2020

Making the water cycle accessible and relevant for English language learners

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Abstract

Students with limited English-proficiency present many unique challenges for educators and schools. These challenges multiply as both the number of students requiring services and the diversity of languages spoken increases. In Iowa's 335 public school districts, the number of students classified as English-language learners (ELL) has nearly tripled in the last 15 years, jumping from 2.1% of the student population during the 1999-2000 school year to 5.7% in 2015- 2016 (Iowa Department of Education (IDOE), 2013; IDOE, 2015). Individual districts currently range from 0 to 57.4% of students requiring ELL services, with 25 of Iowa's districts identifying more than 10% of their students as English-language learners (IDOE, 2015). In Iowa, Spanish is the most common language amongst ELL students with about 67% of students reporting that Spanish is the primary language spoken at home (IDOE, 2016). However, the IDOE recognizes 32 other languages that are spoken by at least 50 students within the state of Iowa with 1,700 students speaking languages categorized as 'other' (IDOE, 2016). Because of this diversity, it is impossible to meet every student's needs by simply providing translations, interpreters, and bilingual teachers.

English-language learners represent a significant yet often overlooked portion of Iowa students. The 'mainstreaming' of low-level ELL students who may speak little or no English places enormous pressure on classroom teachers, yet many schools lack resources to implement sheltered instruction. The purpose of this project is to demonstrate how evidence-based strategies can be used to develop science curriculum for ELL students that leads to mastery and understanding.

Making the Water Cycle Accessible and Relevant for English Language Learners

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This Paper by: Summer Teed

Entitled: Making the Water Cycle Accessible and Relevant for English Language Learners

has been approved as meeting the non-thesis requirement for the

Degree of Master of Arts

Date: 7/20/2020 Dr. Kyle Gray, Advisor

Date: 7/20/2020 Dr. Jody Stone, Outside Reader

Table of Contents

Chapter 1 Introduction

Students with limited English-proficiency present many unique challenges for educators and schools. These challenges multiply as both the number of students requiring services and the diversity of languages spoken increases. In Iowa's 335 public school districts, the number of students classified as English-language learners (ELL) has nearly tripled in the last 15 years, jumping from 2.1% of the student population during the 1999-2000 school year to 5.7% in 2015-2016 (Iowa Department of Education (IDOE), 2013; IDOE, 2015). Individual districts currently range from 0 to 57.4% of students requiring ELL services, with 25 of Iowa's districts identifying more than 10% of their students as English-language learners (IDOE, 2015). In Iowa, Spanish is the most common language amongst ELL students with about 67% of students reporting that Spanish is the primary language spoken at home (IDOE, 2016). However, the IDOE recognizes 32 other languages that are spoken by at least 50 students within the state of Iowa with 1,700 students speaking languages categorized as 'other' (IDOE, 2016). Because of this diversity, it is impossible to meet every student's needs by simply providing translations, interpreters, and bilingual teachers.

Legislation at the federal level has acknowledged the rise in ELL students in our schools by specifically addressing them in the No Child Left Behind Act (NCLB) in 2003 and again in the Every Student Succeeds Act (ESSA) of 2015 (US Department of Education, n.d.). Both pieces of legislation emphasize the need to hold ELL students accountable to the same standards as any other student. The ESSA reorganized the way ELL services are funded, switching it from Title III to Title I. This also allowed schools to be flagged as 'targeted' if any one subgroup, including ELL students was consistently underperforming.

In Iowa, school districts have responded by developing various programs to support ELL students. These typically include a combination of pull-out, sheltered, and mainstream courses.

Pull-out classes with an English as a Second Language (ESL) endorsed teacher help students learn the mechanics of the English language. Sheltered classes are content classes like science or history that, in an ideal setting, have only ELL students in the class, smaller than normal class sizes, and in the best case scenario, a co-teacher with an ESL endorsement. In some instances, ELL students are scheduled into ‘mainstream’ classes with no specific language supports other than what the classroom teacher chooses and is able to provide. Unfortunately, content teachers in mainstream classes often lack in understanding of language development and knowledge of pedagogical approaches to support the language needs of ELLs (Richardson et al., 2007; Reeves, 2014; Stoddart et al., 2002).

English-language learners represent a significant yet often overlooked portion of Iowa students. The ‘mainstreaming’ of low-level ELL students who may speak little or no English places enormous pressure on classroom teachers, yet many schools lack resources to implement sheltered instruction. The purpose of this project is to demonstrate how evidence-based strategies can be used to develop science curriculum for ELL students that leads to mastery and understanding.

Chapter 2 Literature Review

An English-language learner is defined as any student whose primary language is one other than English. The Iowa Department of Education takes this definition a step further to explain that "…the probability of the student's academic success in an English-only classroom is below that of an academically successful peer with an English language background (Iowa Department of Education, 2016, p. 1)." The National Assessment of Educational Progress (NAEP) regularly assesses 4^{th}, 8^{th}, and 12^{th} grade students on math, reading and science, and has shown that this is not only a probability, it's the reality. Between 1998 and 2017, non-ELL students consistently scored better than ELL students in all three areas (National Center for Education Statistics (NCES), 2009; NCES, 2011). A similar trend was seen in Iowa where 8^{th} and 11^{th} grade ELL students continued to score significantly lower than English speaking peers on the Iowa Assessments in 2015 (IDOE, 2016).

Challenges for ELL Students

ELL students struggle to succeed in the science classroom for many reasons, including immigrant or refugee status, diverse cultural backgrounds, gaps in education, and of course, the impeding language barrier. Rakow and Bermudez (1993) identified several challenges for Hispanic American students in particular. Apart from students learning the English language, their study also revealed a lack of parental support, few Hispanic role models, financial barriers, as well as low self-esteem and motivation. Most of the teachers interviewed proudly claimed that they didn't view or treat Hispanic American students any differently than Euro-American students, which would be expected from America's democratized education. However, this failure to distinguish between students from different ethnic backgrounds, Rakow and Bermudez claim, is part of the problem. ELL students don't share many of the same life experiences as their

English-speaking peers, and therefore have very different needs. Schools and teachers both need to recognize these differences and take them into consideration when developing differentiated programs and lessons for English-language learners. The additional challenges that ELL students face can be categorized as cultural factors, varying educational backgrounds, and linguistic factors.

Several studies have examined the effects of diverse cultural backgrounds on learning science in an English-based classroom (Brand et al., 2006; Jegede & Aikenhead, 1999; Westby et al., 1999). Aikenhead (1996) defined culture as a set of attributes shared by a population which includes their customs, attitudes, values, worldview, skills, and behavior. While it may not always be possible to understand every aspect of a student's culture, Ting-Toomey (1999) suggested that one of the most significant cultural factors is the individualism-collectivism continuum. The United States exemplifies an individualistic culture which emphasizes individual achievement and responsibilities. However, most of the cultures in the world are more collectivistic in nature, focusing on the needs and successes of the group as a whole. Students from a collectivist culture value working together and making sure everyone is successful. Many behaviors that come along with these beliefs manifest as copying or 'cheating' in American schools.

Aikenhead (1996) further described science education as a subculture of western society where students are expected to engage in scientific practices like asking questions, designing investigations, and constructing their own explanations for phenomena. This way of thinking may be unfamiliar and incompatible with the cultural and social norms an ELL student is accustomed to. For example, Westby, et al. (1999) identified several cultures (specifically Haitian and some Asian subcultures) in which children are discouraged from figuring things out on their own, suggesting that those students would be "likely to value rote memorization in education and to be unfamiliar with the inquiry processes required in science." This disconnect between cultures makes an inquiry approach to learning uncomfortable and virtually ineffective for many ELL students.

ELL students generally fall into one of two categories. Students in the first category have a comprehensive educational background and are reading and writing at or close to grade-level in their primary language. Most of the time, these students can pick up on content pretty easily with the inclusion of some supplemental materials in their primary language (Cummins, 1980). However, this can also depend on their primary language and how different it is from English (often called language distance). Students that speak languages that don't use the English alphabet or are used to reading lines of text from right to left will still have some obstacles to overcome (Fairbarn & Jones-Vo, 2010). In general though, the scaffolding and modifications needed by students in this first category of language learners are fairly straightforward and simple to implement.

The second category of ELL students is the more common of the two. These students arrive in U.S. classrooms with large gaps in their educational background and occasionally no formal schooling at all. The reasons for these gaps are as diverse as the students; political unrest, poor economic conditions, sexist, racial, ethnic, or religious issues (Fairbarn & Jones-Vo, 2010). These students would benefit greatly from basic literacy instruction in their primary language, which is believed to accelerate learning of a second language, however in many cases that is simply unrealistic due to lack of resources (Fairbarn & Jones-Vo, 2010). Making accommodations to help this second group of ELL students be successful in a general education classroom is much more challenging.

Perhaps the most significant and consistent obstacle for ELL students is the language barrier (Curtis & Millar, 1988). This includes all four domains of language: reading, writing, speaking, and listening. Developing proficiency in a new language takes, on average, seven years (Rakow & Bermudez, 1993). Although this number can vary greatly, most English language learners proceed through the same basic stages of language acquisition. Social language skills develop first, such as the ability to exchange conversational pleasantries and to ask for permission to use the restroom. This is followed by the development of the much more challenging academic language. Teaching English to Speakers of Other Languages (TESOL) has developed a set of standards that recognize this process as well as the fact that language that might be common in one content area might be very different from another (Gottlieb et al., 2006). These standards also clearly lay out five stages of language proficiency from Level 1-Starting to Level 5-Bridging which many schools use to categorize their ELL students and assign their levels of support.

Due to the many diverse needs of ELL students, there is no one-size-fits-all approach to differentiation. Accommodations must be made based on individual needs and circumstances. However, there are some strategies that are considered "best practice" and beneficial to all ELL students. A few of these strategies will be discussed in the following section.

Strategies & Sheltered Instruction

Hass and Gort (2009) argued that sheltered content learning is by far the most effective approach for ELL students. They described an 'additive' bilingual environment in which students acquire skills in English while simultaneously continuing to develop mastery in their primary language, the same language in which they will study other content areas. These bilingual programs are designed to transition students from learning content in their native language to gradually becoming more and more proficient in English and eventually enter full immersion. Several studies have shown that students in a sheltered, bilingual environment perform significantly better than do ELL students in an English-only setting (Alanis, 2000; Ramirez et al., 1991; Rolstad et al., 2005).

A sheltered, bilingual learning environment on its own however does not automatically spell success for ELL students. Richardson, et al. (2007) described a sheltered content approach in a case study of a bilingual science teacher and her introductory earth science class. The sole purpose of this class was to prepare ELL students with the vocabulary necessary to succeed in the general education earth science class. The researchers determined that, while the students indeed came away from the class with some scientific vocabulary, the teacher's focus on the development of academic language prevented students from being able to answer questions like 'why?' or 'how?' and instead just memorized terms without really understanding their meaning.

To assist teachers, who may or may not be bilingual, in delivering the most effective sheltered instruction, researchers have developed lesson-planning strategies and templates specifically for teaching content in a sheltered classroom. The Sheltered Instruction Observation Protocol (SIOP) model is a lesson planning framework that consists of 8 components which are further broken down into 30 different features (Echevarria et al., 2013). For example, the component 'Building Background' includes features such as 'Links explicitly made between past learning and new concepts' and 'Key vocabulary emphasized.' Since its development, multiple studies have shown success with using the SIOP model in a variety of content areas, especially when paired with professional development or other lesson building strategies. (Honigsfeld & Cohan, 2008; Inceli, 2015; Short & Echevarria, 2005). The SIOP model is currently thought to be the best way to address ELL students' needs.

In addition to the SIOP model, numerous studies identify teaching strategies that, when used appropriately increase the achievement of ELL students. Some of the general strategies include repetition and opportunities for practice, gestures or other visual cues, and use of objects, props or other hands-on materials (Facella et al., 2005; Furner et al., 2005). Another study described tiered questioning and showed how, with the right scaffolding, ELL students can actually answer questions at all levels of Bloom's taxonomy (Hill & Flynn, 2008). Teaching literacy strategies, making both home language and home culture connections, and using discourse strategies were all shown to help students learn how to use language in a science setting (Quinn et al., 2012).

Many of these research-based strategies have been organized and compiled in various resource books for teachers. In *Making Content Comprehensible for English Learners,* Echevarria, et al (2013) describe numerous strategies for working with ELL students of all levels. They present these strategies in conjunction with the SIOP framework. For each component of SIOP, the authors describe research-based strategies that should be used within that part of the lesson and provide vignettes to show how those strategies may be applied among various grade levels and content areas.

Another useful organization of research-based strategies is provided by Levin et al. in *The GO TO strategies: Scaffolding Options for Teachers of English Language Learners, K-12* (2013). This compilation lists strategies under the 5 principles of instruction for English language learners:

1. Focus on Academic Language, Literacy, and Vocabulary
2. Link Background Knowledge and Culture to Learning
3. Increase Comprehensible Input and Language Output
4. Promote Classroom Interaction
5. Stimulate Higher Order Thinking Skills and the Use of Learning Strategies

The authors also include a matrix from which teachers can locate appropriate strategies based on students' current English proficiency level and the domain of language being targeted.

Finally, several studies on targeted professional development (PD) showed improved achievement among ELL students (Johnson & Marx, 2009; Hart & Lee, 2003; Lee, 2004). Many teachers found success in their classrooms after attending workshops that focused on incorporating literacy into science lessons. Training on instructional congruence was also shown to be effective in reaching ELL students from varying cultural background (Zain et al., 2010). Instructional congruence is a concept first described by Lee and Fradd (1998) in which students are able to relate their everyday linguistic and cultural experiences to their experiences in the science classroom. Teachers that actively use instructional congruence must have a deep understanding of both their content and their students' diverse culture and language and they make these connections explicit in their teaching. Effective use of instructional congruence was shown to improve students' perceptions of science both inside and out of the classroom.

In summary, there are many research-based methods for improving achievement among ELL students, from the way classes are structured to the framework used to design lessons and the strategies that are used within them. However, since ELL students continue to score significantly below peers on standardized tests, these strategies are clearly not being implemented consistently or effectively.

Theoretical Framework

A commonly used framework for studies involving English language learners is Vygotsky's zone of proximal development, or ZPD (Turuk, 2008). Vygotsky's theory states that a student's cognitive growth and development only occurs when that student is working on a task within their ZPD, which is defined by the range of tasks in which the lower boundary is made up of tasks that the student could successfully complete independently and the upper boundary consists of tasks that they could successfully complete with help from a more advanced peer or teacher (Vygotsky, 1978). When it comes to either content development or language acquisition, students will only experience growth if they are consistently given tasks slightly above what they would currently be able to accomplish independently. However, the teacher must also provide intentional supports to help the student be successful at that level. This strategy, known as scaffolding is a valuable tool when working with ELL students. (Turuk, 2008; Verenikina, 2003; Walqui, 2006).

The key to Vygotsky's theory leading to cognitive growth and development is the social interaction necessary for students to complete tasks within their ZPD. For this reason, teachers may often provide scaffolding for students by pairing or grouping them with peers at a similar level. In this strategy of cooperative learning each member of a group has an individual responsibility but the overarching task can only be completed with contributions from all group members (Doolittle, 1997).

Another application of this theory is the gradual release of responsibility (GRR) model (Pearson & Gallagher, 1983). Commonly used in general education classrooms, the GRR model consists of 4 phases in which the teacher gradually decreases the amount of support learners receive as they acquire experience through practice with peers and eventually achieve independence. When being used with ELL students however, teachers need to keep in mind that the process can be recursive. That is, not all students may not be able to move smoothly from one phase to the next at the same pace and may require additional modeling while their peers move on to group or independent practice (Echevarria et al., 2013).

Project Objective

English-language learners are expected to meet the same rigorous academic standards as students that have grown up in an English-speaking world, despite all of the additional challenges they face. Due to lack of resources including professional development for teachers or bilingual teachers, some of the most proven methods of ELL instruction are simply not feasible.

Therefore, content teachers are given the considerable task of differentiating their instruction to meet the needs of these diverse students who, by definition, are not likely to be successful. The goal of this project is to demonstrate how research-based strategies can be successfully incorporated into a secondary science unit on the water cycle to improve achievement in ELL students.

Chapter 3 Project

State Standards

The curriculum presented in this project aligns to two different sets of standards. First is the Next Generation Science Standards (NGSS), adopted by the state of Iowa in August 2015. (IDOE, n.d.; NGSS Lead States, 2013). These standards represent not only a new set of benchmarks against which to measure students' content knowledge, but a completely new three-strand approach to teaching and learning that identifies the acquisition of scientific practices and the understanding of cross-disciplinary concepts as equally important as learning the actual science content. Several of the science and engineering practices (SEPs) identified within the NGSS are of particular concern for teachers of ELL students. 'Developing and Using Models', 'Constructing Explanations', 'Engaging in Argument from Evidence', and 'Obtaining, Evaluating and Communicating Information' were all identified as practices that present significant challenges for ELLs (Quinn et al., 2012). Furthermore, engaging in these kinds of scientific practices, collaborating with other students, constructing knowledge from hands-on inquiry experiences, and using various forms of technology may be unfamiliar or perhaps even uncomfortable for many ELL students. Finally, the content within the NGSS is carefully organized and spiraled from kindergarten all the way to twelfth grade. This means that ELL students who often experience gaps in their education may often lack background knowledge necessary to master grade level standards.

The second set of standards referenced is the English Language Proficiency (ELP) standards adopted by Iowa in January 2014 (IDOE, n.d.; ELPA21, n.d.). This set of standards identifies 10 academic functions of language that are believed to be necessary to engage in each of the core content areas (English language arts, mathematics, social studies, and science). The ELP standards describe what ELL students should be able to do in each of the domains of language (listening, speaking, reading and writing) at each grade level K-12. Additionally, the document identifies where a link exists between an ELP standard and one of the science and engineering practices (SEP) from the NGSS. For example, ELP Standard 4: "Construct grade-appropriate oral and written claims and support them with reasoning and evidence" aligns closely with the SEP "Engaging in argument from evidence". With the adoption of the ELP standards and the state-wide professional development with which they were rolled out, Iowa made it clear that language instruction for our ELL students is not solely in the hands of our ESL teachers. Content teachers are equally responsible for teaching language and literacy as it related to that specific area. As suggested in the SIOP Model, I incorporated language targets based on the ELP standards throughout my unit as students engaged in all four domains of language.

I chose to develop a unit on a common topic in Earth and Space Science, the water cycle. This topic aligns to the standard 'MS-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by the energy from the sun and the force of gravity' (NGSS Lead States, 2013). This earth and space science standard emphasizes the SEP 'Developing and Using Models' and the crosscutting concept (CCC) 'Matter and Energy'. The third component of the standard, the disciplinary core idea (DCI) describes the major stages and processes that make up the water cycle, much of which depends on a basic understanding of the physical science concepts states of matter and phase changes. This standard determined the main sequence of my unit as well as helped define my final assessment. I also used the final assessment to evaluate students on the ELP standard 'ELP.9-12.3 An ELL can speak and write about grade-appropriate complex literary and informational text and topics' (ELPA21, n.d.).

Unit Plans

The following pages describe a unit created to support ELL students in developing and applying an understanding of the water cycle based on standard MS-ESS2-4 (NGSS Lead States, 2013) while learning how to use and practicing academic language in a science setting. The unit incorporates many of the research-based strategies described in Chapter 2. A summary of the selected strategies is shown in Table 1 while an outline of the activities and assessments that make up the unit can be found in Table 2.

Table 1

Summary of ELL Strategies Used Within Unit

ELL Strategy	Purpose
Gradual release of responsibility (GRR)	Provide scaffolding that allows a student to achieve independence in a new skill or task
Graphic organizer	Increase comprehension of oral or written language
Think-pair-share / Wait time	Provide additional oral and/or written language processing time
Varied question formats	Increase interaction by matching questions to students' proficiency levels
Collaborative dialogue	Model and promote students' use of spoken academic language
Teacher read aloud / Choral reading	Model fluent reading, teach a reading strategy and/or improve reading comprehension
Cloze sentences / Word bank / Cognates / Key sentence frames / Mix and match / Card sort	Increase comprehension of written language by learning and using academic vocabulary

Table 2

Outline of Unit Activities and Assessments

Unit Introduction	Pre-assessment: Class discussion Activity: Defining various bodies of water Formative Assessment
Part #1: Rivers and Elevation	Activity: Graphing Rivers by Elevation Assessment: Rivers and Elevation
Part #2: States of Matter and Evaporation	Pre-assessment: The Missing Water Activity: Investigating States of Water Reading: What is Matter? Activity: Mix and Match Formative Assessment
Part #3: Condensation and Precipitation	Pre-assessment: The Wet Glass Activity: Modeling the Water Cycle
Part #4: The Water Cycle	Activity: Journey Through the Water Cycle Activity: Card Sort Assessment: Water Cycle Quiz
Final Assessment	Water Cycle Model and Presentation

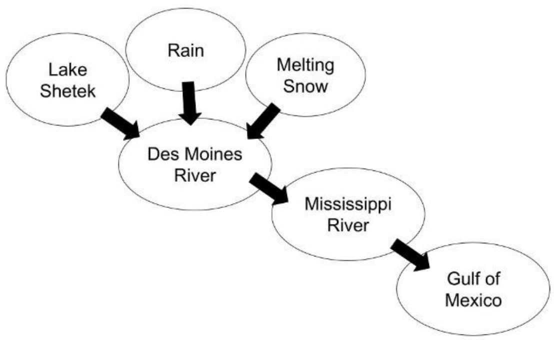
Unit Introduction

To begin this unit, the teacher needs to select a water source to serve as an anchor phenomenon students will use to develop their understanding around throughout the unit. This should be a local body of water with which most students are familiar. (For example, I used the Des Moines River, which is visible from my classroom window and which many students cross over every single day.) The teacher should engage students in a conversation about body of water, asking students to share what they can observe or what they may already know about it. If students are reluctant to volunteer answers right away, the teacher may want to use the '*think, pair, share'* strategy. This gives all students additional time to really consider the question and discuss it with a partner before speaking out in front of the whole class. Another good strategy to get more students involved in the discussion is '*varied question formats.'* Open ended questions like "What do you know about the river?" can be difficult for students with limited language proficiency, so the teacher could also ask some simpler, guiding questions like "Is the water moving?" or "Is the water solid or liquid?" One final strategy to use during this conversation is 'v*erbal scaffolding*'. The teacher should first encourage students who provide only one or two word responses to elaborate by saying "tell me more" or "explain". Then, the teacher should paraphrase, or restate the students' responses in another form to clarify their meaning and model correct pronunciation of key words and proper sentence structure. The teacher should recognize all suggestions given by the students, perhaps recording them on a whiteboard.

Some specific questions that should be discussed during this introduction are "where does the water come from?" and if the water is moving, such as in the case of a river, "where does the water go?" In order to answer these questions in as much detail as possible, students will be allowed to use any resources available to them (maps, textbooks, computers or phones) to attempt to answer the questions in more detail. Many of my students pulled up Google Maps on their phone and used it to trace the path of the river from beginning to end. Once students have had a chance to explore independently, the teacher should bring the class back together and lead students in creating a '*graphic organizer*' that summarizes their conclusions (Figure 1). The teacher should tell students that they will be adding to this diagram as they learn about something called the water cycle.

Figure 1

Example Model of Anchor Phenomenon



For emerging English speakers, the next activity will be very helpful in activating prior knowledge and building common vocabulary. First, students will brainstorm different places on Earth where water can be found while the teacher maintains a list on the board. This may lead to multi-lingual conversations among students as they discuss how to say the names of different bodies of water. Once most well-known bodies of water have been identified, the teacher should create a Google slide for each one. (As an alternative, large sheets of poster or construction paper could be used.) Then, the teacher should assign a pair of students to each slide, taking care to group the beginning level speakers with higher level students. The students will then work together to complete their assigned slide by adding a definition and a picture. The class will then review the slide show together. The teacher should guide them through making corrections to the definitions when necessary, making sure to highlight the key characteristics of each body of water and the differences among them. This activity should be followed up with a brief formative assessment that asks students use a '*word bank'* to identify bodies of water based on pictures or descriptions and complete '*cloze sentences'* based on the definitions they wrote or what they had learned about the anchor phenomenon (Figure 2).

Figure 2

Example of Assessment Item Using Cloze Sentences and Word Bank

A _______________ is a medium or large body of freshwater surrounded by land. They can be connected by _______________, which are large bodies of water that flow from one place to another. Most of the water on Earth is found in the _______________, which is a large body of salty water.

Word Bank
Lake
Ocean
Rivers

Part 1: Rivers and Elevation

The first big idea for this unit focuses on rivers and the cause of their motion (gravity). To begin, the teacher will need to help students understand and define the term ‘elevation’. In addition to referencing real examples, such as local landforms or manipulating physical models, such as 3-dimensional maps, ELL students that speak a language that shares roots with English, such as Spanish, French, or German, will benefit from identifying ‘*cognates*’. For example, the word ‘elevation’ in Spanish is ‘elevación’. When there are no cognates for a new vocabulary word, the teacher could ask students to try to think of other similar words in English. For example, my students recognized that ‘elevation’ sounds similar to ‘elevator’, so we discussed how the meanings of the two words are similar. To keep track of this new term, along with others throughout the unit, the teacher may choose to guide students through filling out a ‘*Word Square*’ (see Appendix) on a 3x5 card which can then be attached to a small metal ring.

The teacher will then provide each student with the student handout for the activity ‘*Graphing Rivers by Elevation’* along with the map of rivers of the United States and the chart of cities and their elevations (see Appendix). Using the GRR model, the teacher should choose a river and lead students through the process of 1) identifying which way the river is flowing, 2) listing the cities the river passes by in order along with the elevation, and 3) plotting each elevation on the map to demonstrate the path of the river. Students will then choose three other rivers from the map to graph. ELL students may need to see another example or be able to work with a peer before they are able to do this independently. Teachers should also be aware that students who choose to graph the Snake/Columbia River, which flows somewhat south to north, often list the cities in the opposite order. This error becomes quite obvious once all of the rivers have been graphed, since the slope of one of the lines will be completely backwards. However, the error reveals a deeply held misconception that the flow of rivers is based on cardinal direction rather than elevation. To address it, the teacher may choose to project the graphs of students who have done it incorrectly (without identifying those students) and lead a class discussion about why it is incorrect.

This activity should be followed up with a discussion of why water flows from high to low elevation. Some students may be confused by the question at first because it seems like common sense, but by using '*think, pair, share'* and '*varied question formats'*, the teacher should be able to get someone to say 'gravity'. The teacher may then choose to have students complete a second '*word square*', defining gravity as the force that pulls things towards the Earth. Students will also return to their original '*graphic organizers*' of the anchor phenomenon and add the term gravity to explain why water moves the way it does. Finally, students will complete the quiz '*Rivers and Elevation*' (see Appendix).

Part 2: States of Matter and Evaporation

The next part of the unit introduces the first phase change in the water cycle; evaporation. To begin, the teacher should display the map from the previous activity, remind students that all of the rivers on that map are constantly flowing into the ocean, then pose the question "does this mean that the ocean is getting fuller and fuller all the time?" Some students may become alarmed that this is indeed the case, but the teacher can assure them that it can't be true or coastal cities could not exist. However, students should be curious and motivated to figure out why the ocean isn’t getting deeper.

To start to answer that question, the class will set up an experiment. They will need to fill two identical containers with equal amounts of water. One container will be covered with plastic wrap and secured with a rubber band. At this point, students should make predictions about how the two containers might change over the course of a couple of days (ideally, over a weekend). If students seem unsure about what to expect, the teacher may prompt them to think about puddles on the ground after it rains, or hanging up a wet towel after a day at the pool. ELL students may also need a ‘*Key sentence frame*’ to help word their prediction. For example, “I think that the water in Container A will ___, but the water in Container B will ___.” After a day or two, it should be obvious that the water level has dropped in the uncovered container. Students should be allowed to get up close to the containers and discuss their ideas amongst each other. (Rather than emptying the containers right away, they should be left in a visible place for a few more days. They will be used again to demonstrate condensation.)

Next, the teacher should distribute the formative assessment “*The Missing Water*” (see Appendix) and read both the prompt and the possible responses aloud to the class. Students should make their selections independently. Once they see the possible explanations, it may become clear that many of them are actually familiar with the concept of evaporation. Spanish speakers may even know the term, as it is very similar to the English word. Some students however will still select the wrong answer at this point, and that’s okay. The teacher should take note of those students and check in with them frequently during the next activity.

In “*Investigating States of Water*” (see Appendix), students will explore the various states of matter and how they change from one to another by recording both quantitative and qualitative data as they melt and boil a beaker of ice cubes on a hot place. Teachers concerned about ELL students performing a lab like this need to keep the GRR framework in mind. First, the teacher should read the instructions aloud one step at a time (or call on individual students to read them) while modeling each step in front of the class, pointing out the names of lab equipment and drawing attention to underlined words. Then, place the students in small, mixed groups so that they can lean on one another to complete the tasks. The teacher will need to check in with each group frequently and may need to occasionally clarify instructions. The main things that students need to observe in this activity are that the temperature increases as the water goes from solid to liquid to gas, and the mass decreases a lot when the water begins to boil.

The lab should be followed up with the reading titled "*What is Matter*?" retrieved from Newsela.com, a website that publishes content that can be scaled to various reading levels. Depending on the background and English language proficiency levels of students in the class, the reading may be administered in various ways. In a class with mainly low-performing students, the teacher may use the '*Choral Reading'* strategy, reading the text aloud and encouraging students to read along. If enough students are able, the teacher may choose to call on individual students to take turns reading aloud. Either way, the teacher leads the entire class through the reading together and models how to determine the big ideas of each paragraph and highlight or underline key terms. For more advanced students, the teacher may choose to form small reading groups. Each group could use a version of the reading scaled to an appropriate level for that group. Once students have completed the reading, they should work in pairs or small groups to complete the '*What is Matter*?' organizer (see Appendix).

To wrap up this part of the unit, the teacher should lead a discussion about the original experiment, the water that had mysteriously disappeared from the uncovered container. Students should now be able to identify the process of evaporation occurring in the container. With some additional prompting, they should also be able to determine that the water disappeared much more slowly than in the lab when we set the beaker on the hot plate because the room wasn't as hot, but still had some heat (energy) in it.

Finally, the teacher may choose to have students complete a '*word square'* for 'evaporation', pointing out '*cognates'* if applicable. Students should also return to their original graphic organizers and add any new information they have learned, such as an arrow to represent water moving due to evaporation along with the cause of evaporation, energy from the Sun. They should also do the "*Mix and Match*" activity (see Appendix) to review the vocabulary that has been introduced so far. For this strategy, a set of cards containing vocabulary words and pictures should be randomly distributed among students who then have to find their matches. Each pair of students should then share their cards with the rest of the class and explain why they go together. If students need more practice, the teacher can mix up the cards again and, once students have found their new partners, have them work together to create a sentence about the picture using vocabulary word.

Part 3: Condensation and Precipitation

The next big idea in this unit introduces another phase change, condensation, which is often challenging for students to understand. To start, the teacher should reference the experiment from the previous lesson. At this point, there should be drops of water on the underside of the plastic wrap on the covered container. As students try to explain why the drops are there, they may bring up other examples such as a cold can of pop or a foggy mirror or window. After some discussion, the teacher should hand out the formative assessment, "*The Wet Glass*" (see Appendix), read all of the options aloud and have students answer the questions independently.

Next, students will complete "*Modeling the Water Cycle*" (see Appendix). As before, the teacher should incorporate GRR by modeling each of the instructions in the lab while they are read aloud and placing the students into small, mixed groups. This activity allows students to review what they have already learned about the water cycle (evaporation) and then see how that water vapor condenses when it cools (clouds), and then falls back down as liquid water (rain). Unfortunately, some students may get the wrong idea and believe that the water raining down is actually the ice melting and leaking through the aluminum foil. To mitigate this, the teacher may choose to use colored ice cubes or simply add a drop of food coloring on top of the ice. Since the water in the jar is clear, this should prove to students that no new water is entering it.

Before wrapping up the activity, students will read "*The Water Cycle*" from Newsela.com. Once again, the reading can be done as a whole class with '*Choral Reading'* or in small groups, depending on the students' abilities. The reading will provide them with the vocabulary to complete the diagrams and answer the questions on the modeling activity. If desired, the teacher will then lead students through completing '*word squares*' for 'condensation' and 'precipitation' before adding these terms along with any other new understandings onto their '*graphic organizers'*. This is also an appropriate place for a formative assessment about states of mater and phase changes (Figure 3).

Figure 3

Example of Assessment Item Using Cloze Sentences and Word Bank

A glass of water left out in the Sun will _______________, changing from a _______________ to a _______________.

Word Bank	
condense	solid
evaporate	liquid
precipitate	gas

Part 4: The Water Cycle

To introduce the final part of this unit, the teacher should remind students that, in the previous activity, the amount of water in the jar never increased or decreased. The water just moved around inside the jar and changed form due to either changes in energy or gravity. It is the same on Earth; the amount of water never changes, but a single drop can travel all the way around the world through the water cycle and it has been doing so for billions of years. Students may be impressed to learn that the water in their bodies may have also once been part of a dinosaur. To emphasize this point, students will complete "*Journey Through the Water Cycle*." The teacher should project the website on the board while the students pull it up on their own devices. The teacher should have everyone select the same starting point, for example, a cloud and model how to record it on the handout. Students should try to predict what will happen next before actually clicking 'next'. If cloud was selected, some students will remain in the clouds while others will precipitate to various places such as a river, lake, or the ground. The teacher should demonstrate how to fill in the handout, recording the next place inside of the next box and labeling the connecting arrow with the process that got them there. Students will then continue their journeys independently. The program does introduce some new terms that may or may not have been discussed previously, such as consumption, respiration, and transpiration. The teacher may ask students to raise their hand whenever they come across a word they don't know and the teacher or the student can write the word in the front of the room. Once all students have completed two journeys, the teacher can lead a class discussion about the unfamiliar terms and model how to figure out what they mean. For example, if a student had 'consumption' as part of their journey, they can look at the location of the water before (probably a lake or river) and after (an animal or person) and interpret what must have happened to the water. The teacher may also choose to have select students present their journeys to the class or share with one another in small groups.

Before taking the assessment, students will complete one final activity, a '*card sort'* to review the water cycle (see Appendix). The activity is composed of four sets of cards; stages within the water cycle (blue ovals), processes that move water from one stage to another (yellow arrows), states of matter (green hexagons), and causes of the processes (white rectangles). Rather than overwhelming students with all of the cards, the teacher should start by distributing just the first two sets (ovals and arrows). Students should work in pairs to arrange the cards in a way that makes sense. They may need some encouragement to shift from making a simple chain to a connected loop that demonstrates the continuity of the water cycle. As students complete their arrangement, the teacher should provide them with the other two sets of cards which students will use to label the state of each stage and the cause of each process. For students that need more practice, the teacher can mix up the cards and have them repeat the activity. For students that complete the task easily, the teacher can challenge them to create multiple arrangements. After the activity, students will take the '*Water Cycle Quiz'* (see Appendix).

Final Assessment

After the final quiz, the teacher should introduce the '*Water Cycle Project*' (see Appendix). The task for this project is to create a model that traces a drop of water from the body of water used as the anchor phenomenon to a body of water in or near the student's hometown and back again. As shown on the handout, students will first complete a template similar to the one used in '*Journey Through the Water Cycle*'. This will help students plan out their pathway, but the final model could take on many different forms. Students struggling to figure out a pathway may benefit from using the cards from the previous activity. The teacher may need to provide students with maps or a globe as well as some basic craft materials such as markers and poster paper.

Once complete, students will present their model to the class. The teacher needs to provide at least one class period once most of the models are complete for students to practice their presentations. ELL students will benefit from writing out exactly what they plan to say using '*key sentence frames'* which they can then read directly from while presenting (Figure 4).

Figure 4

Example of a Key Sentence Frame

First, when the water is in ___________ (*stage*), it is a ___________ (*solid, liquid or gas*). Then, the water ___________ (*process*). This is because of ___________. Now, the water is a ___________ (*solid, liquid or gas*).

My students submitted a variety of project types that reflected the diversity in skills and backgrounds among them. There were a few very neatly drawn and carefully labeled posters that resembled diagrams you would find in a text book. Two students created three-dimensional models that included toy dinosaurs, cotton ball clouds and carefully constructed land forms. Finally, there were several different forms of digital projects including slide shows, flow charts, and even a Kahoot (online quiz game). The rubric I created for this project is designed to evaluate students' mastery of the water cycle regardless of the format. I have also provided a rubric that may be used to evaluate the students' actual presentations. I was able to lean on my co-teacher for this; she scored the presentations while I focused on the content included within the model.

Chapter 4 Reflection

I taught this unit during the second semester of a year-long sheltered class along with a co-teacher endorsed in ESL. This was our second time teaching the class together, though I had taught it previously with another co-teacher for one year and one year prior to that with a bilingual associate. Neither my current co-teacher nor I are bilingual. Also, because her additional duties include testing new students, there were several times throughout the unit that she was not able to be in class. Nevertheless, having two adults in the classroom on most days was definitely a factor in the success of students in this class.

The primary home language for students in the class was Spanish, but Marshallese and two African dialects were also present. Furthermore, even the Spanish-speakers came from several different countries including Guatemala, El Salvador, and Honduras. Students ranged in age from 14-19. Seventy percent of students in the class were classified as freshmen (9^{th} grade) based on credits earned, but there were also several sophomores and one junior. Over half of the students in the class were in their first year in the district with only one student being here longer than 2 and a half years. Most of the students had been in my sheltered class since the beginning of the year, but a few joined later in the semester and two students arrived directly from Guatemala right in the middle of the unit. All students in the class were considered either Level 1 or Level 2 on TESOL's five-stage language proficiency scale based on assessment data from the previous school year.

Assessment Results

There are two summative assessments that reflect the students' learning from this unit. The first is the quiz that was administered at the end of instruction but prior to the start of the final project. The quiz assessed the key vocabulary from the unit by having students label and color code a given model of the water cycle. An analysis of these scores is provided in Table 3.

The second set of data comes from the final project itself. This project was an open-ended modeling project that assessed students' understanding of the water cycle, particularly the role of energy in transporting matter around the world. Students were required to use specific vocabulary words to complete their model ensuring they would have a minimum number of stages and steps to accurately gauge their overall understanding. They also had to present their model to the class, allowing them to explain with spoken words or gestures anything that wasn't explicit in the model. An analysis of data from this assessment is provided in Table 3.

Table 3

Analysis of Raw Scores and Percentages on Summative Assessments

	Water Cycle Quiz		Water Cycle Project	
	Points (out of 10)	Percent	Points (out of 40)	Percent
Average:	8.0	80	32.5	81
Median:	8.5	85	34	85
Mode:	10, 9.5, 9	100, 95,90	37	93
Max:	10	100	40	100
Min:	5	50	20	50

The majority of students were successful on at least one of the assessment tools, and many were able to demonstrate their proficiency on both methods of assessment. This was a huge improvement from the beginning of the unit when most students could not identify where the water in the Des Moines River (my chosen anchor phenomenon) came from, where it went or why it was moving at all. The student that received failing scores on both the quiz and the project received interventions after the quiz, during the project and after the project.

Reflection

When I first proposed this project, I presented the following goals:

1) To gather pre and post assessment data that shows growth, and

2) To develop a research-based ELL unit including assessments and rubrics, learning activities with both student handouts and background information for teachers, enrichment and intervention suggestions, and day to day plans with content and language targets.

Based on my observations and the assessment data collected, my first goal has been met. Most students showed not only growth but mastery of the performance expectation. However, I believe the greater success is the design of the final project itself. I have taught the water cycle before, and as a summative assessment asked students to create a model of the water cycle and present it. In hindsight, this task did not involve a lot of thought. Many students would simply recreate a textbook drawing or worse, copy from another student. Even if they did the work on their own, all of their presentations ended up being essentially identical. By giving the students the task of explaining a specific pathway within the water cycle, their models and presentations both gained a purpose. Adding the personal connection of including the students' original hometowns in the model also meant that every project was unique. This meant that students were more engaged in one another's presentations and I, as the teacher could really tell if they understood the water cycle or not.

As for my second goal, I believe I came pretty close to creating a complete curriculum package that incorporates targeted, research-based strategies for ELL students. For me, curriculum work is never done, and I will certainly make changes to this unit in the future. For example, I had wrongly assumed that the phase changes melting and freezing would be very familiar to students already and, since they are not really central to the water cycle, I did not plan any specific learning around them. I realized though, when we got to the end of the unit, that even though students were familiar with those concepts, they often had trouble coming up with the words. They picked up on the terms evaporation and condensation pretty quickly though. I think there are two reasons for this. First, I taught them explicitly alongside several examples. Second, both of those words are very similar in Spanish, which most of my students speak. I didn't teach melting and freezing explicitly and the Spanish versions of these words sound quite different. In the future, I will make sure to teach melting and freezing specifically, maybe during the downtime in the "States of Water" activity. I also made sure to add arrows to label them in the diagram at the bottom of the "What is matter?" organizer, even though melting is only explained in the highest version of the reading.

One aspect of the second goal that I fell short on was providing day-to-day plans and learning targets. This is one of the biggest challenges with teaching ELL students. Even after teaching the same course or even the same units for several years, the amount of time an activity will take can be hard to predict as it can vary greatly depending on the students in the seats. The teacher must be willing to improvise and go with the flow based on students' backgrounds, skill level, questions they ask, topics they show interest in, formative assessment data, unexpected interruptions and more. I was expecting the entire water cycle unit to last 3-4 weeks total. Instead, it took 23 class periods, not including the final project which lasted for another week. Some things that slowed us down included shortened or missed class periods due to weather, frequent absences (both by students and my co-teacher), re-teaching and re-assessing. My lesson plans often changed at the last minute depending on who was or wasn't in the room at the beginning of class. Therefore, instead of providing day-to-day plans, I described the basic sequence of activities and assessments along with some insight from my own experiences. I would encourage anyone who is planning to use this unit to be flexible and always have a back-up plan.

Working on this project has made several impacts on me as a professional that will affect the way I teach from here on out. For example, one of the resources I leaned on heavily throughout this work was *The GO TO strategies: Scaffolding Options for Teachers of English Language Learners, K-12* (Levin et al., 2013). I identified several of these strategies explicitly in my write-up of the water cycle unit including '*Word Squares*' '*Think-Pair-Share*', and '*Mix and Match*'. I also used many more ELL-targeted strategies informally throughout my teaching of the unit, including '*Teacher Talk*', '*Wait Time*', '*Collaborative Dialogue*', and '*Comprehension Checking*'. I plan to continue trying more strategies from this resource and making them a regular part of every unit.

I also became much more familiar with the ELP standards throughout my work on this project. This greatly increased my awareness of the need to explicitly teach language skills along with science content. This is a huge area of growth for me. In the future, I hope that every lesson I teach will include specific instruction on at least one of the four domains of language and that these will build on each other throughout the year. For example, at the beginning of the year, I could model various strategies for reading science text, then gradually put more and more of the responsibility on the students, first in small groups and then individually.

Finally, I hope that I can share all that I have learned with other teachers in my department and throughout our entire school. As our population of English learners continues to grow, we will need more and more educators equipped with the knowledge and resources to meet our students where they're at and help them move forward.

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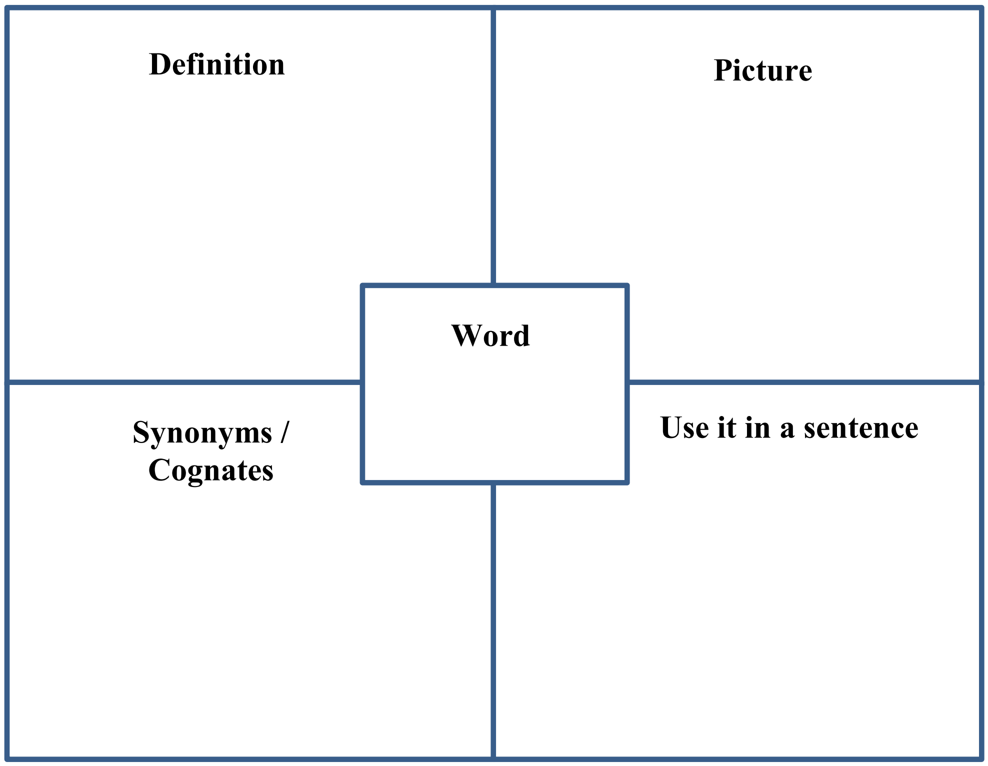
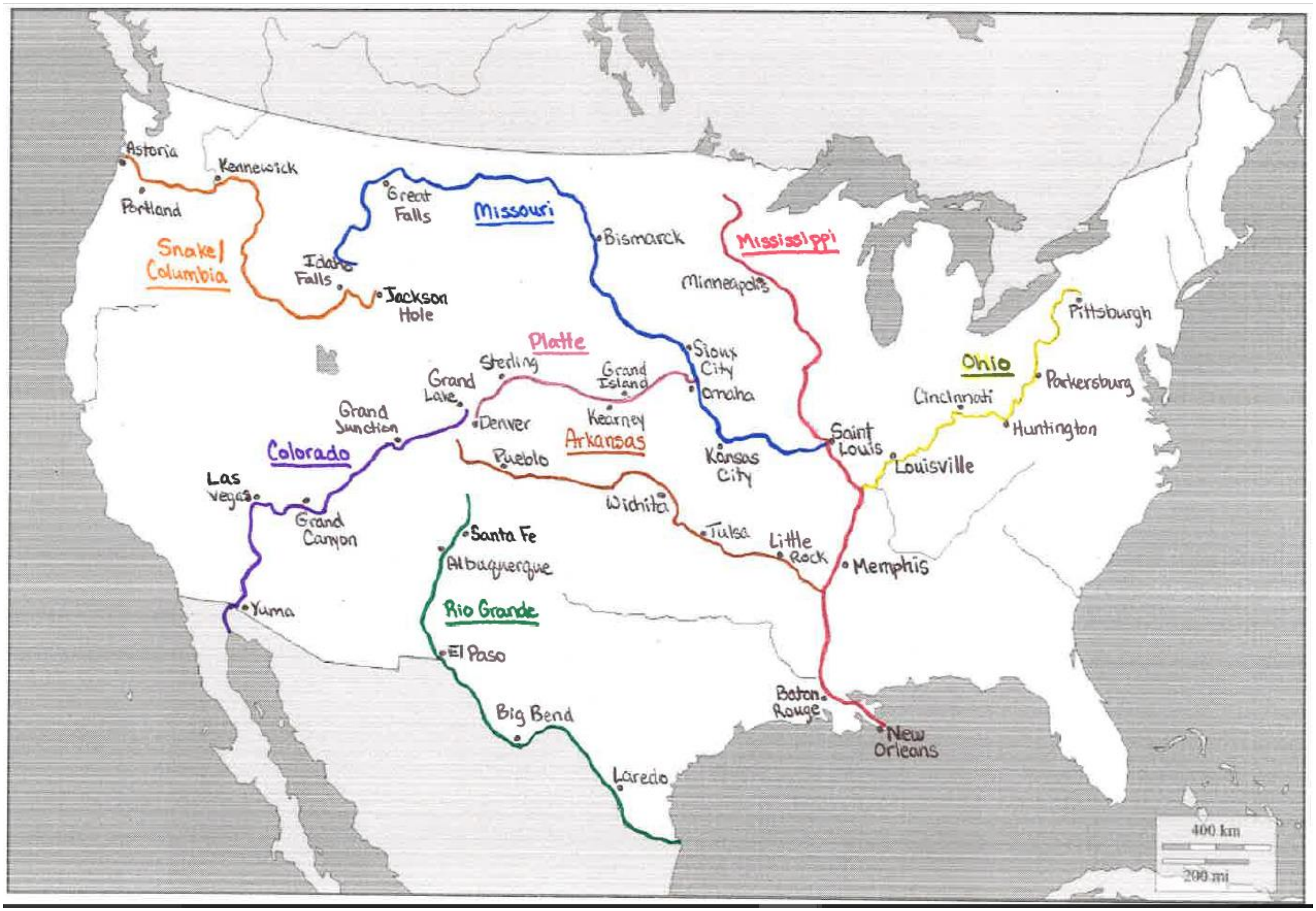
Appendix

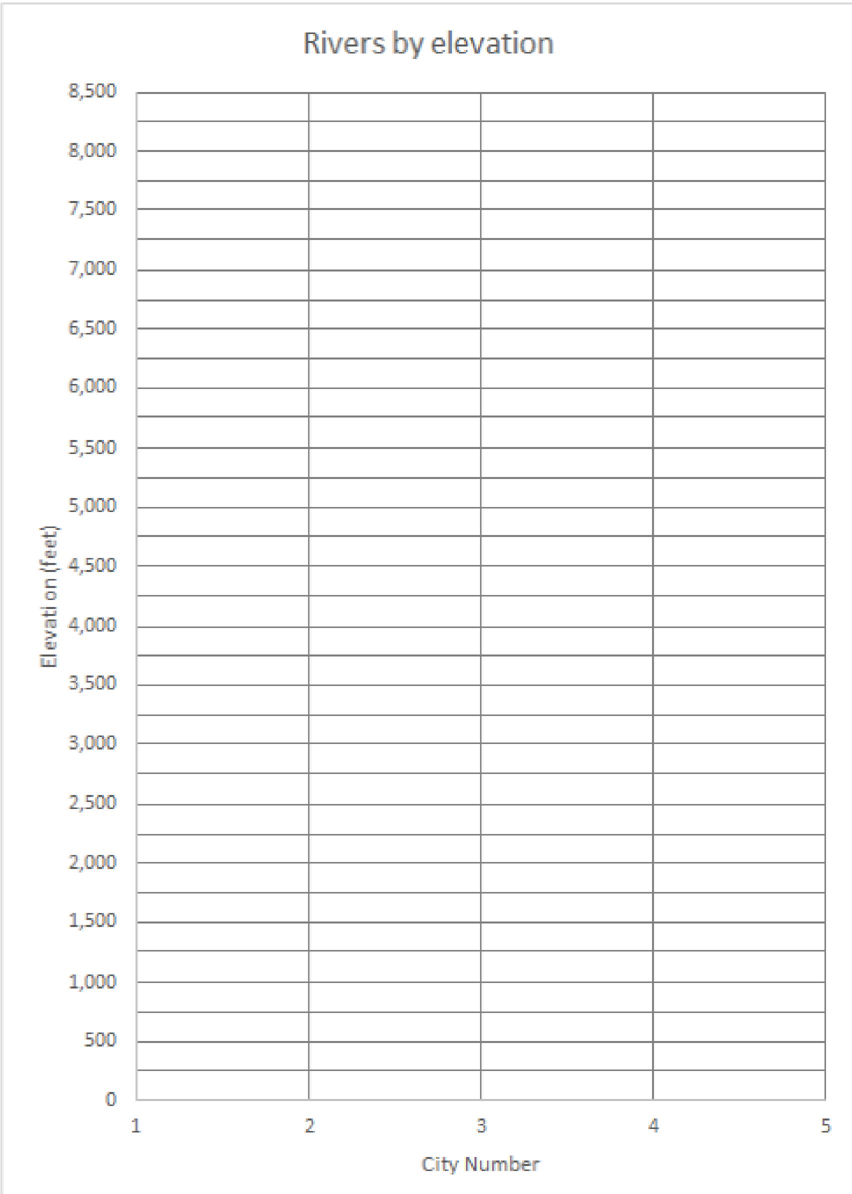
Word Square





Astoria
Kennewick
Portland
Snake/
Columbia
Great
Falls
Missouri
Bismarck
Idaho
Falls
Jackson
Hole
Mississippi
Minneapolis
Pittsburgh
Platte
Sterling
Grand
Lake
Grand
Island
Sioux
City
Omaha
Ohio
Parkersburg
Cincinnati
Huntington
Grand
Junction
Denver
Kearney
Arkansas
Saint
Louis
Louisville
Colorado
Pueblo
Kansas
City
Las
Vegas
Wichita
Grand
Canyon
Santa Fe
Tulsa
Little
Rock
Memphis
Albuquerque
Yuma
Rio Grande
El Paso
Baton
Rouge
New
Orleans
Big Bend
Laredo
400 km
200 mi

Graphing Rivers by Elevation



1) River name ____________________ Color ____________
   1st city ______________ Elev. _________
   2nd city ______________ Elev. _________
   3rd city ______________ Elev. _________
   4th city ______________ Elev. _________
   5th city ______________ Elev. _________

2) River name ____________________ Color ____________
   1st city ______________ Elev. _________
   2nd city ______________ Elev. _________
   3rd city ______________ Elev. _________
   4th city ______________ Elev. _________
   5th city ______________ Elev. _________

3) River name ____________________ Color ____________
   1st city ______________ Elev. _________
   2nd city ______________ Elev. _________
   3rd city ______________ Elev. _________
   4th city ______________ Elev. _________
   5th city ______________ Elev. _________

4) River name ____________________ Color ____________
   1st city ______________ Elev. _________
   2nd city ______________ Elev. _________
   3rd city ______________ Elev. _________
   4th city ______________ Elev. _________
   5th city ______________ Elev. _________

City	Elevation (in feet above sea level)
Albuquerque	5,312
Astoria	23
Baton Rouge	56
Big Bend National Park	1,800
Bismarck	1,686
Cincinnati	482
Denver	5,280
El Paso	3,740
Grand Canyon Nat. Park	2,400
Grand Island	1,860
Grand Junction	4,583
Grand Lake	8,369
Great Falls	3,330
Huntington	564
Idaho Falls	4,705
Jackson Hole	6,237
Kansas City	909
Kearney	2,152
Kennewick	407

City	Elevation (in feet above sea level)
Laredo	450
Las Vegas	2,001
Little Rock	335
Louisville	466
Memphis	338
Minneapolis	830
New Orleans	2
Omaha	1,089
Parkersburg	614
Pittsburg	1,364
Portland	50
Pueblo	4,692
Saint Louis	466
Santa Fe	7,199
Sioux City	1,201
Sterling	3,875
Tulsa	722
Wichita	1,302
Yuma	141

Formative Assessment: Rivers and Elevation

City	Elevation (in feet)
Fort Dodge	?
Des Moines	955
Ottumwa	?
Keokuk	568

1. Draw an arrow on the picture above to show which way the Des Moines River is flowing.
2. Complete the sentence: *The Des Moines River flows this way because…*

   ____

3. The water in the Des Moines River comes from:

   a. smaller streams and lakes   b. rain

   c. melting snow and ice   d. all of these

4. Which of these could be the **elevation** of **Ottumwa**?

   a. 542   b. 673

   c. 968   d. 1,155

5. Which of these could be the **elevation** of **Fort Dodge**?

   a. 542   b. 673

   c. 918   d. 1,155

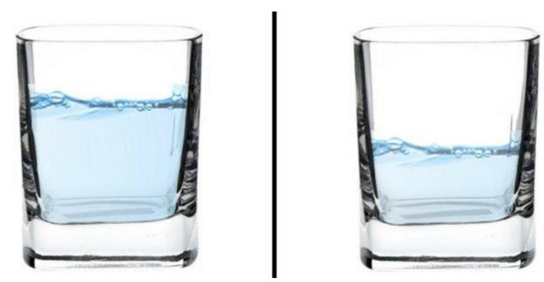
6. **True** or **False**: All rivers go to the ocean

4	3	2	1	0
All questions answered correctly; sentence is complete and uses proper grammar.	All questions answered correctly; sentence is not complete or grammatically correct.	Most questions answered correctly; sentence is at least partially correct.	A few questions answered correctly; attempt is made on the sentence.	All questions are incorrect.

The Missing Water

A group of students set a glass of water on the table and left it sitting out over the weekend. When they came back on Monday, they noticed that the glass did not have as much water in it. The students wondered what happened to the missing water.

Juanita: I think that the glass must have a hole in it somewhere and the water leaked out because of gravity.



Oliver: I think that the water got absorbed into the glass.

Helen: I think that the classroom must have gotten very cold over the weekend and the water in the glass got smaller.

Pedro: I think that the energy in the room changed the water into a gas and it went into the air in the room.

Which student do you think is correct?

How could you test their explanations?

The Wet Glass

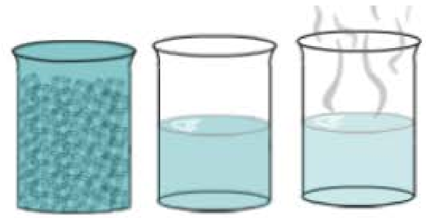
Cassandra was sitting on the beach enjoying the warm salty air and the sunshine. She became thirsty so she poured herself a glass of ice cold lemonade. After a few minutes, she noticed that the outside of the glass had little drops of water all over it. Where did this water come from?

1. The glass must have tiny holes in it that let the lemonade leak out.
2. The glass must have been wet to begin with.
3. Water vapor in the air turned into water droplets when they hit the cold glass.

Which explanation do you think is the most correct?

How could you test that explanation?

Investigating States of Water



Materials:

Safety glasses	Beaker
Ice cubes	Thermometer
Hot plate	Scale

Instructions:

1. Fill up your beaker with **solid** ice cubes.
2. Place the beaker on a scale, and write the mass in the data table.
3. Place a thermometer into the beaker, and write the temperature in the data table.
4. Draw a picture of what you see.
5. Place the beaker on the hot plate.
6. When all the ice has melted into **liquid** water, carefully remove the beaker from the hot plate and repeat steps 2-5.
7. Continue heating the beaker until you see bubbles and **water vapor** coming off of the water. Wait 3 minutes.
8. Carefully remove the beaker from the hot plate and repeat steps 2-4.

	Mass	**Temperature**	**Drawing**
solid ice	_______ g	_______ °C	
liquid water	_______ g	_______ °C	
water vapor (gas)	_______ g	_______ °C	

Summarize:

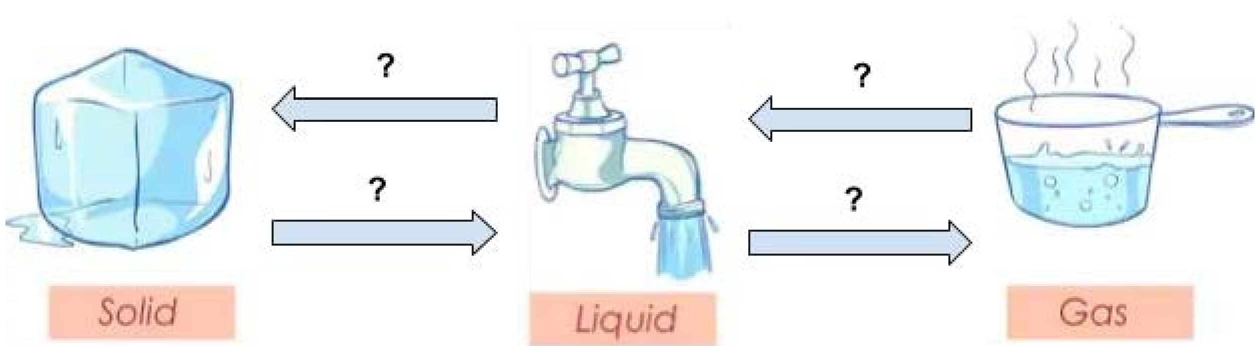
What happened to the temperature?

What happened to the mass?

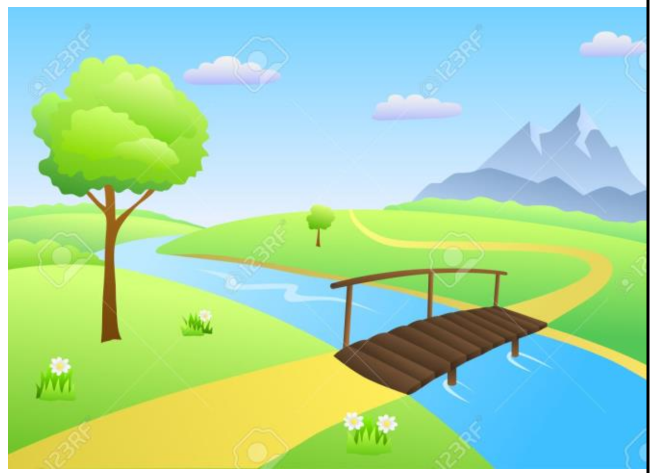
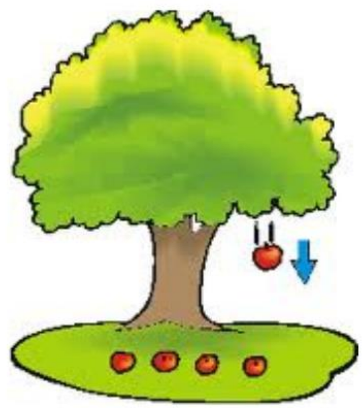
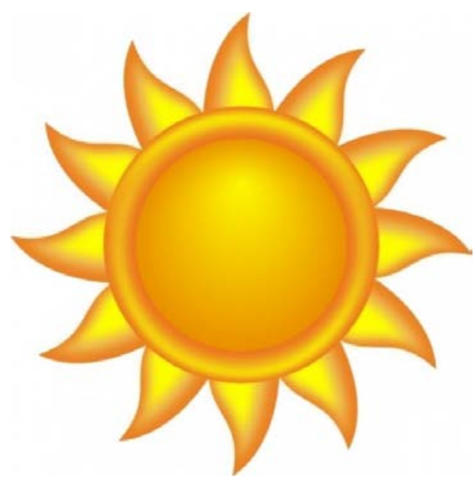
What is Matter?

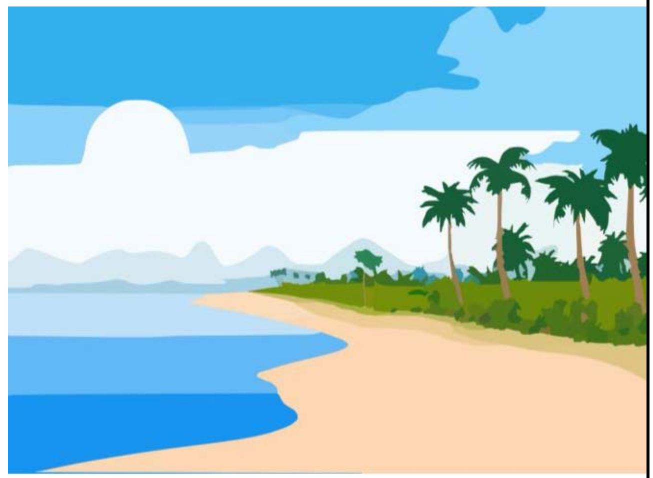
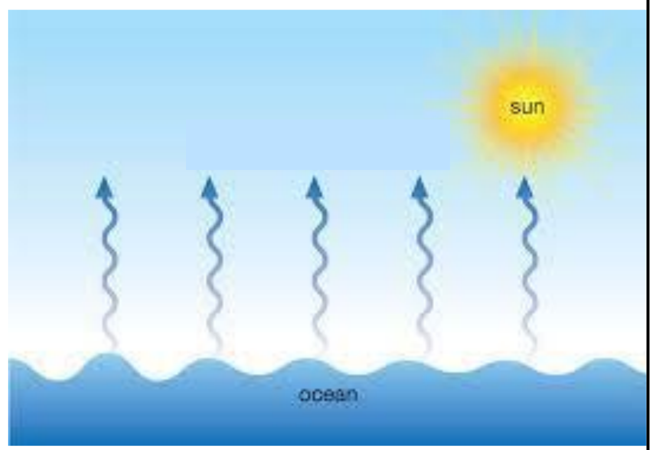
Characteristics *Matter is...* *Matter has…*	Examples	Matter changes when...

	Solid	Liquid	Gas
Characteristics	*Solids have…*	*Liquids have…* *Liquids do not have...*	*Gases do not have...*
Examples			



Activity: Mix and Match

River	
Gravity	
Energy	

Ocean	
Evaporate	
Melt	

Solid	
Liquid	
Gas	

Modeling the Water Cycle

Materials:

Large jar	Aluminum foil
Wire coat hanger	Ice cubes
Small paper cup	Water
Lamp with 200 watt bulb	Salt

Instructions:

1. Place a spoonful of salt in the jar.
2. Add water to the jar to a depth of about 3 cm.
3. Carefully swirl the jar until the salt is dissolved. Taste the water. *This represents the ocean, which is full of salt water.*
4. Place the wire stand and paper cup inside the jar. Make sure the cup is right in the middle.
5. Make a cone out of the foil, and place it over the top of the jar. Fold the edges down.
6. Place several ice cubes inside of the foil cone. Cover it with another piece of foil. *This represents the cold air way up above Earth's surface.*
7. Turn on the lamp and shine it at the water in the bottom of the jar. *The lamp represents the Sun.* **Be careful; it will get very hot.**
8. Watch what happens. You should see drops of water form on the bottom of the foil cone. *This represents clouds forming in the sky.*
9. When there is enough water in the cup, turn off the light and carefully remove the cup. Taste the water. *This represents fresh water in a lake or river.*

In the space below, draw a detailed picture of what you just observed.

In your picture:

-Label the following:

sun	**ocean**
clouds	**lake**

-use a red arrow to show **'evaporation'**
-use green to circle the area where **'condensation'** happens
-use a blue arrow to show **'precipitation'**

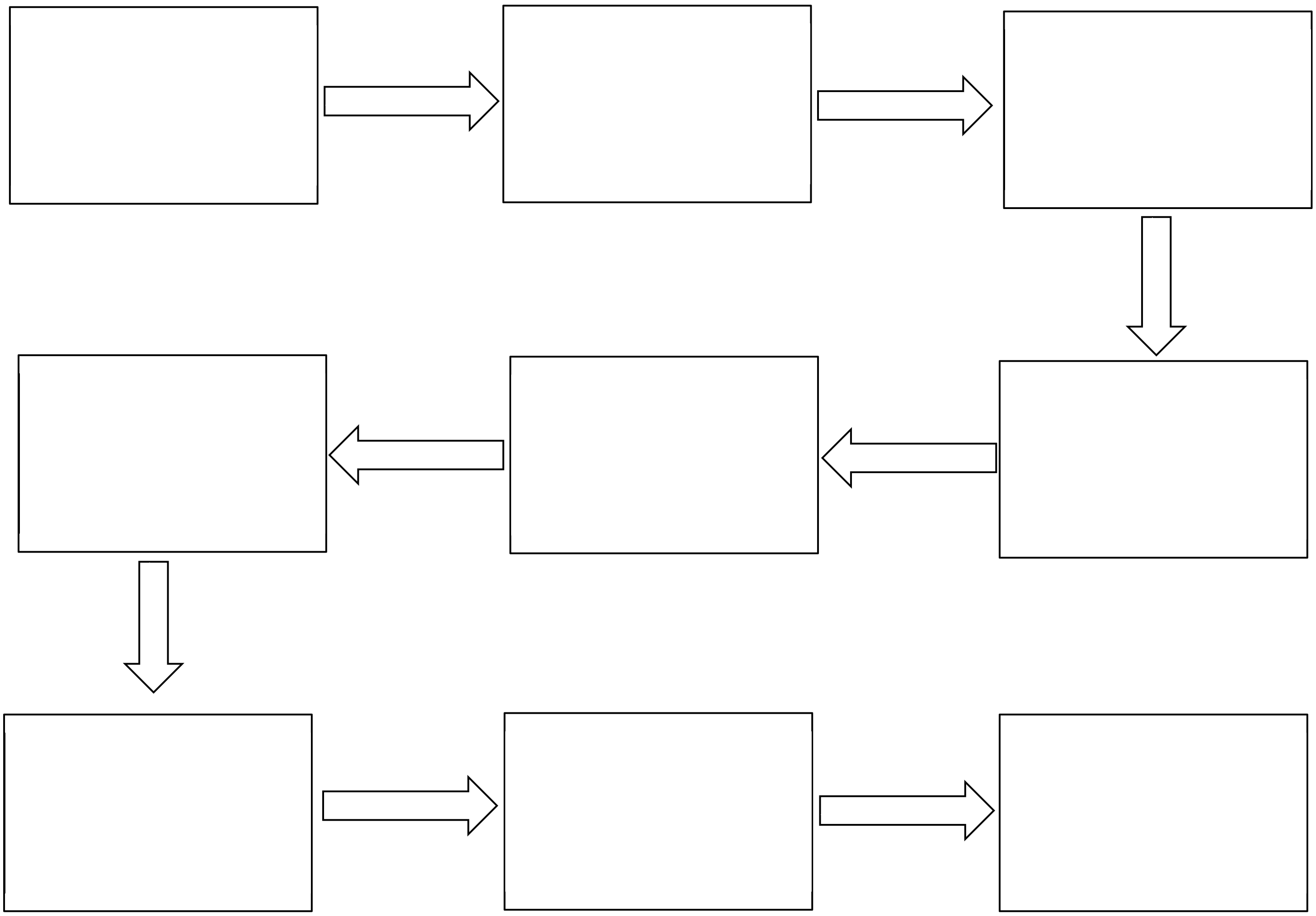
Summary Questions:

1. What caused the water to <u>evaporate</u>?
2. What caused the water to <u>condense</u>? What does this represent?
3. What caused the water to <u>fall</u> into the cup? What does this represent?

Journey Through the Water Cycle

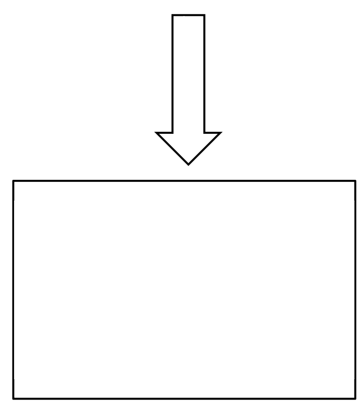
Go to the website: http://www.discoverwater.org/blue-traveler/

Use the website to track a single water droplet through the water cycle.
Record your journey using the boxes and arrows below.



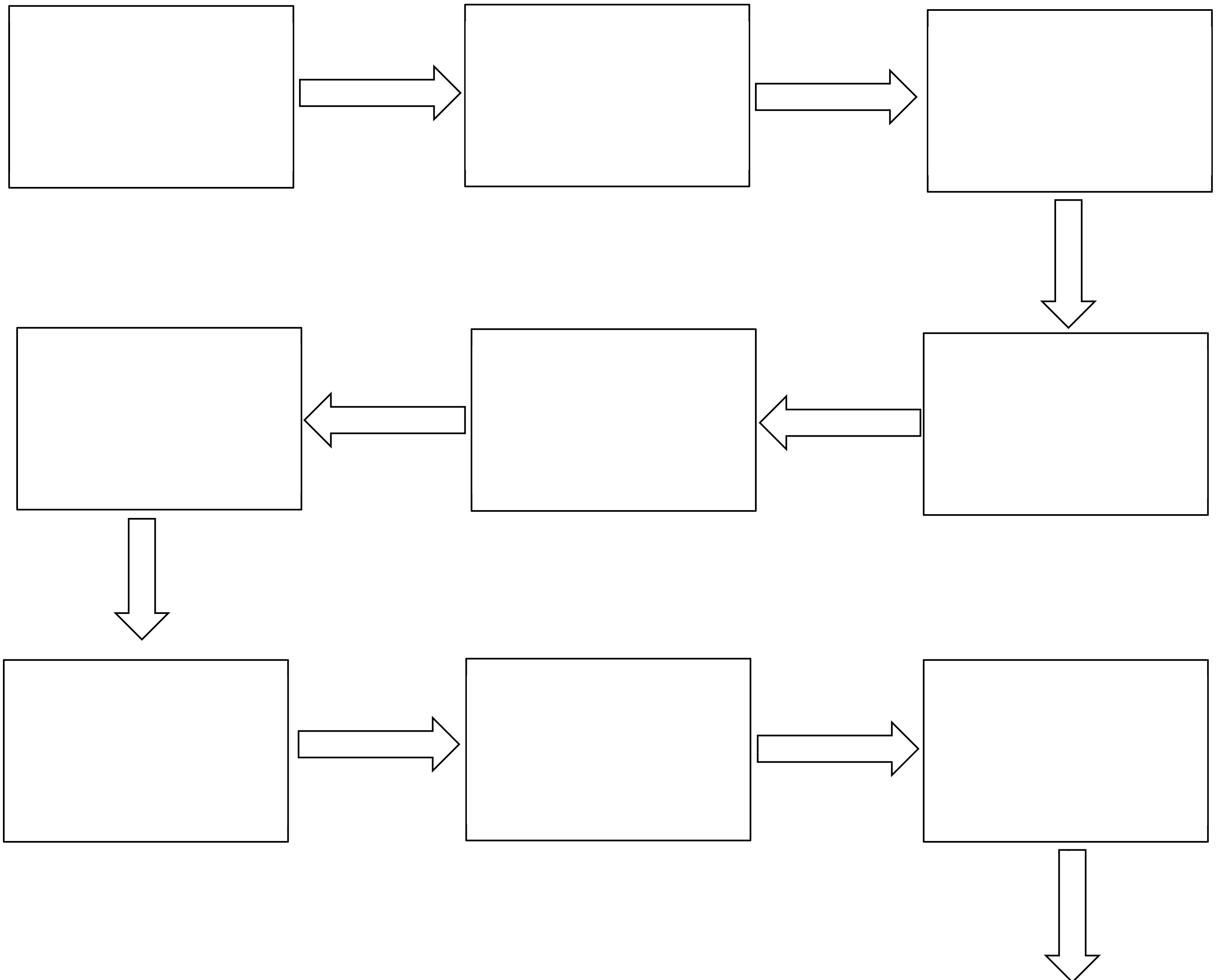
When **solid** or **liquid** water falls from a cloud to the Earth,

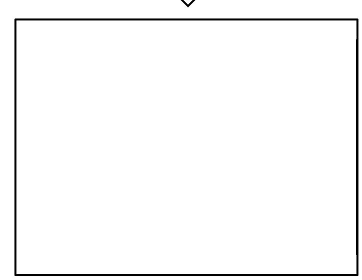
it is called ____________________.



When **liquid** water in the ocean changes to a gas and goes into the

atmosphere, it is called ____________________.





When water goes from **solid** ice in a glacier to **liquid** water in a river,

it is called _____________________.

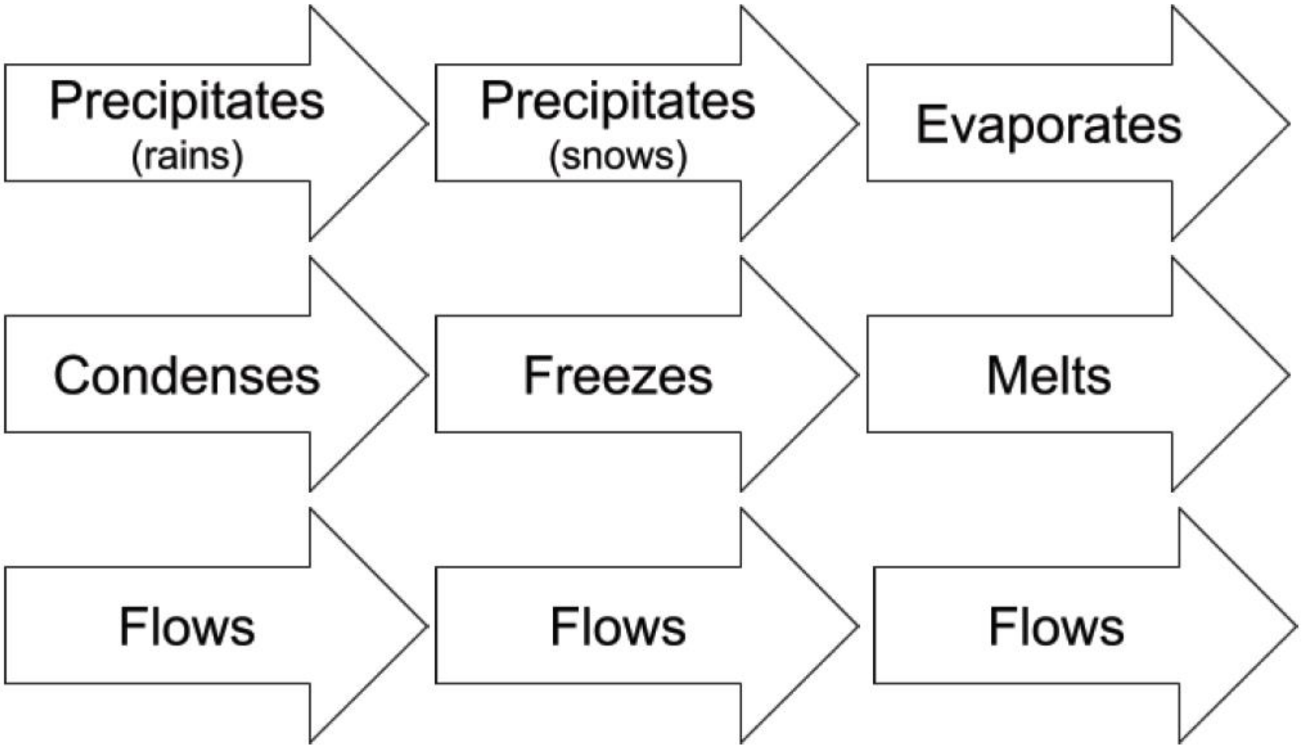
When water becomes part of an animal, it is called _____________________.

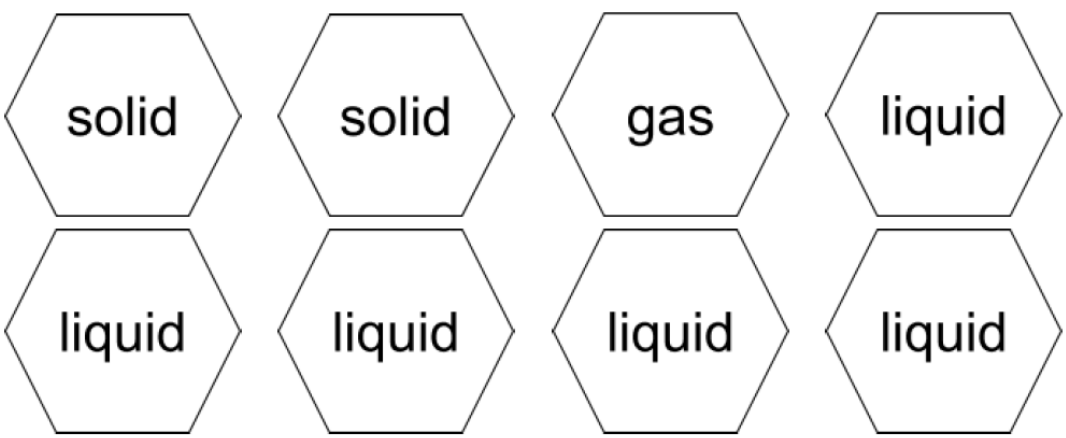
When animals breathe out **water vapor**, it is called _____________________.

When plants release **water vapor** from their leaves, it is called _____________________.

Activity: Card Sort

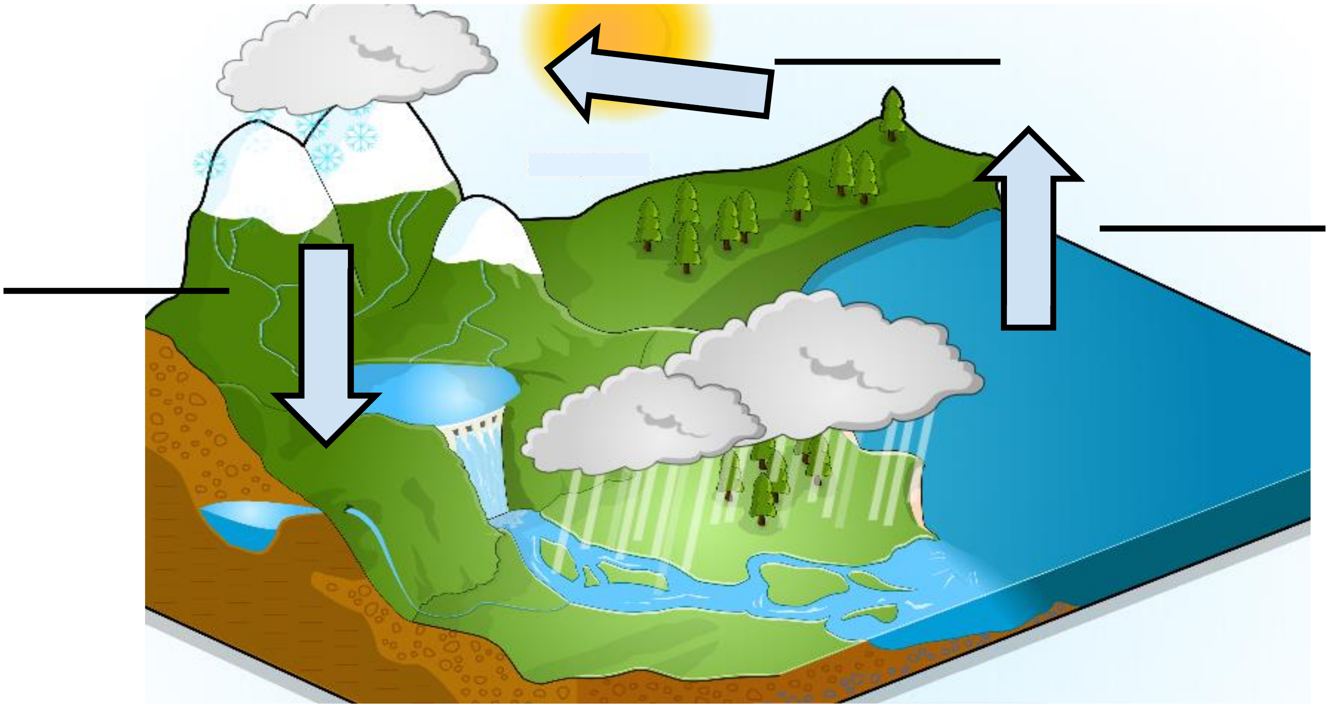
Lake	**River**
Small Streams	**Snow and Ice**
Ocean	**Atmosphere**
Cloud (solid)	**Cloud** (liquid)


Precipitates (rains)
Precipitates (snows)
Evaporates
Condenses
Freezes
Melts
Flows
Flows
Flows


solid
solid
gas
liquid
liquid
liquid
liquid
liquid

gravity	gravity	gravity
gravity	+ energy	+ energy
gravity	- energy	- energy

Water Cycle Quiz



1. **Label** the three arrows in the picture above with the three main processes in the water cycle: **condense**, **evaporate**, and **precipitate**.
    a. Use **pink** to highlight the process that is caused by **gaining energy (from the Sun).**
    b. Use **yellow** to highlight the process that is caused by **gravity.**
    c. Use **blue** to highlight the process that is caused by **losing energy (getting colder).**

2. Find **three** places in the picture where water would be a **liquid** and color them **orange.**

    ________________ ________________ ________________

3. Find **two** places in the picture where water would be a **solid** and color them **green.**

    ________________ ________________

4. Find **one** place in the picture where water would be a **gas** and **draw an 'x'** with your pencil.

    ____

Word bank

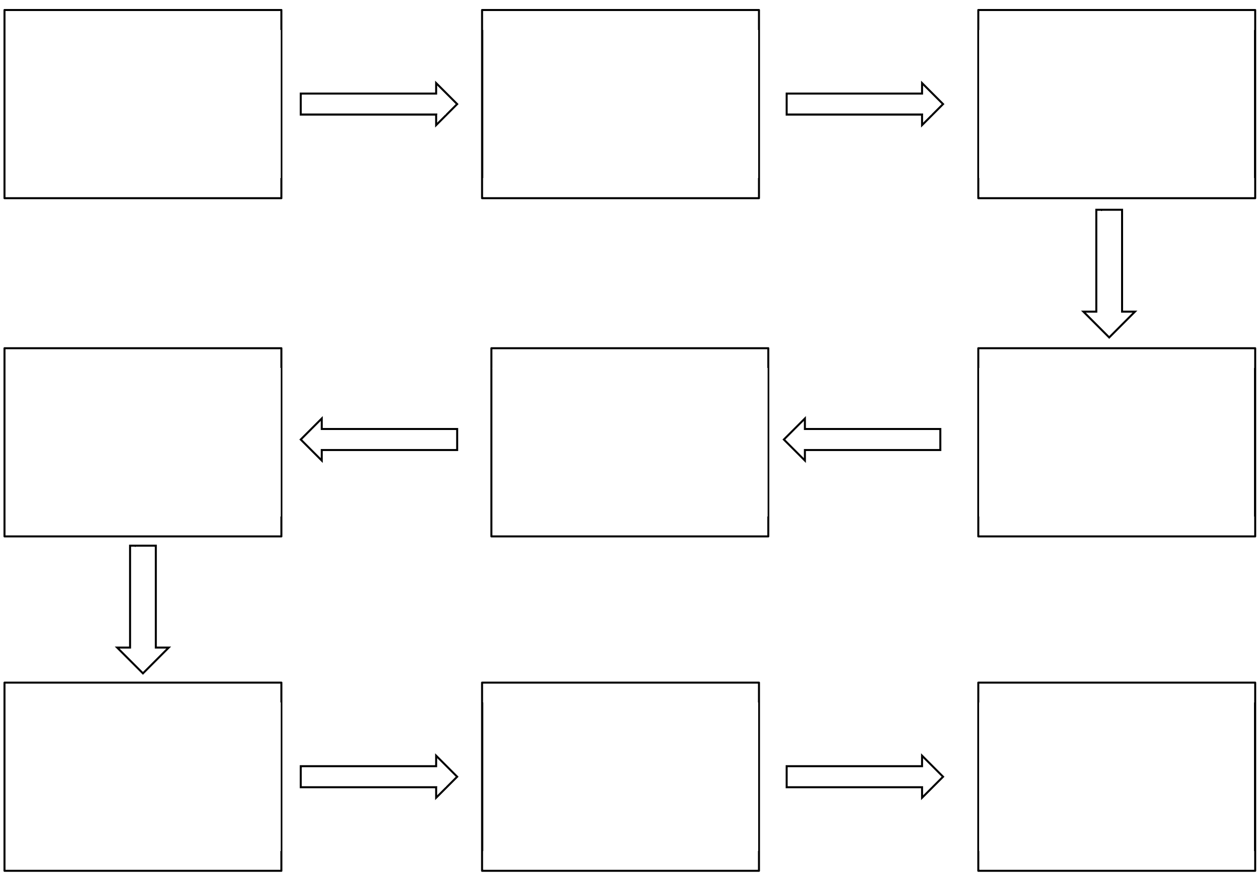
clouds	**rain**	**river**	**ocean**
atmosphere	**snow**	**lake**	**glacier**

Water Cycle Model and Presentation

We have learned that water moves around the Earth through the different parts of the water cycle. Create a model of the water cycle and use it to explain how a drop of water in the Des Moines River could travel all the way to your hometown and back again.

- Your model could be anything; for example, a poster, a book, a PowerPoint, or a 3D model
- All three states of matter must be included (solid, liquid, gas)
- You need to describe each process the water goes through and what causes it
- All of the following vocabulary words should be used:

Solid	*Evaporate*	*Freeze*	*Gravity*
Liquid	*Condense*	*Melt*	*Elevation*
Gas	*Precipitate*	*Flow*	*Energy*



Water Cycle Model Rubric

	4 - 100%	3 - 88%	2 - 75%	1 - 63%	0 - 50%
Stages of Water Cycle	Model accurately identifies each stage of the water cycle including: ☐ atmosphere ☐ clouds ☐ rain/snow ☐ ≥ two bodies of water	Model accurately identifies each stage of the water cycle with 2 or fewer errors or omissions.	Model attempts to identify each stage of the water cycle with 3 to 4 errors or omissions.	Model attempts to identify each stage of the water cycle with 5 or more errors or omissions.	Model does not accurately identify stages of the water cycle.
States of Matter	Model accurately identifies the state of matter at each stage and includes all three states: ☐ solid ☐ liquid ☐ gas	Model accurately identifies the state of matter at each stage with 2 or fewer errors or omissions.	Model attempts to identify the state of matter at each stage with 3 or 4 errors or omissions.	Model attempts to identify the state of matter at each stage with 5 or more errors or omissions.	Model does not accurately identify states of matter.
Processes	Model accurately describes each process and includes all required processes: ☐ evaporation ☐ condensation ☐ precipitation ☐ freeze ☐ melt ☐ downhill flow	Model accurately describes each process with 2 or fewer errors or omissions.	Model attempts to describe each process with 3 or 4 errors or omissions.	Model attempts to describe each process with 5 or more errors or omissions.	Model does not accurately describe processes.
Causes	Model accurately identifies the cause of each process and includes all three causes. ☐ gaining energy ☐ losing energy ☐ gravity/elevation	Model accurately identifies the cause of each process with 2 or fewer errors or omissions.	Model attempts to identify the cause of each process with 3 or 4 errors or omissions.	Model attempts to identify the cause of each process with 5 or more errors or omissions.	Model does not accurately identify the causes of the processes.
Model	Model completes the task neatly and creatively demonstrates a deep understanding of the water cycle.	Model completes the task as well as neatly and/or creatively demonstrates a general understanding of the water cycle.	Model is lacking in 1 of the following: completeness, neatness/creativity, understanding.	Model is lacking in 2 of the following: completeness, neatness/creativity, understanding.	Model is lacking in completeness , neatness/creativity, and understanding.

Water Cycle Presentation Rubric

	2 **Always**	**1** **Sometimes**	**0** **Never**
Student presents information clearly, concisely, and logically such that listeners can follow the organization of the model.			
Students presents information using complete and grammatically correct sentences.			
Student uses relevant academic vocabulary accurately.			
Student presents information at an appropriate volume.			
Student is professional as a presenter and as an audience member.			

Total: ___________ out of 10