth provided early civilization with a way of keeping track of the months of the year. Humans continued to observe the Moon from over 100,000 miles away for generations, until 1969, when the United States first put a man on the Moon. Several Moon landings have allowed us to gather all sorts of firsthand research about the Moon's **craters**, gravity, composition, etc. Despite all the knowledge we have about the Moon, most people do not understand many basic moon concepts. For example, the cause of the Moon's phases.

During each month, the Moon's appearance changes in a consistent pattern. Sometimes the Moon is large and bright, while at other times of the month, it appears small or completely dark. Take a moment and think about what causes this cycle to occur.

What causes the phases of the Moon to change? Or in other words, why does the Moon look different at different times throughout the month?
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How well do you think you understand the cause of the Moon's phases? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 2: Common Mistakes

Many students incorrectly think that the phases of the Moon are caused by...

MISCONCEPTIONS	
X	The Earth's shadow on the moon.
X	The Earth's rotation on its axis.
X	The Moon's position relative to different geographic locations on Earth.
X	Clouds

Compare your ideas about the cause of the Moon's phases to the incorrect ideas above. What are some similarities and/or differences between the misconceptions and your thoughts about the phases of the Moon?

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*Discuss with your partner the similarities and differences you found.
In what ways has your thinking about the cause of the Moon's phases changed during this lesson?

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How well do you think you understand the cause of the Moon's phases? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 3: The Correct Answer

Build your background knowledge of the Moon's phases before the reading by watching this video.

https://www.youtube.com/watch?v=wz01pTvuMa0

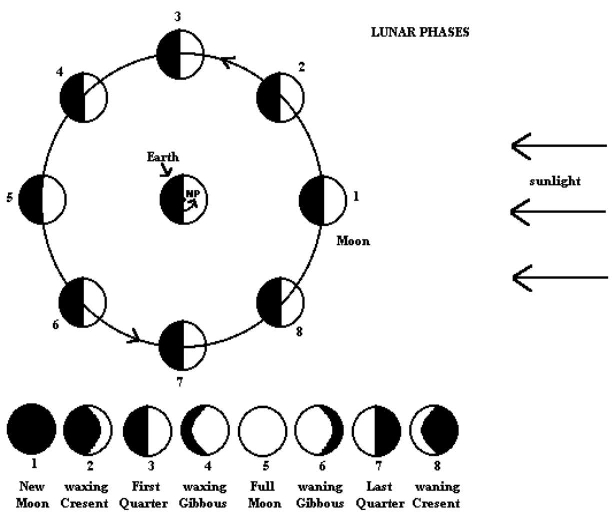
****Read the next section with your reading partner.**
****Tip: Read the questions for each section before you read the paragraph to help give you a purpose.**

The Phases of the Moon

To understand what causes the phases of the moon to occur, one must understand the motions of the Earth and the Moon. The Moon **orbits** the Earth while the earth orbits around the Sun. The Sun and Moon therefore both travel around the Sun. The Moon takes roughly one month or 27 1/3 days to complete a trip around the Earth. During this time, the relative positions of the Sun, Earth, and Moon are constantly changing. This constant change in position is a major factor why we see the different phases of the Moon.

Light from the Sun is constantly shining on both the Earth and the Moon. Some of this light is absorbed but another portion of the light is **reflected**. The Moon does not create its own light. We are able to see the Moon because it reflects some of the Sun's light in our direction. Based on where the Moon is in its orbit around the Earth, we see different portions of the lit Moon. The changing amount of sunlight we see reflected by the Moon, makes it appear as though the Moon is changing shape. We call these different appearances of the Moon, the phases of the Moon.

The phases of the Moon fall into two main categories, **waxing** and **waning**. Waxing refers to the phases where the visible part of the Moon is increasing. The Moon's first phase is the **New Moon**. During a New Moon, the lit portion of the Moon is not visible to Earth and it may appear that there is no Moon at all. As the Moon begins to travel on its counter-clockwise path around the Earth, less than half the Moon is visible. This is called the **waxing crescent** phase. When the Moon is one quarter of its way around the Earth, it is in the **first quarter** phase. At this point, half of the moon is visible from Earth. The visible portion of the Moon continues to grow during its **waxing gibbous** phase until the Moon reaches its halfway point on its path around the Earth. At the halfway point, the Moon is fully lit and is referred to as a **full Moon**.



Paragraph I

Main Idea –

Detail 1:

Detail 2:

Paragraph 2

Main Idea:

Detail 1:

Detail 2:

Paragraph 3

Main Idea:

Detail 1:

Detail 2:

The remaining phases of the Moon are considered the waning phases. During this time, the visible portion of the Moon is decreasing. After the Moon passes the halfway point on its path around the Earth, it is in the **waning gibbous** phase. During this time, more than half of the moon is lit. When the Moon is three quarters of its way around the Earth, it is referred to as a **last quarter moon** and half of the moon is visible to Earth. The visible portion of the Moon continues to decrease during the **waning crescent** phase until the Moon appears completely dark and the cycle begins again with a new Moon.

In summary, the **relative motions** of the Earth and the Moon cause the phases of the Moon. The Moon does not create light but reflects it from the Sun. As the Moon travels on its path around the Earth, different portions of the Moon are visible. These different visible portions are categorized into eight distinct phases. The Moon is not actually changing shape and the phases are not a result of the Earth blocking sunlight from hitting the moon. The Moon continuously orbits the Earth resulting in a constant monthly rotation of the Moon's phases.

Paragraph 3

Main Idea –

Detail 1:

Detail 2:

Paragraph 4

Summary -

Answer the following questions about the above reading using the word bank.

Word Bank

changing waning full reflects

new orbits waxing

1) The Moon ___________ the Earth on a 27 1/3 day cycle.

2) The relative positions of the Earth, Moon, and Sun are constantly ______________.

3) The Moon does not create light but ___________ it from the Sun.

4) The visible portion of the Moon increases during the _____________ phases and decreases during the _______________ phases.

5) The first of the Moon's phases is called the ____________ Moon.

6) A __________ Moon occurs when the Moon is at its half way point on its orbit around the Earth.

7) Different portions of the Moon are ____________ at different points on the Moon's path around the Earth.

SECTION 4: Reflect and Reconsider

Now that you have learned more about the Moon's phases, answers the following question again.

What causes the phases of the Moon to change? Or in other words, why does the Moon look different at different times throughout the month?

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In what ways has your thinking about the cause of the Moon's phases changed during this lesson?

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How well do you think you understand the cause of the Moon's phases? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 5: Extension Activity

This section includes three hands-on activities about earthquakes. You are to choose **one** to complete with a partner.

Kinesthetic Moon Phase Activity

1) Use the following materials to re-enact the video you watched above:
   - -pencil
   - -styrofoam ball
   - -lamp with light shade removed
   - -video recorder
2) Record your demonstration of the Moon's phases on video.
3) Include a verbal description of each phase and what causes these phases to occur.

Oreo Moon Phases

Use a paper plate and 8 Oreos to create a model of the Moon's phases. Be sure to label each phase. Represent the Earth and the Sun in your model. You may want to take a photo of your creation so you can finish by eating the Moon's phases!

Moon Poem

Create a poem from the perspective of the "Man in the Moon." Explain the changing phases of the Moon and include a creative description of all 8 phases.

The Phases of the Moon – Rubric #1

Component Concepts	1	0
The Moon is visible due to the light it reflects from the Sun.		
The Moon orbits the Sun on an approximately one-month cycle.		
Different portions of the Moon are visible to Earth depending on where the Moon is on its path around the Earth. These portions represent the different phases of the Moon.		

Total: _______ /3

The Phases of the Moon – Rubric #2

Component Concepts	1	0
The Moon is visible due to the light it reflects from the Sun.		
The Moon orbits the Sun on an approximately one-month cycle.		
Different portions of the Moon are visible to Earth depending on where the Moon is on its path around the Earth. These portions represent the different phases of the Moon.		

Total: _______ /3

Change in Score: _______

V. Rock Cycle

NYS Standards

Standard 4: The Physical Setting

Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

2.2h The rock cycle model shows how types of rock or rock material may be trans- formed from one type of rock to another.

Next Generation Science Standards

MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process. [Clarification Statement: Emphasis is on the processes of melting, crystallization, weathering, deformation, and sedimentation, which act together to form minerals and rocks through the cycling of Earth's materials.]

Background Research:

The rock cycle is an integral concept for understanding how a large portion of the Earth's resources are created and recycled. The rock cycle includes the three main rock types and demonstrates their interconnectedness. Many of the processes of the rock cycle are immediate, some are continuous, and others take thousands or millions of years to occur. Some stages of the rock cycle are readily visible to humans, where others occur deep within the Earth or take so long they cannot be observed within a human lifetime. The above features of the rock cycle are evidence that the rock cycle is a complex system which is why students often maintain misconceptions about how the rock cycle operates.

The rock cycle involves the interaction of several different components (igneous rocks, metamorphic rocks, sedimentary rocks, erosion, deposition, compaction, etc.) and therefore requires "systems-thinking" to understand . "Systems-thinking" involves higher order thinking skills such as analyzing and synthesizing. These skills rank high on Bloom's taxonomy of thinking skills and require high levels of cognitive effort and ability (Kali, Orion, & Eylon, 2003). Students who have lower cognitive ability often struggle with higher order thinking skills which could lead to the development of significant misconceptions when trying to understand the rock cycle. Some studies have found that "systems-thinking" might be an innate ability not able to be taught or forced. These findings present considerable challenges to teachers trying to present the rock cycle to students of ranging ability levels.

Assaraf and Orion (2005) summarized the following thinking skills necessary for students to understand Earth systems such as the rock cycle:

1. The ability to identify components and processes in a system.
2. The ability to identify relationships among a system's components.
3. The ability to organize processes and components within a framework.
4. The ability to make generalizations.
5. The ability to understand the dynamic nature of systems.
6. The ability to recognize parts of a system that are not readily visible.

7. The ability to understand the cyclic nature of a system
8. The ability to think temporally about relationships among components of a system.

If a student is lacking in any of the above mentioned abilities, it would be very difficult for them to fully understand the rock cycle leading to the potential for the generation of misconceptions.

A study performed by Sibley, Anderson, and Heidemann in 2007 supported Assaraf and Orion's findings. Sibley and Anderson found that the parts of a system that are not "readily apparent or visible" present significant barriers to the understanding of Earth's systems. This is significant to the understanding of the rock cycle because a large portion of it occurs underground unable to be seen by the human eye. When students are unable to assimilate the underground portions of the rock cycle, many misconceptions are likely to occur.

Although there are many student misconceptions regarding the rock cycle, listed below are a few of the most common that teachers should look for in their classrooms:

- The rock cycle is steady and continuous (King, 2008) as cited in (Francek, 2013)
- The rock cycle takes millions of years to occur (King, 2008) as cited in (Francek, 2013)
- Only igneous and sedimentary rocks go through the rock cycle (Ford, 2003) as cited in (Francek, 2013)
- Each part of the rock cycle is stagnant and isolated and cannot change or be transformed into any other part of the rock cycle system (Kali et al., 2003)
- The internal and external processes of the rock cycle are not related or connected (Kali et al., 2003)

Objectives:

Students will:

- Identify their personal conceptions of what the rock cycle is.
- Compare their personal conceptions to the scientifically accurate explanation of what the rock cycle is.
- Evaluate the effectiveness of the presented explanation and modify their previously held conceptions about the rock cycle if necessary.
- Explain how the rock cycle works.
- Apply their knowledge of the rock cycle to a an extension activity (create an experiment, a video, and/or a story)

Materials:

- "Rock Cycle" conceptual change worksheets (versions I&II)
- Internet Access
- iPad
- Aluminum foil
- Regular and white chocolate
- Hot plate
- Beaker & beaker tongs
- Knife
- Construction paper
- Markers/Colored Pencils/Crayons
- Glue sticks
- Sedimentary, Igneous, and Metamorphic rock samples

Lesson Summary:

This lesson utilizes a conceptual change text to help students remediate their misconceptions associated with the rock cycle. There are two versions of the text (Version I&II). Version II is modified to assist students with difficulties in the areas of reading and writing.

Section I begins with a short reading passage about what the rock cycle is and a little about how it works. This section serves to build background knowledge and introduce the topic. Teachers should either read this section aloud to the class or the students should be given the option to read with a partner. Students are then asked to draw their own version of the rock cycle diagram and are given terms to label their diagram. Prior to students answering this section, the teacher should explain to the students that they should not be afraid to get the answer wrong. The goal of this section is simply to recognize their current thoughts about the rock cycle so they can improve upon them. The students should do this section individually, as misconceptions might not be detected if students are influenced by their peers. The section closes by having them rate their understanding of the topic on a 1-10 scale.

Section 2 presents students with some common misconceptions about the rock cycle. The teacher should either read this section aloud to the class or students should be given the option to read with a partner. Partner reading will allow struggling readers to have the support of a classmate. Stronger readers should also be allowed to read ahead if they choose. Students should discuss with their partners how their initial answers compared to the misconceptions. The teacher should culminate this section by facilitating a class discussion about the misconceptions and provide any necessary clarification. Students are asked to compare their conceptions with the misconceptions and record any similarities. They are then asked how their thinking has changes so far during the lesson and to rate their understanding of the topic on 1-10 scale.

Section 3 presents students with a correct diagram of the rock cycle and some text that explains it. The section begins with a short video about the rock cycle that serves to provide students with some more background knowledge before the reading. The video is followed by a reading passage about the rock cycle, the teacher should either read this section with the entire class or give students the option to read in their partner groups. The teacher should also summarize the main concepts within the section and provide clarification through facilitating a class discussion. The section closes with a series of questions about the reading, which also serves to scaffold them in constructing an accurate model of the rock cycle. Students are again asked to note how their thinking has changed during the lesson and to rate their understanding on a 1-10 scale.

Section 4 requires students to revisit their initial conceptions and redraw their rock cycle diagram according to what they have learned during the lesson. This reflection on their initial conceptions will cause them to further analyze any misconceptions they may have had and help to consolidate a new more accurate understanding of the cause of the rock cycle. Section 4 closes with a few questions that ask them to state explicitly how their thinking has changed in regards to the rock cycle and how confident they are in their understanding of the topic. They are asked a final time to rate their understanding of the topic on a 1-10 scale.

Section 5 includes three activities that serve as extension opportunities about the rock cycle. These extension activities help students further their understanding by utilizing different modalities of learning and make the learning more relevant to their lives. This section provides differentiation by allowing students to choose what activities they will perform. It also provides differentiation for students of varying ability levels. Students who finish earlier will complete 2 out of the 3 activities while students who take longer to read and write in the earlier sections will only be required to complete one of the activities from this section.

Modifications/Differentiation:

This lesson is designed for student groups of various ability levels. In particular, it has been modified to assist students who struggle with reading and writing. The lesson worksheet comes in two versions, Version I and Version II. Version II is to be given to students who struggle with reading and writing and includes the following modifications:

- Bolded and Underlined key terms.
- Vocabulary previews
- Word Banks
- Note-taking/Outlining assistance
- Partner Reading
- Reduced workload to allow focus on key concepts

This lesson includes elements of differentiation by giving students choice in utilizing partner or independent work. It also differentiates by providing extension activities of varying lengths (Section 5).

Rationale:

This lesson utilizes a conceptual change text to serve as formative assessment of student understanding of the rock cycle. As indicated by the above research, students typically possess misconceptions about the rock cycle because it requires students to possess "systems-thinking" skills. The "systems-thinking" perspective requires a higher level of both cognitive ability and effort, which often leads to poor understanding of the concept. The conceptual change text in this lesson allows students the opportunity to critically analyze their conceptions and then provides scaffolding to assist them in correcting any misconceptions they may have. The student responses to the questions are to be used as a formative assessment tool by the teacher as well. By reading the student responses, teachers can determine what misconceptions about the rock cycle exist in their classroom and adjust their instruction accordingly.

References

Sibley, D. F., Anderson, C. W., & Heidemann, M. (2007). Box Diagrams to Assess Students' Systems Thinking about the Rock, Water and Carbon Cycles. *Journal Of Geoscience Education*, *55*(2), 138-146.

Kali, Y. y., Orion, N., & Eylon, B. (2003). Effect of Knowledge Integration Activities on Students' Perception of the Earth's Crust as a Cyclic System. *Journal Of Research In Science Teaching*, *40*(6), 545-565. doi:10.1002/tea.10096

Francek, M. m. (2013). A Compilation and Review of over 500 Geoscience Misconceptions. *International Journal Of Science Education*, *35*(1), 31-64. doi:10.1080/09500693.2012.736644

Assaraf, O. B., & Orion, N. n. (2005). Development of System Thinking Skills in the Context of Earth System Education. *Journal Of Research In Science Teaching*, *42*(5), 518-560. doi:10.1002/tea.20061

Version I
Name: ______________________________ Period: ___________

Check Your Misconceptions: <u>The Rock Cycle</u>

SECTION 1: What do you think?

Although most rocks look and feel as though they never change, rock material is constantly being created and destroyed in what we call the rock cycle. There are three main types of rocks: igneous, metamorphic, and sedimentary. Each type of rock is unique because it was formed in a different way. However, there are forces that break down these rocks and allow them to be formed into different types of rock. This transition of rock types is called the rock cycle.

<u>TASK:</u>

Based on your current knowledge of the rock cycle, use arrows and the following terms to create a diagram that demonstrates the changes in rock types that occur in the rock cycle.

TERMS

Heat & Pressure **Compaction & Cementation** **Magma**

Weathering & Erosion **Sediments** **Melting & Cooling**

<u>IGNEOUS ROCK</u>

<u>METAMORPHIC ROCK</u> **<u>SEDIMENTARY ROCK</u>**

Using the terms from above, describe how rock types change form in the rock cycle.

How well do you think you understand the cause of earthquakes? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

SECTION 2: Common Mistakes

Many students incorrectly think that...

MISCONCEPTIONS	
X	The rock cycle is steady and continuous.
X	The rock cycle takes millions of years to occur.
X	Only igneous and sedimentary rocks go through the rock cycle.
X	Each part of the rock cycle is stagnant and isolated and cannot change or be transformed into any other part of the rock cycle system.
X	The internal and external processes of the rock cycle are not related or connected.

Compare your ideas about the rock cycle to the incorrect ideas above. What are some similarities and/or differences between the misconceptions and your thoughts about the rock cycle?

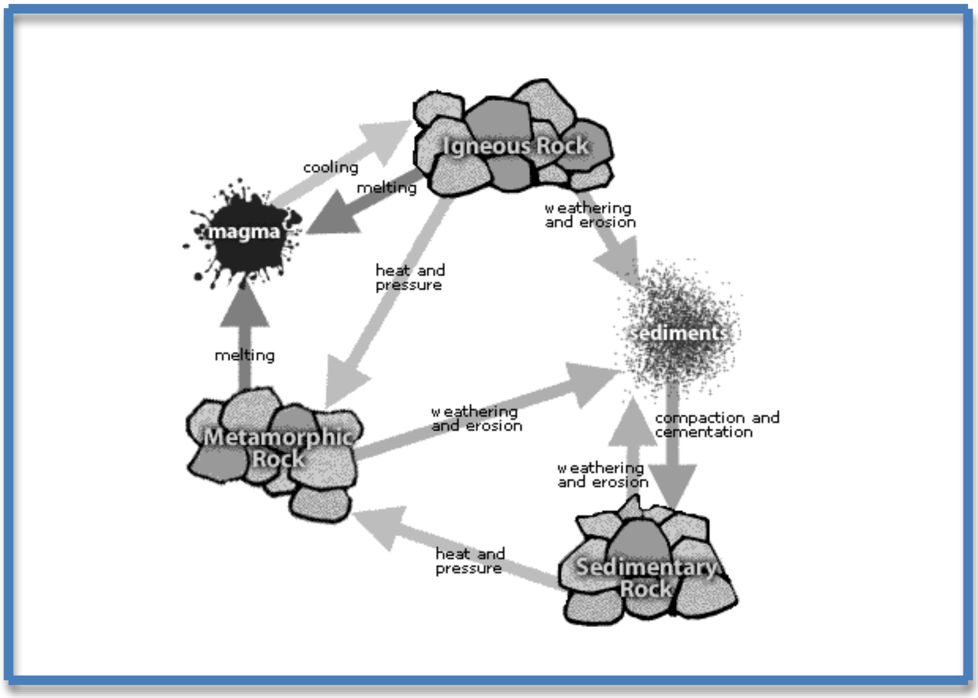
*Discuss with your partner the similarities and differences you found.
In what ways has your thinking about the rock cycle changed during this lesson?

How well do you think you understand how the rock cycle works? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

SECTION 3: The Correct Answer

Build your background knowledge of the rock cycle before the reading by watching this video.

https://www.youtube.com/watch?v=pm6cCg_Do6k



The diagram above is a correct depiction of the rock cycle. The three rock types are Igneous, Metamorphic, and Sedimentary. Both magma and sediment are rock materials that are on their way to becoming a certain rock type. The arrows represent the transformation of one rock type to another. Each arrow represents an agent of change that causes rocks to change type. The four agents of change include melting & cooling, heat & pressure, weathering & erosion, compaction & cementation.

Melting of rock material usually occurs deep underground where extremely high temperatures exist. Any rock type, sedimentary, metamorphic, or igneous, exposed to these temperatures is melted into a hot molten material called magma. When this magma travels upwards towards the Earth's surface, it begins to cool and harden into igneous rock.

Heat & pressure can act on any rock type to produce a metamorphic rock. When any rock material is buried deep enough, the pressure of overlying rock material can cause the minerals within the rock to realign, forming a new metamorphic rock. This process also occurs when any rock material is exposed to a heat source that is hot enough to cause the minerals to realign but not hot enough to cause melting.

Weathering & erosion act on exposed rocks at the Earth's surface. The process of weathering occurs when wind, water, ice, sunlight, and chemicals break down rock material into smaller pieces called sediment. These sediments are then carried away and deposited in another location by the process of erosion. Erosion is usually performed by wind or water that pushes or carries rock material from place to place. All rock types exposed at Earth's surface are subject to weathering & erosion.

Compaction & cementation result after agents of erosion deposit sediment. When more and more sediments are piled on top of each other, the increased weight compacts the underlying sediment. When enough pressure accumulates, the sediment is compacted into a sedimentary rock. Sometimes certain chemicals are present in the piles of sediment that act like concrete when dried. The cementation clumps and hardens the rock together resulting in a sedimentary rock. Sedimentary rocks can be composed of any rock type that has been broken down into smaller pieces.

As you can see from the diagram and the description of the agents of change, the rock cycle is a continuous cycle flowing in many different directions. All the rock types are continually changing into all of the other rock types. Some of the changes are fast and others take millions of years. All of the parts of the rock cycle are connected in some way and are in a constant state of change.

Answer the following questions about the above reading.

1) Arrows in the rock cycle represent ______________ of one rock type to another.
2) Melted rock material is called _______________.
3) The right amount of heat and pressure can produce _________________ rocks.
4) All rock types exposed at the Earth's surface are exposed to ______________ and _______________.
5) Sediment is formed into sedimentary rock through the processes of ________________ and ______________.
6) The Earth's rock material is constantly _______________ from one rock type to another.
7) All parts of the rock cycle are ________________.

SECTION 4: Reflect and Reconsider

Now that you have learned more about the rock cycle, re-draw your diagram of the rock cycle using arrows and the terms below.

TERMS

Heat & Pressure	**Compaction & Cementation**	**Magma**
Weathering & Erosion	**Sediments**	**Melting & Cooling**

THE ROCK CYCLE

IGNEOUS ROCK

METAMORPHIC ROCK **SEDIMENTARY ROCK**

Using the terms from above, describe how rock types change form in the rock cycle.

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In what ways has your thinking about the rock cycle changed during this lesson?

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How well do you think you understand how the rock cycle works? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 5: Extension Activity

This section includes three hands-on activities about the rock cycle. You are to choose any **two** to complete with a partner.

Activity #1 – The Chocolate Rock Cycle

1) Demonstrate the rock cycle using chocolate to represent rock material.
2) You will have to think like a scientist and design this experiment using the following materials:

- 2 chocolate bars (1 regular, 1 white)
- Aluminum foil
- Knife
- Hot plate
- Beaker and beaker tongs
- Safety goggles

3) Use a digital camera or your cell phone to take pictures of each phase of the rock cycle (Igneous, Metamorphic, and Sedimentary)
4) Print the pictures and label them with the correct phase. Turn these pictures into your teacher when completed.

******Be sure to be careful when using the knife and the hot plate. Wear your safety goggles and use the beaker tongs to touch hot materials.

Activity #2 – Rock Cycle Video

1) Make a video using your smart phone or a class iPad that demonstrates the rock cycle. Be sure to narrate your video and explain the phases of the rock cycle and the processes that connect them.
2) Use the following materials or feel free to be creative and use other resources located in the science classroom.
    - Smart phone/iPad
    - Igneous/Sedimentary/Metamorphic rock samples
    - Construction paper
    - Scissors
    - Glue sticks
    - Markers/Colored Pencils/Crayons
    - Any other materials in the science classroom (that are safe and relatively inexpensive).
3) Use the following terms during your narration of the video.
    - Sedimentary
    - Igneous
    - Metamorphic
    - Magma
    - Sediment
    - Melting & Freezing
    - Compaction & Cementation
    - Heat & Pressure

Activity #3 – Rock Cycle Story

Pretend that you are a piece of sediment that has traveled through the rock cycle. Tell about your journey and explain what it looked like and what it felt like to transform into the different rock types. Be sure to include the following terms in your story.

- Sedimentary
- Igneous
- Metamorphic
- Magma
- Sediment
- Melting & Freezing
- Compaction & Cementation
- Heat & Pressure

Version II
Name: ______________________________ Period: ___________

Check Your Misconceptions: <u>The Rock Cycle</u>

SECTION 1: What do you think?

Although most rocks look and feel as though they never change, rock material is constantly being created and destroyed in what we call the rock cycle. There are three main types of rocks: igneous, metamorphic, and sedimentary. Each type of rock is unique because it was formed in a different way. However, there are forces that break down these rocks and allow them to be formed into different types of rock. This transition of rock types is called the rock cycle.

<u>TASK:</u>

Based on your current knowledge of the rock cycle, use arrows and the following terms to create a diagram that demonstrates the changes in rock types that occur in the rock cycle.

TERMS

Heat & Pressure **Compaction & Cementation** **Magma**

Weathering & Erosion **Sediments** **Melting & Cooling**

<u>IGNEOUS ROCK</u>

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Using the terms from above, describe how rock types change form in the rock cycle.

How well do you think you understand the cause of earthquakes? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

SECTION 2: Common Mistakes

Many students incorrectly think that...

MISCONCEPTIONS	
X	The rock cycle is steady and continuous.
X	The rock cycle takes millions of years to occur.
X	Only igneous and sedimentary rocks go through the rock cycle.
X	Each part of the rock cycle is stagnant and isolated and cannot change or be transformed into any other part of the rock cycle system.
X	The internal and external processes of the rock cycle are not related or connected.

Compare your ideas about the rock cycle to the incorrect ideas above. What are some similarities and/or differences between the misconceptions and your thoughts about the rock cycle?

*Discuss with your partner the similarities and differences you found.
In what ways has your thinking about the rock cycle changed during this lesson?

How well do you think you understand how the rock cycle works? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

SECTION 3: The Correct Answer

Build your background knowledge of the rock cycle before the reading by watching this video.

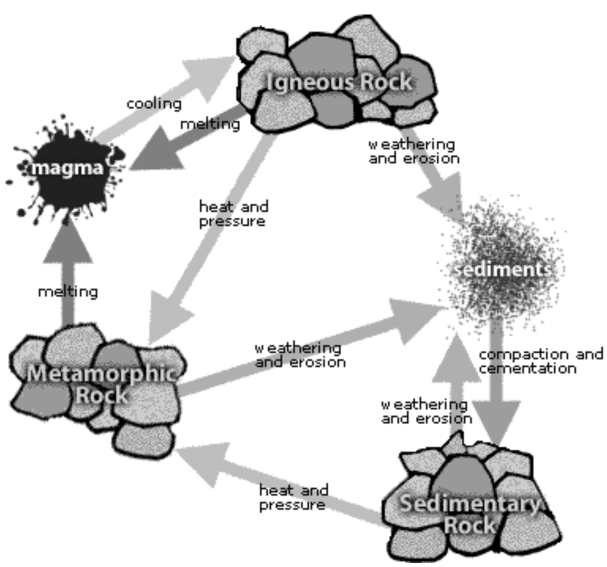
https://www.youtube.com/watch?v=pm6cCg_Do6k

*****Reading Tips:**

1) **Preview the vocabulary**
2) **Read the questions first to establish a purpose.**
3) **Read with a partner.**
4) **Take notes as you go to help keep you focused.**

Preview the Vocabulary

Agents of change – forces that change one rock type to another
Transformation – changing from one thing to another
Realign – to organize into a new pattern
Deposit – to put something somewhere



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Weathering & erosion act on exposed rocks at the Earth's surface. The process of **weathering** occurs when wind, water, ice, sunlight, and chemicals break down rock material into smaller pieces called sediment. These sediments are then carried away and deposited in another location by the process of **erosion**. Erosion is usually performed by wind or water that pushes or carries rock material from place to place. All rock types exposed at Earth's surface are subject to weathering & erosion.

Compaction & cementation result after agents of erosion deposit sediment. When more and more sediments are piled on top of each other, the increased weight compacts the underlying sediment. When enough pressure accumulates, the sediment is **compacted** into a sedimentary rock. Sometimes certain chemicals are present in the piles of sediment that act like cement when dried. The **cement** clumps and hardens the rock together resulting in a sedimentary rock. Sedimentary rocks can be composed of any rock type that has been broken down into smaller pieces.

As you can see from the diagram and the description of the agents of change, the rock cycle is a continuous cycle flowing in many different directions. All the rock types are continually changing into all of the other rock types. Some of the changes are fast and others take millions of years. All of the parts of the rock cycle are connected in some way and are in a constant state of change.

Paragraph 1

Main Idea –

Paragraph 2

Main Idea –

Detail 1:

Detail 2:

Paragraph 3

Main Idea –

Detail 1:

Detail 2:

Paragraph 4

Main Idea –

Detail 1:

Detail 2:

Paragraph 5

Main Idea –

Detail 1:

Detail 2:

Paragraph 6

Summary:

Word Bank

metamorphic	**connected**	**magma**	**weathering**	**transformations**
compaction	**erosion**	**changing**	**cementation**	

Answer the following questions about the above reading.

1) Arrows in the rock cycle represent _____________ of one rock type to another.
2) Melted rock material is called ______________.
3) The right amount of heat and pressure can produce ________________ rocks.
4) All rock types exposed at the Earth's surface are exposed to _____________ and ______________.
5) Sediment is formed into sedimentary rock through the processes of _______________ and _____________.
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SECTION 4: Reflect and Reconsider

Now that you have learned more about the rock cycle, re-draw your diagram of the rock cycle using arrows and the terms below.

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THE ROCK CYCLE

IGNEOUS ROCK	
METAMORPHIC ROCK	SEDIMENTARY ROCK

Using the terms from above, describe how rock types change form in the rock cycle.

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In what ways has your thinking about the rock cycle changed during this lesson?

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How well do you think you understand how the rock cycle works? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 5: Extension Activity

This section includes three hands-on activities about the rock cycle. You are to choose **one** to complete with a partner.

Activity #1 – The Chocolate Rock Cycle

5) Demonstrate the rock cycle using chocolate to represent rock material.
6) You will have to think like a scientist and design this experiment using the following materials:
   - 2 chocolate bars (1 regular, 1 white)
   - Aluminum foil

- Knife
- Hot plate
- Beaker and beaker tongs
- Safety goggles

7) Use a digital camera or your cell phone to take pictures of each phase of the rock cycle (Igneous, Metamorphic, and Sedimentary)
8) Print the pictures and label them with the correct phase. Turn these pictures into your teacher when completed.

******Be sure to be careful when using the knife and the hot plate. Wear your safety goggles and use the beaker tongs to touch hot materials.

<u>Activity #2 – Rock Cycle Video</u>

4) Make a video using your smart phone or a class iPad that demonstrates the rock cycle. Be sure to narrate your video and explain the phases of the rock cycle and the processes that connect them.
5) Use the following materials or feel free to be creative and use other resources located in the science classroom.
    - Smart phone/iPad
    - Igneous/Sedimentary/Metamorphic rock samples
    - Construction paper
    - Scissors
    - Glue sticks
    - Markers/Colored Pencils/Crayons
    - Any other materials in the science classroom (that are safe and relatively inexpensive).
6) Use the following terms during your narration of the video.
    - Sedimentary
    - Igneous
    - Metamorphic
    - Magma
    - Sediment
    - Melting & Freezing
    - Compaction & Cementation
    - Heat & Pressure

<u>Activity #3 – Rock Cycle Story</u>

Pretend that you are a piece of sediment that has traveled through the rock cycle. Tell about your journey and explain what it looked like and what it felt like to transform into the different rock types. Be sure to include the following terms in your story.

- Sedimentary
- Igneous
- Metamorphic
- Magma
- Sediment
- Melting & Freezing
- Compaction & Cementation
- Heat & Pressure

Rock Cycle Diagram #1

RUBRIC

Score	**4**	**3**	**2**	**1**
Cyclical Nature	The rock types are all connected to each other with arrows pointing in the appropriate directions. The diagram clearly represents a cyclical pattern.	The rock types are mostly connected except one or two connections are missing. The diagram hints towards the rock cycle having a cyclical pattern.	Some of the rock types are connected some of the directions of flow are apparent. The diagram does not represent a cyclical pattern.	The rock types are connected by only only one direction. A cyclical pattern is not apparent.
Processes of Change **(melting&cooling, heat&pressure, compaction&cementation, weathering&erosion)**	All 4 processes of change are included and are placed in the proper locations in the rock cycle.	2-3 processes of change are included and placed in the proper locations of the rock cycle.	Only 1 process of change is included and placed in the proper location of the rock cycle.	No processes of change are included and placed in the proper location of the rock cycle.
Materials	Magma and Sediment are included and placed in the proper locations in the rock cycle.	Magma and Sediment are included and one of them is placed in the poper location in the rock cycle.	Magma or Sediment is included and one of them is placed in the proper location in the rock cycle.	Neither Magma or Sediment are included. Or they are included but neither are placed in the correct location.

Score: __________ out of 12

Rock Cycle Diagram #2

RUBRIC

Score	**4**	**3**	**2**	**1**
Cyclical Nature	The rock types are all connected to each other with arrows pointing in the appropriate directions. The diagram clearly represents a cyclical pattern.	The rock types are mostly connected except one or two connections are missing. The diagram hints towards the rock cycle having a cyclical pattern.	Some of the rock types are connected some of the directions of flow are apparent. The diagram does not represent a cyclical pattern.	The rock types are connected by only only one direction. A cyclical pattern is not apparent.
Processes of Change **(melting&cooling, heat&pressure, compaction&cementation, weathering&erosion)**	All 4 processes of change are included and are placed in the proper locations in the rock cycle.	2-3 processes of change are included and placed in the proper locations of the rock cycle.	Only 1 process of change is included and placed in the proper location of the rock cycle.	No processes of change are included and placed in the proper location of the rock cycle.
Materials	Magma and Sediment are included and placed in the proper locations in the rock cycle.	Magma and Sediment are included and one of them is placed in the poper location in the rock cycle.	Magma or Sediment is included and one of them is placed in the proper location in the rock cycle.	Neither Magma or Sediment are included. Or they are included but neither are placed in the correct location.

Score: __________ out of 12

Change in Score: __________

VI. Air Pressure

NYS Standard:

STANDARD 4: The Physical Setting

Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

2.1b As altitude increases, air pressure decreases.

Next Generation Science Standards:

MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions. [Clarification Statement: Emphasis is on how air masses flow from regions of high pressure to low pressure, causing weather (defined by temperature, pressure, humidity, precipitation, and wind) at a fixed location to change over time, and how sudden changes in weather can result when different air masses collide. Emphasis is on how weather can be predicted within probabilistic ranges. Examples of data can be provided to students (such as weather maps, diagrams, and visualizations) or obtained through laboratory experiments (such as with condensation).

Background Research:

A proper understanding of air pressure is essential for students to understand the majority of scientific concepts related to weather. One must understand the physics of air pressure in order to comprehend the structure of the atmosphere. The water cycle and weather patterns are all connected to air pressure. Unfortunately, most students do not fully understand air pressure and therefore struggle to understand weather concepts.

Despite the constant presence of air all around us, most of us have very little understanding of air pressure and its significance to our everyday lives. The main reason people struggle to understand air and air pressure is that air is colorless, odorless, and tasteless (Bulunz, Jarrett, and Bulunz, 2009). The only time air is obviously apparent is when it is moving. Many students believe that air is only present when they can see the wind blow objects around or feel it on their skin (Bulunz & Jarrett, 2009). When components in scientific concepts are not easily visible to the human eye, such as air and air pressure, they become very abstract to students. Abstract demonstrations and explanations require a higher degree of cognitive effort and ability to comprehend. Many students struggle with such cognitive demands.

Some studies have found that misconceptions about air and air pressure are common even among teachers. One academic study conducted in 2009 found that a sample population of pre-service teachers only scored an average of 42% on a test about the basic properties of air. This implies that the average teacher has only a partial understanding of air and air pressure and possesses misconceptions. These misconceptions are unknowingly passed on to students via their instructors (Bulunz & Jarrett, 2009).

In addition to faulty teacher knowledge of air and air pressure, instruction related to these topics has been found to be inadequate. Traditional science instruction features primarily lecture-based instruction with some laboratory exercises. Studies have shown that students improved their conceptual understanding of the properties of air only after extensive participation in hands-on experiments and demonstrations (Bulunz, Jarrett,

& Bulunz, 2009) Many students may not be exposed to sufficient hands-on activities to fully grasp the abstract concept of air pressure leading to incomplete undersandings and misconceptions.

Although there are many student misconceptions regarding the rock cycle, listed below are a few of the most common that teachers should look for in their classrooms:

- Gases are not matter because they are invisible (Stepans, 1994).
- Gas has no weight — even if it has color it has no weight (Stavy, 1990).
- Air only exerts force or pressure when it is moving (Sere, 1982, as cited in Bulunz, Jarrett, & Bulunz, 2009).
- There is no pressure from the atmosphere because I can't feel it.

Objectives:

Students will:

- Identify their personal conceptions about air and air pressure.
- Compare their personal conceptions to the scientifically accurate explanation of air pressure.
- Evaluate the effectiveness of the presented explanation and modify their previously held conceptions about air and air pressure if necessary.
- Explain what causes air pressure and the relationship between altitude and air pressure works.
- Apply their knowledge of air pressure to an extension activity (build a barometer, perform an experiment, create a brochure).

Materials:

- "Air Pressure" conceptual change text worksheets (Version I&II)
- Internet Access
- iPads
- Jars
- Balloons
- Rubber bands
- Straws
- Scissors
- Tape
- Soda cans
- Hot Plate
- Beaker tongs
- Safety goggles

Lesson Summary:

This lesson utilizes a conceptual change text to help students remediate their misconceptions associated with air and air pressure. There are two versions of the text (Version I&II). Version II is modified to assist students with difficulties in the areas of reading and writing.

Section I begins with a short reading passage about the properties of air. This section serves to build background knowledge and introduce the topic. Teachers should either read this section aloud to the class or the students should be given the option to read with a partner. Students are then asked to answer three questions about air and air pressure. Prior to students answering this section, the teacher should explain to the students that they should not be afraid to get the answer wrong. The goal of this section is simply to recognize their current thoughts about air and air pressure so they can improve upon them. The students should do this section individually, as misconceptions might not be detected if students are influenced by their peers. The section closes by having them rate their understanding of the topic on a 1-10 scale.

Section 2 presents students with some common misconceptions about air and air pressure. The teacher should either read this section aloud to the class or students should be given the option to read with a partner. Partner reading will allow struggling readers to have the support of a classmate. Stronger readers should also be allowed to read ahead if they choose. Students should discuss with their partners how their initial answers compared to the misconceptions. The teacher should culminate this section by facilitating a class discussion about the misconceptions and provide any necessary clarification. Students are asked to compare their conceptions with the misconceptions and record any similarities. They are then asked how their thinking has changes so far during the lesson and to rate their understanding of the topic on 1-10 scale.

Section 3 presents students with a correct explanation of the properties of air and air pressure. The section begins with a short video about air pressure that serves to provide students with some more background knowledge before the reading. The video is followed by a reading passage about air and air pressure, the teacher should either read this section with the entire class or give students the option to read in their partner groups. The teacher should also summarize the main concepts within the section and provide clarification through facilitating a class discussion. The section closes with a series of questions about the reading, which also serves to scaffold them in constructing an accurate model of air pressure. Students are again asked to note how their thinking has changed during the lesson and to rate their understanding on a 1-10 scale.

Section 4 requires students to revisit their initial conceptions and re-answer the questions about air and air pressure from the beginning of the activity according to what they have learned during the lesson. This reflection on their initial conceptions will cause them to further analyze any misconceptions they may have had and help to consolidate a new more accurate understanding of air pressure. Section 4 closes with a few questions that ask them to state explicitly how their thinking has changed in regards to air pressure and how confident they are in their understanding of the topic. They are asked a final time to rate their understanding of the topic on a 1-10 scale.

Section 5 includes three activities that serve as extension opportunities about air pressure. These extension activities help students further their understanding by utilizing different modalities of learning and make the learning more relevant to their lives. This section provides differentiation by allowing students to choose what activities they will perform. It also provides differentiation for students of varying ability levels. Students who finish earlier will complete 2 out of the 3 activities while students who take longer to read and write in the earlier sections will only be required to complete one of the activities from this section.

Modifications/Differentiation:

This lesson is designed for student groups of various ability levels. In particular, it has been modified to assist students who struggle with reading and writing. The lesson worksheet comes in two versions, Version I and Version II. Version II is to be given to students who struggle with reading and writing and includes the following modifications:

- Bolded and Underlined key terms.
- Vocabulary previews
- Word Banks
- Note-taking/Outlining assistance

- Partner Reading
- Reduced workload to allow focus on key concepts

This lesson includes elements of differentiation by giving students choice in utilizing partner or independent work. It also differentiates by providing extension activities of varying lengths and learning modalities (Section 5).

Rationale:

This lesson utilizes a conceptual change text to serve as formative assessment of student understanding of air and air pressure. As indicated by the above research, students typically possess misconceptions about air and air pressure because air is colorless, odorless, and tasteless. The difficulty in detecting the presence of air makes it an abstract concept for students to understand. The concept is so difficult that many teachers and instructional methods fail to teach it properly. The abstract nature of air and air pressure leads to the generation of many misconceptions. The conceptual change text in this lesson allows students the opportunity to critically analyze their conceptions and then provides scaffolding to assist them in correcting any misconceptions they may have. The student responses to the questions are to be used as a formative assessment tool by the teacher as well. By reading the student responses, teachers can determine what misconceptions about air and air pressure exist in their classroom and adjust their instruction accordingly.

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Version I
Name: ______________________________ Period: ___________

Check Your Misconceptions: ***Air Pressure***

SECTION 1: What do you think?

Most of us are aware that we are surrounded by air. If we weren't, we couldn't breathe. There would be no weather without air. So we know it's there and yet most people know very little about air. We most likely don't know much about air because it is colorless, odorless, and tasteless. Air is therefore hard to detect by our natural senses. Consider for a moment what you know about air and answer the following questions to the best of your ability.

1) Does air have mass? How do you know?

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2) Is air exerting pressure on you right now? How do you know?

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3) Why do our ears pop when we fly?

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How well do you think you understand the properties of air and air pressure? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 2: Common Mistakes

Many students incorrectly think that...

MISCONCEPTIONS	
X	Gases are not matter because they are invisible.
X	Air has no weight. Even if it has color it has no weight.
X	Air only exerts force or pressure when it is moving.
X	There is no pressure from the atmosphere because I can’t feel it.

Compare your ideas about air and air pressure to the incorrect ideas above. What are some similarities and/or differences between the misconceptions and your thoughts about air and air pressure?

*Discuss with your partner the similarities and differences you found.
In what ways has your thinking about air and air pressure changed during this lesson?

How well do you think you understand the properties of air and air pressure? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

SECTION 3: The Correct Answer

Build your background knowledge of air and air pressure before the reading by watching this video.

https://www.youtube.com/watch?v=7_yf-iRf8Vc

Air is a collection of gases that surrounds us at all times. It is a collection of tiny particles just like liquids and solids are. The difference is that air molecules are spaced far apart and are therefore less dense. This is why we don’t always see or feel the air around us. The air in our atmosphere is composed of 78% Nitrogen, 21% Oxygen, and a small percentage of other gases like Carbon Dioxide. Every one of these gases is made up of individual atoms that each have mass. Air is composed of these gases and therefore has mass also. Because air has mass, it is attracted to the Earth by gravity.

The force of gravity pulls the air molecules towards the Earth. This stacks the air molecules in a vertical pattern with each air molecule exerting a force on the one below it. This force is what we call air pressure. Consider stacking several textbooks on top of each other. The books towards the bottom of the stack would have the most pressure on them because they have more mass stacked on top of them. The same is true for air in our atmosphere. Air pressure is greatest at the surface of the Earth because there is a large column of air stacked above it. As you travel higher in the atmosphere by climbing up a mountain or flying in a plane, the air pressure decreases because their will be less air molecules stacked above you. It is important to note that although air pressure is caused by a column of air stacked above you, the force of air pressure acts in all directions and not just from above.

If you’ve ever wondered why your ears pop when you fly in an airplane, it has to do with air pressure. When you are in an airplane on the runway, the air pressure is relatively high because there is a large column of air stacked above you. When you take off and travel higher into the atmosphere, there is less and less air stacked above you. Less air stacked above you, decreases the pressure on the outside of your ears. The pressure inside your ears is higher than its surroundings so your ears “pop” or release pressure to reach equilibrium with their environment.

Knowing about air pressure is useful for more than just explaining why our ears pop. Knowledge of air pressure allows us to understand and predict weather. The rising and cooling of air, which is the source of our weather, has to do primarily with air pressure. Without an accurate understanding of air pressure, we would be unable to create accurate weather predictions that are very important to our society.

Answer the following questions about the above reading.

1) **Air is made up of atoms and therefore has ____________.**
2) **The force of _____________ pulls air molecules towards the earth.**
3) **Air molecule are stacked on top of each other which causes __________________.**
4) **Air pressure is ____________ at the surface of the earth because there is a larger column of air above it.**

5) **Air pressure is ____________ high in the atmosphere because there is a smaller column of air stacked above.**
6) **Our ears pop on an airplane because our try to reach ____________ with the surrounding environment.**
7) **Understanding air pressure is important because it allows us to _____________ the weather.**

SECTION 4: Reflect and Reconsider

Now that you have learned more about air and air pressure, re-answer the questions from the beginning.

1) Does air have mass? How do you know?

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2) Is air exerting pressure on you right now? How do you know?

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3) Why do our ears pop when we fly?

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In what ways has your thinking about air and air pressure changed during this lesson?

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How well do you think you understand the properties of air and air pressure? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 5: Extension Activity

This section includes three hands-on activities about air pressure. You are to choose any **two** to complete with a partner.

Activity #1 – Create Your Own Barometer

Collect the list of materials below from your teacher and then go to the website below and follow the directions to create your own barometer. A barometer is an instrument that measures air pressure. With this instrument, you will be able to measure and predict the weather. When you have finished creating your barometer, write a short paragraph on how the barometer works.

Materials needed:

- Scissors
- Tape
- Balloon
- Jar
- Rubber band
- Drinking straw

Website:

http://www.wikihow.com/Make-a-Simple-Weather-Barometer

Activity #2 – Can Crush Experiment

Collect the list of materials below from your teacher and then go to the website below and watch the video. After you watch the video, use your materials to replicate the experiment from the video. Use a class iPad or your cell phone to record your experiment. During your recording, explain to the viewers what is going on and how it relates to air pressure. Be safe when working with the hot plate and wear your safety goggles!!!

Website:

http://www.youtube.com/watch?v=lT3PJ0RY4oY

Activity #3 – Air Plane Pamphlet

Oftentimes, young children on airplanes get scared when their ears pop. They get scared because they don't know what is happening to their ears. Your job is to create a kid-friendly pamphlet that explains to kids on airplanes why their ears pop and that it is okay. These pamphlets could be placed in the seatbacks of airplanes for kids to read and help them better enjoy their flight. You can create your pamphlet by hand using markers and construction paper or you can use the Microsoft Publisher software. Just make sure your pamphlet uses kid-friendly language, is simple and straightforward, is colorful, and includes pictures.

Version II
Name: ______________________________ Period: ___________

Check Your Misconceptions: ***Air Pressure***

SECTION 1: What do you think?

Most of us are aware that we are surrounded by air. If we weren't, we couldn't breathe. There would be no weather without air. So we know it's there and yet most people know very little about air. We most likely don't know much about air because it is colorless, odorless, and tasteless. Air is therefore hard to detect by our natural senses. Consider for a moment what you know about air and answer the following questions to the best of your ability.

1) Does air have mass? How do you know?

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2) Is air exerting pressure on you right now? How do you know?

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3) Why do our ears pop when we fly?

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How well do you think you understand the properties of air and air pressure? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 2: Common Mistakes

Many students incorrectly think that...

MISCONCEPTIONS	
X	Gases are not matter because they are invisible.
X	Air has no weight. Even if it has color it has no weight.
X	Air only exerts force or pressure when it is moving.
X	There is no pressure from the atmosphere because I can't feel it.

Compare your ideas about air and air pressure to the incorrect ideas above. What are some similarities and/or differences between the misconceptions and your thoughts about air and air pressure?

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*Discuss with your partner the similarities and differences you found.
In what ways has your thinking about air and air pressure changed during this lesson?

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How well do you think you understand the properties of air and air pressure? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 3: The Correct Answer

Build your background knowledge of air and air pressure before the reading by watching this video.

https://www.youtube.com/watch?v=7_yf-iRf8Vc

*****Reading Tips:**

5) **Preview the vocabulary**
2) **Read the questions first to establish a purpose.**
3) **Read with a partner.**
4) **Take notes as you go to help keep you focused.**

Preview the Vocabulary

Atoms – the smallest part of an element, unable to be seen by the human eye
Mass - an amount of matter, similar to weight
Gravity – force of attraction from a large body like a planet
Air pressure – pressure caused by the stacking of air molecules
Atmosphere – relatively thin layer of gases that surrounds the Earth
Equilibrium – a state of balance
Predict – to make an assumption about the future based on evidence

AIR PRESSURE

Air is a collection of gases that surrounds us at all times. It is a collection of tiny particles just like liquids and solids are. The difference is that air molecules are spaced far apart and are therefore less dense. This is why we don't always see or feel the air around us. The air in our atmosphere is composed of 78% Nitrogen, 21% Oxygen, and a small percentage of other gases like Carbon Dioxide. Every one of these gases is made up of individual **atoms** that each have mass. Air is composed of these gases and therefore has mass also. Because air has **mass**, it is attracted to the Earth by gravity.

The force of **gravity** pulls the air molecules towards the Earth. This stacks the air molecules in a vertical pattern with each air molecule exerting a force on the one below it. This force is what we call **air pressure**. Consider stacking several textbooks on top of each other. The books towards the bottom of the stack would have the most pressure on them because they have more mass stacked on top of them. The same is true for air in our atmosphere. Air pressure is greatest at the surface of the Earth because there is a large column of air stacked above it. As you travel higher in the **atmosphere** by climbing up a mountain or flying in a plane, the air pressure decreases because their will be less air

Paragraph 1

Main Idea –

Detail 1:

Detail 2:

Paragraph 2

Main Idea –

Detail 1:

Detail 2:

molecules stacked above you. It is important to note that although air pressure is caused by a column of air stacked above you, the force of air pressure acts in all directions and not just from above.

If you've ever wondered why your ears pop when you fly in an airplane, it has to do with air pressure. When you are in an airplane on the runway, the air pressure is relatively high because there is a large column of air stacked above you. When you take off and travel higher into the atmosphere, there is less and less air stacked above you. Less air stacked above you, decreases the pressure on the outside of your ears. The pressure inside your ears is higher than its surroundings so your ears "pop" or release pressure to reach **equilibrium** with their environment.

Knowing about air pressure is useful for more than just explaining why our ears pop. Knowledge of air pressure allows us to understand and **predict** weather. The rising and cooling of air, which is the source of our weather, has to do primarily with air pressure. Without an accurate understanding of air pressure, we would be unable to create accurate
weather predictions that are very important to our society.

Paragraph 3

Main Idea –

Detail 1:

Detail 2:

Paragraph 4

Summary -

Use the word bank to answer the following questions about the above reading.

Word Bank

equilibrium **air pressure** **less** **mass** **predict** **gravity** **greater**

1) **Air is made up of atoms and therefore has ____________.**
2) **The force of _____________ pulls air molecules towards the earth.**
3) **Air molecule are stacked on top of each other which causes __________________.**
4) **Air pressure is ____________ at the surface of the earth because there is a larger column of air above it.**
5) **Air pressure is ____________ high in the atmosphere because there is a smaller column of air stacked above.**
6) **Our ears pop on an airplane because our try to reach ____________ with the surrounding environment.**
7) **Understanding air pressure is important because it allows us to _____________ the weather.**

SECTION 4: Reflect and Reconsider

Now that you have learned more about air and air pressure, re-answer the questions from the beginning.

1) Does air have mass? How do you know?

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2) Is air exerting pressure on you right now? How do you know?

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3) Why do our ears pop when we fly?

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In what ways has your thinking about air and air pressure changed during this lesson?

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How well do you think you understand the properties of air and air pressure? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

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SECTION 5: Extension Activity

This section includes three hands-on activities about air pressure. You are to choose **one** to complete with a partner.

Activity #1 – Create Your Own Barometer

Collect the list of materials below from your teacher and then go to the website below and follow the directions to create your own barometer. A barometer is an instrument that measures air pressure. With this instrument, you will be able to measure and predict the weather. When you have finished creating your barometer, write a short paragraph on how the barometer works.

Materials needed:

- Scissors
- Tape
- Balloon
- Jar
- Rubber band
- Drinking straw

Website:

http://www.wikihow.com/Make-a-Simple-Weather-Barometer

Activity #2 – Can Crush Experiment

Collect the list of materials below from your teacher and then go to the website below and watch the video. After you watch the video, use your materials to replicate the experiment from the video. Use a class iPad or your cell phone to record your experiment. During your recording, explain to the viewers what is going on and how it relates to air pressure. Be safe when working with the hot plate and wear your safety goggles!!!

Website:

http://www.youtube.com/watch?v=lT3PJ0RY4oY

Activity #3 – Air Plane Pamphlet

Oftentimes, young children on airplanes get scared when their ears pop. They get scared because they don't know what is happening to their ears. Your job is to create a kid-friendly pamphlet that explains to kids on airplanes why their ears pop and that it is okay. These pamphlets could be placed in the seatbacks of airplanes for kids to read and help them better enjoy their flight. You can create your pamphlet by hand using markers and construction paper or you can use the Microsoft Publisher software. Just make sure your pamphlet uses kid-friendly language, is simple and straightforward, is colorful, and includes pictures.

Air Pressure Questions #1

Rubric

Score	4	3	2	1
Air has Mass	Air does have mass. Air is composed of a variety of gases that are each composed of atoms.	Air does have mass. Air is made up of particles that have mass.	Air has mass.	Air does not have mass.
Air Pressure	Yes, air is exerting pressure on me right now. Air molecules are stacked high above us into the atmosphere causing pressure in all directions.	Yes, air exerting pressure on me right now. Air molecules are pushing downward on me.	Yes, air exerting pressure on me right now.	No, air is not exerting pressure on me right now.
Why Ears "Pop"	As the air plane increases in altitude, there are less air molecule stacked above resulting in lower pressure. The pressure inside our ears is greater than the surrounding pressure, so our ears pop to release pressure and reach equilibrium.	Our ears pop because there are less air molecules stacked above you when you are higher in the atmosphere, resulting in lower pressure.	Our ears pop because the air pressure is lower at higher altitudes.	Any non-scientific or inaccurate answer.

Score: __________ out of 12

Air Pressure Questions #2

Rubric

Score	4	3	2	1
Air has Mass	Air does have mass. Air is composed of a variety of gases that are each composed of atoms.	Air does have mass. Air is made up of particles that have mass.	Air has mass.	Air does not have mass.
Air Pressure	Yes, air is exerting pressure on me right now. Air molecules are stacked high above us into the atmosphere causing pressure in all directions.	Yes, air exerting pressure on me right now. Air molecules are pushing downward on me.	Yes, air exerting pressure on me right now.	No, air is not exerting pressure on me right now.
Why Ears "Pop"	As the air plane increases in altitude, there are less air molecule stacked above resulting in lower pressure. The pressure inside our ears is greater than the surrounding pressure, so our ears pop to release pressure and reach equilibrium.	Our ears pop because there are less air molecules stacked above you when you are higher in the atmosphere, resulting in lower pressure.	Our ears pop because the air pressure is lower at higher altitudes.	Any non-scientific or inaccurate answer.

Score: __________ out of 12

Change in Score: __________

VII. Earthquakes

NYS Standards:

Standard 4: The Physical Setting.

Key Idea 2:Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land.

2.2f Plates may collide, move apart, or slide past one another. Most volcanic activity and mountain building occur at the boundaries of these plates, often resulting in earth- quakes.

Background Research:

Earthquakes are one of the most popularized natural disasters throughout the world and at the same time one of the most misunderstood. Whether someone has experienced an earthquake firsthand or only seen news footage of an earthquake event, they could probably give you an accurate description of the destructive results. However, many people cannot accurately describe the cause of an earthquake (Simsek, 2007). An accurate understanding of the cause of earthquakes is essential to our society's ability to create effective earthquake response programs that minimize human injury and property damage.

There are many reasons that students may not possess accurate understandings of the cause of earthquakes. One reason is that students often combine aspects of several different natural disasters into their conception of what an earthquake is (Simsek, 2007). Many students believe that rain storms, floods, landslides, and fires are all components of an earthquake. These are all separate phenomena with distinct causes. When a student combines these ideas, understanding the exact cause of an earthquake becomes confusing.

Religious beliefs and myths also influence student ideas about the cause of earthquakes (Tsai, 2001). In research studies about earthquakes, students were recorded as saying that earthquakes occur because God wants them to. Other students responded that earthquakes occur to punish people for wrongdoings. Although these reasons are very non-scientific and illogical, the effect of religion and culture should not be underestimated when considering student misconceptions of earthquakes.

Another reason that students struggle with understanding what causes earthquakes is that the processes that result in earthquakes are hidden underground. Students cannot see the tectonic processes that lead to earthquakes directly and therefore have to rely on abstract understandings of large plate movements. The cause of earthquakes is not visible and intuitive for students, which leads to students creating ideas based on unrelated surface processes that they can see like storms, fires, landslides, etc.

Finally, students often maintain misconceptions about the cause of earthquakes due to faults in their informational sources. Several studies surveyed students where they received their knowledge of earthquakes from and the majority of students responded that the media was their primary information source. Media does not always aim to educate but more often focuses on entertainment. Information obtained from the general media is often unreliable and non-scientific. Teachers were their secondary information source but unfortunately many curriculums focus primarily on earthquake safety and do not stress the causes of earthquakes. Without solid instruction on the causes of earthquakes it is not surprising that many misconceptions about the subject exist.

Although there are many student misconceptions about the causes of earthquakes, listed below are a few of the most common that teachers should look for in their classrooms:

- According to Kirby, some students believe earthquakes occur from collapse of subterranean hollow spaces (as cited in Francek, 2013).

- According to the USGS website, some students believe that weather triggers earthquakes (as cited in Francek, 2013).

- According to Simsek, some students believe that earthquakes occur because of landslides (as cited in Francek, 2013).

- According to Libarkin et al, some students believe earthquakes are caused by heat, temperature, climate, weather, people, and animals, gas pressure, gravity, the rotation of the Earth, 'exploding soil' or volcanoes (as cited in Francek, 2013).

Objectives:

Students will:

- Identify their personal conceptions of what causes earthquakes.
- Compare their personal conceptions to the scientifically accurate explanation of what causes earthquakes.
- Evaluate the effectiveness of the presented explanation and modify their previously held conceptions about earthquakes if necessary.
- Explain what causes earthquakes.
- Create a pamphlet, video, or physical demonstration illustrating the cause of earthquakes.

Materials:

- "Earthquakes" Conceptual Change Text Worksheets (Version I&II)
- Internet Access
- Pan
- Water
- Pebble
- Computer Access (preferably with Microsoft Publisher)
- iPad or some form of video camera

Lesson Summary:

This lesson utilizes a conceptual change text to help students remediate their misconceptions associated with the cause of earthquakes. There are two versions of the text (Version I&II). Version II is modified to assist students with difficulties in the areas of reading and writing.

Section I begins with a short reading passage about what earthquakes are and why it is important to know what causes them. This section serves to build background knowledge and introduce the topic. Teachers should either read this section aloud to the class or the students should be given the option to read with a partner. Students are then asked write down what they think causes earthquakes. Prior to students answering this section, the teacher should explain to the students that they should not be afraid to get the answer wrong. The goal of this section is simply to recognize their current thoughts about the cause of earthquakes so they can improve upon them. The students should do this section individually, as misconceptions might not be detected if students are influenced by their peers. The section closes by having them rate their understanding of the topic on a 1-10 scale.

Section 2 presents students with some common misconceptions surrounding the cause of earthquakes. The teacher should either read this section aloud to the class or students should be given the option to read with a partner. Partner reading will allow struggling readers to have the support of a classmate. Stronger readers should also be allowed to read ahead if they choose. Students should discuss with their partners how their initial answers compared to the misconceptions. The teacher should culminate this section by facilitating a class discussion about the misconceptions and provide any necessary clarification. Students are asked to compare their conceptions with the misconceptions and record any similarities. They are then asked how their thinking has changes so far during the lesson and to rate their understanding of the topic on 1-10 scale.

Section 3 presents students with the correct explanation of what causes earthquakes. The section begins with a short video about earthquakes that serves to provide students with some more background knowledge before the reading. The video is followed by a reading passage about earthquakes, the teacher should either read this section with the entire class or give students the option to read in their partner groups. The teacher should also summarize the main concepts within the section and provide clarification through facilitating a class discussion. The section closes with a series of questions about the reading, which also serves to scaffold their response to the question about the cause of earthquakes. Students are again asked to note how their thinking has changed during the lesson and to rate their understanding on a 1-10 scale.

Section 4 requires students to revisit their initial conceptions and rewrite their answer to the initial question about the cause of earthquakes according to what they have learned during the lesson. This reflection on their initial conceptions will cause them to further analyze any misconceptions they may have had and help to consolidate a new more accurate understanding of the cause of earthquakes. Section 4 closes with a few questions that ask them to state explicitly how their thinking has changed in regards to the cause of earthquakes and how confident they are in their understanding of the topic. They are asked a final time to rate their understanding of the topic on a 1-10 scale.

Section 5 includes three activities that serve as extension opportunities about earthquakes. These extension activities help students further their understanding by utilizing different modalities of learning and make the learning more relevant to their lives. This section provides differentiation by allowing students to choose what activities they will perform. It also provides differentiation for students of varying ability levels. Students who finish earlier will complete 2 out of the 3 activities while students who take longer to read and write in the earlier sections will only be required to complete one of the activities from this section.

Modifications/Differentiation:

This lesson is designed for student groups of various ability levels. In particular, it has been modified to assist students who struggle with reading and writing. The lesson worksheet comes in two versions, Version I and Version II. Version II is to be given to students who struggle with reading and writing and includes the following modifications:

- Bolded and Underlined key terms.
- Vocabulary previews
- Word Banks
- Note-taking/Outlining assistance
- Partner Reading
- Reduced workload to allow focus on key concepts

This lesson includes elements of differentiation by giving students choice in utilizing partner or independent work. It also differentiates by providing an extension activities of varying lengths (Section 5).

Rationale:

This lesson utilizes a conceptual change text to serve as formative assessment of student understanding of the cause of earthquakes. As indicated by the above research, students typically possess misconceptions about the cause of earthquakes due to its abstract nature, possible religious and cultural beliefs, and insufficient education on the topic. The conceptual change text in this lesson allows students the opportunity to critically analyze their conceptions and then provides scaffolding to assist them in correcting any misconceptions they may have. The student responses to the questions are to be used as a formative assessment tool by the teacher as well. By reading the student responses, teachers can determine what misconceptions about earthquakes exist in their classroom and adjust their instruction accordingly.

References

Simsek, C. (2007). Children's Ideas about Earthquakes. *Journal of Environmental & Science Education*, 2007, *2* (1), 14-19.

Tsai, C. (2001). Ideas about earthquakes after experiencing a natural disaster in Taiwan: An analysis of students' worldviews. *International Journal of Science Education*, *23* (10): 1007-1016.

Francek, M. (2013). A Compilation and Review of over 500 Geoscience Misconceptions. *International Journal of Science Education*, *35*(1), 31-64.

Verison I
Name: ______________________________ Period: ___________

Check Your Misconceptions: EARTHQUAKES!

SECTION 1: What do you think?

Earthquakes are very popular natural disasters that occur all over the world on a daily basis. Depending on their strength, earthquakes can lead to human injury and millions of dollars worth of property damage. The shaking of the earth's crust caused by earthquakes can rupture underground gas and water pipes leading to explosions and flooding. Electrical lines are often knocked down causing mass power outages. Buildings not built to withstand the vibrations caused by earthquake waves can become damaged or destroyed. Unfortunately, humans are often injured or killed by falling debris during earthquakes.

As you can see, earthquakes are very serious natural hazards that we must be prepared for. In order to prepare for earthquakes, we must understand what causes them. Before we explore what causes earthquakes, let's take a moment to see what you think.

In your own words, explain what causes earthquakes to occur.

____
____
____
____

How well do you think you understand the cause of earthquakes? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 2: Common Mistakes

Many students incorrectly think that...

MISCONCEPTIONS	
X	Earthquakes occur from the collapse of underground hollow spaces.
X	Weather (rain, wind, temperature, etc.) triggers earthquakes.
X	Earthquakes occur because of landslides.
X	The rotation of the Earth leads to earthquakes.
X	Earthquakes are caused by gas pressure and volcanoes.
X	Gravity causes earthquakes.

Compare your ideas about the cause of earthquakes to the incorrect ideas above. What are some similarities and/or differences between the misconceptions and your thoughts about the cause of earthquakes?

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*Discuss with your partner the similarities and differences you found.
In what ways has your thinking about the cause of earthquakes changed during this lesson?

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How well do you think you understand the cause of earthquakes? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 3: The Correct Answer

Build your background knowledge of Earthquakes  **before the reading by watching this video.**

https://www.youtube.com/watch?v=VSgB1IWr6O4

You can't feel it but you are moving right now. You are on one of Earth's twelve lithospheric plates. These plates are large sections of Earth's lithosphere that are constantly in motion. The plates can move in three different directions relative to each other. They can move apart, push into each other, or slide past each other.

When plates are moving into or past each other, there is a great deal of pressure and friction between the plates. The pressure is increased by the jagged edges of the plates that lock into each other adding even more friction. The massive forces of the moving plates build up pressure until finally the rock breaks at a weak point. When the rocks break, or faults, the plates slip past each other violently.

The faulting releases a great deal of energy. This energy travels outward in all directions from the location of the fault, which is called the focus. Directly above the focus, on the surface of the Earth, is the epicenter. The area around the epicenter receives the most energy from the earthquake and therefore experiences the most destruction. Depending on the strength of the earthquake, vibrations can be felt for over 100 miles away from the epicenter.

The energy waves given off by earthquakes are called seismic waves. These waves travel through the Earth and can be measured by scientists all over the world with instruments called seismographs. There are different types of seismic waves that each have unique characteristics. The most important characteristic is that the waves travel at different speeds. By measuring the difference in time it takes the different waves to arrive to 3 different seismographs, scientists can determine exactly where an earthquake occurred.

Understanding what causes earthquakes is important because that knowledge allows us to predict where future earthquakes are likely to occur. Knowing ahead of time where earthquakes might occur, allows us to make the necessary preparations that minimize the amount of human injury and property damage caused by an earthquake. Preparing for an earthquake includes building earthquake resistant structures, making emergency plans, and educating people how to stay safe during an earthquake.

Answer the following questions about the above reading.

1) The Earth is made up of _________________ that are constantly moving into, away from, or past each other.
2) Large amounts of friction and pressure build up between the lithospheric plates and result in ________________ that release the pressure.
3) Earthquakes create _____________ waves that transport energy through the Earth.
4) The location where the earthquake actually occurs is called the ________________.
5) The location on the Earth's surface directly above the earthquake is called the ________________.
6) Scientists use ________________ to measure and locate earthquakes.
7) Knowing why earthquakes occur helps us to _______________ where earthquakes are likely to occur in the future.

SECTION 4: Reflect and Reconsider

Now that you have learned more about earthquakes, answers the following question again.

In your own words, explain what causes earthquakes to occur.

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In what ways has your thinking about the cause of earthquakes changed during this lesson?

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How well do you think you understand the cause of earthquakes? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 5: Extension Activity

This section includes three hands-on activities about earthquakes. You are to choose any **two** to complete with a partner.

Activity #1 – Demonstrating How Seismic Waves Travel

1) Fill a shallow pan with water.
2) Drop a small pebble into the center of the pan.
3) Observe how the ripples travel through the water.
4) Draw your experimental setup and show what the ripples in the pan look like.
5) Write a short paragraph describing how the ripples in the water are similar to seismic waves. Use the following terms in your response.
   - Seismic waves
   - Focus
   - Fault
   - Earthquake

Activity #2 – Earthquake Preparedness Pamphlet

1) Go to http://www.ready.gov/earthquakes and read about earthquake safety.
2) Create a pamphlet with illustrations that informs people how to prepare for an earthquake and what to do during an earthquake.
3) Feel free to use Microsoft Publisher or create your pamphlet by hand.

Activity #3 – You are the Teacher!

1) Pretend that a younger student asks you to explain what causes earthquakes to occur.
2) Use an analogy to explain the faulting that occurs between 2 lithospheric plates. You can use the analogy of snapping your fingers to represent faulting or create one of your own.
3) Act out a conversation about the analogy with your partner and record it on video using a classroom iPad.
4) Your explanation should include the terms:
   - Plates
   - Friction
   - Pressure
   - Faults
   - Earthquake
   - Waves

Verison II

Name: ______________________________ Period: ___________

Check Your Misconceptions: EARTHQUAKES!

SECTION 1: What do you think?

***Reading Tip: Preview the Vocabulary**

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natural disaster – an event that happens in nature that causes damage to humans and the environment. Natural disasters include earthquakes, volcanoes, storms, floods, landslides, etc.

rupture – to crack or break

withstand – to hold up or resist destruction

debris – broken materials, rubble

Earthquakes are very popular **natural disasters** that occur all over the world on a daily basis. Depending on their strength, earthquakes can lead to human injury and millions of dollars worth of property damage. The shaking of the earth's crust caused by earthquakes can **rupture** underground gas and water pipes leading to explosions and flooding. Electrical lines are often knocked down causing mass power outages. Buildings not built to **withstand** the vibrations caused by earthquake waves can become damaged or destroyed. Unfortunately, humans are often injured or killed by falling **debris** during earthquakes.

As you can see, earthquakes are very serious natural hazards that we must be prepared for. In order to prepare for earthquakes, we must understand what causes them. Before we explore what causes earthquakes, let's take a moment to see what you think.

In your own words, explain what causes earthquakes to occur.

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How well do you think you understand the cause of earthquakes? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

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SECTION 2: Common Mistakes

Many students incorrectly think that...

MISCONCEPTIONS	
X	Earthquakes occur from the collapse of underground hollow spaces.
X	Weather (rain, wind, temperature, etc.) triggers earthquakes.
X	Earthquakes occur because of landslides.
X	The rotation of the Earth leads to earthquakes.
X	Earthquakes are caused by gas pressure and volcanoes.
X	Gravity causes earthquakes.

Compare your ideas about the cause of earthquakes to the incorrect ideas above. What are some similarities and/or differences between the misconceptions and your thoughts about the cause of earthquakes?

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*Discuss with your partner the similarities and differences you found.
In what ways has your thinking about the cause of earthquakes changed during this lesson?

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How well do you think you understand the cause of earthquakes? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

____

SECTION 3: The Correct Answer

Build your background knowledge of Earthquakes  **before the reading by watching this video.**

https://www.youtube.com/watch?v=VSgB1IWr6O4

****Read the next section with your reading partner. Tip: Read the questions for each section before you read the paragraph to help give you a purpose.**

You can't feel it but you are moving right now. You are on one of Earth's twelve **lithospheric plates**. These plates are large sections of Earth's lithosphere that are constantly in motion. The plates can move in three different directions relative to each other. They can move apart, push into each other, or slide past each other.

When plates are moving into or past each other, there is a great deal of pressure and friction between the plates. The pressure is increased by the jagged edges of the plates that lock into each other adding even more friction. The massive forces of the moving plates build up pressure until finally the rock breaks at a weak point. When the rocks break, or **faults**, the plates slip past each other violently.

The faulting releases a great deal of energy. This energy travels outward in all directions from the location of the fault, which is called the **focus**. Directly above the focus, on the surface of the Earth, is the **epicenter**. The area around the epicenter receives the most energy from the earthquake and therefore experiences the most destruction. Depending on the strength of the earthquake, vibrations can be felt for over 100 miles away from the epicenter.

The energy waves given off by earthquakes are called **seismic waves**. These waves travel through the Earth and can be measured by scientists all over the world with instruments called seismographs. There are different types of seismic waves that each have unique characteristics. The most important characteristic is that the waves travel at different speeds. By measuring the difference in time it takes the different waves to arrive to 3 different seismographs, scientists can determine exactly where an earthquake occurred.

Understanding what causes earthquakes is important because that knowledge allows us to **predict** where future earthquakes are likely to occur. Knowing ahead of time where earthquakes might occur, allows us to make the necessary preparations that minimize the amount of human injury and property damage caused by an earthquake. Preparing for an earthquake includes building earthquake resistant structures, making emergency plans, and educating people how to stay safe during an earthquake.

Paragraph 1
Main Idea:

Paragraph 2
Main Idea –
Detail 1:
Detail 2:

Paragraph 3
Main Idea –
Detail 1:
Detail 2:

Paragraph 4
Main idea –
Detail 1:
Detail 2:

Paragraph 5
Summary:

Answer the following questions about the above reading using the word bank.

Word Bank

faults	**focus**	**epicenter**
predict	**plates**	**seismic**

1) The Earth is made up of _________________ that are constantly moving into, away from, or past each other.
2) Large amounts of friction and pressure build up between the lithospheric plates and result in ________________ that release the pressure.
3) Earthquakes create _____________ waves that transport energy through the Earth.
4) The location where the earthquake actually occurs is called the _______________.
5) The location on the Earth's surface directly above the earthquake is called the ________________.
6) Scientists use ________________ to measure and locate earthquakes.
7) Knowing why earthquakes occur helps us to _______________ where earthquakes are likely to occur in the future.

SECTION 4: Reflect and Reconsider

Now that you have learned more about earthquakes, answers the following question again.

In your own words, explain what causes earthquakes to occur.

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In what ways has your thinking about the cause of earthquakes changed during this lesson?

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How well do you think you understand the cause of earthquakes? Answer with a number 1 to 10 (1 is no idea and 10 is perfect understanding)

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SECTION 5: Extension Activity

This section includes three hands-on activities about earthquakes. You are to choose **one** to complete with a partner.

Activity #1 – Demonstrating How Seismic Waves Travel

1) Fill a shallow pan with water.
2) Drop a small pebble into the center of the pan.
3) Observe how the ripples travel through the water.
4) Draw your experimental setup and show what the ripples in the pan look like.
5) Write a short paragraph describing how the ripples in the water are similar to seismic waves. Use the following terms in your response.

- Seismic waves	- Focus
- Fault	- Earthquake

Activity #2 – Earthquake Preparedness Pamphlet

1) Go to http://www.ready.gov/earthquakes and read about earthquake safety.
2) Create a pamphlet with illustrations that informs people how to prepare for an earthquake and what to do during an earthquake.
3) Feel free to use Microsoft Publisher or create your pamphlet by hand.

Activity #3 – You are the Teacher!

1) Pretend that a younger student asks you to explain what causes earthquakes to occur.
2) Use an analogy to explain the faulting that occurs between 2 lithospheric plates. You can use the analogy of snapping your fingers to represent faulting or create one of your own.
3) Act out a conversation about the analogy with your partner and record it on video using a classroom iPad.
4) Your explanation should include the terms:

-Plates	-Friction
- Pressure	- Faults
-Earthquake	- Waves

Earthquake Rubric #1

SCORE	3	2	1
Plates	The earth's solid surface is made up of several individual plates.	The earth's surface is one solid mass of rock material.	X
Movement	The earth's plates are in constant motion: converging, diverging, and sliding past eachother.	The earth's plates move but answer does not include all 3 directions.	The earth's plates do not move.
Friction	The edges of the plates are jagged which cause large amounts of friction and pressure to build up.	Large amounts of pressure builds up between the plates.	No mention of pressure or friction.
Release	Pressure builds between the plates until a portion of plates break or slip. A massive amount of energy is released in the form of seismic waves. The energy release leads to an earthquake.	The plates move past each other releasing energy and causing an earthquake.	Any non-scientific response such as earthquake is caused by an explosion or volcano.

Score: _____________ out of 12

Earthquake Rubric #2

SCORE	3	2	1
Plates	The earth's solid surface is made up of several individual plates.	The earth's surface is one solid mass of rock material.	X
Movement	The earth's plates are in constant motion: converging, diverging, and sliding past eachother.	The earth's plates move but answer does not include all 3 directions.	The earth's plates do not move.
Friction	The edges of the plates are jagged which cause large amounts of friction and pressure to build up.	Large amounts of pressure builds up between the plates.	No mention of pressure or friction.
Release	Pressure builds between the plates until a portion of plates break or slip. A massive amount of energy is released in the form of seismic waves. The energy release leads to an earthquake.	The plates move past each other releasing energy and causing an earthquake.	Any non-scientific response such as earthquake is caused by an explosion or volcano.

Score: ___________ out of 12

Change in Score: ___________

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