Creating learning opportunities for students with Science on a Sphere

By

Kara R. B. Bates

Report submitted to the Faculty of
Virginia Polytechnic Institute and State University
In partial fulfillment of the requirements for the degree of
Master of Science in Agricultural and Life Sciences

Blacksburg, Virginia

Committee:

James C. Anderson II, Chair
Hannah Scherer
Matthew Eick

Abstract

In many classrooms, teachers are looking for ways to increase student engagement. Disengaged students are not reaching their full potential and experience relatively high levels of anxiety and frustration, which negatively impacts learning. Providing multiple hands-on and problem-solving learning opportunities can increase student engagement. The new curriculum developed for use on the Science on a Sphere provides educators with a resource to create problem-solving learning opportunities in their classrooms by using cooperative learning. These opportunities will help students understand how to work in collaborative groups while learning about and solving science-related problems. The curriculum consists of activities themed around climate change and human health. Additionally, the curriculum has been aligned to the Virginia Standards of Learning. To assess the curriculum, teachers and administrators reviewed, assessed, and provided feedback on the lesson plans and handouts. Overwhelmingly, most respondents stated that while the activities were well thought-out, would be beneficial for increasing students' learning, and provided problem-solving learning opportunities for students, they would not feel comfortable using and interacting with the Science on a Sphere without first participating in some form of training. Therefore, prior to making this curriculum available to other teachers, professional development opportunities should be provided to teach educators how to use and interact with the Sphere.

Table of Contents

Chapter One

Introduction

Background and Setting

It is difficult to watch a news report or read a newspaper article without seeing disparaging reports about how much lower Americans' science skills are compared to the science skills of individuals in other countries (Swanbrow, 2011). American adults were surveyed in 1988 and again in 2008 using an index of civic literacy "to track changes in scientific literacy over time" (Swanbrow, 2011, para. 6). In 1988, 10% of American adults had sufficient understanding of basic scientific knowledge; while in 2011, American adults improved to only 28% (Swanbrow, 2011). The 2004 National Science Board (NSB) study also showed that adult Americans have a knowledge gap concerning science skills. The adults surveyed in the study indicated they are interested in and support science and technology endeavors, but two-thirds of those who participated did not fully understand such science basics as the steps of the scientific process. In addition, most of the adults in the study noted that they obtained a majority of their information from television, print media, and the internet (National Science Board, 2004). There are few systems in place to make sure that the information presented in these formats are accurate. Ultimately, this negatively affects American ingenuity and progress. "By 2009, for the first time, over half of U.S. patents were awarded to non-U.S. companies because STEM [Science, Technology, Engineering, and Mathematics] shortcomings are forcing a hold on innovation" (National Math and Science Initiative, n.d.).

The question remains, how can scientific knowledge be improved in American youth so that they become scientifically knowledgeable adults? One way to address this problem is to begin reshaping American classrooms to increase student engagement by providing multiple

hands-on and problem-based learning opportunities. The research exists to show that disengaged students are not reaching their full potential (Stoner & Fincham, 2012). Students do not truly learn by "sitting and getting;" as a result, they tend to be disengaged from not just the teacher but with the material they are supposed to learn (Smith, Sheppard, Johnson, & Johnson, 2005). "The impact of students not being engaged in the classroom has many broad-reaching effects, including poor morale of…students" (Stoner & Fincham, 2012, p. 1).

Disengaged students, regardless of age or level, experience a decrease in instrinsic motivation, and they often feel they are removed from learning (Skinner & Belmont, 1993). As a result, they have tendencies to become passive, bored, and anxious, and they often give up at the first sign of challenges (Skinner & Belmont, 1993). It is imperative that teachers look beyond the content and topics and find ways to engage students by using a variety of tools, including discussions, collaborative projects, hands-on experiences (Smith et al., 2005), and flipped classrooms (Stoner & Fincham, 2012).

With a flipped classroom, students view a pre-recorded lecture prior to class; they then use class time to discuss the material, answer questions, and work on applying what they learned. Regardless of the techniques that are used, the important aspect to consider is that teachers must pro-actively seek ways to keep their students engaged; if one option does not work with their students, there are many other options they can try (Stoner & Fincham, 2012). In other words, engaging students goes beyond a traditional lecture and a power point.

In order for true learning to take place, student-centered hands-on activities are needed because they help students connect ideas to the big picture of the curricula (Lord, 2009). Hands-on learning is best described as learning by doing (Haury & Rillero, 1994). It is not simply manipulating a series of classroom activities; rather, with hands-on learning, students are

engaged in in-depth investigations with objects, materials, phenomena, and ideas and draw meaning and understanding from those experiences (Haury & Rillero, 1994). With hands-on learning environments, the focus shifts from being teacher-centered to student-centered. In this situation, the role of student shifts from focusing solely on finding the right answers to forming generalizations and finding patterns (Murrells, 2013). Providing "hands-on activities in isolation of context or ideas really are [not particularly helpful for instruction nor learning]" (Lord, 2009, p. 36). When integrated correctly, hands-on activities can help students learn complex concepts (Lord, 2009). One of the major hurdles facing science education is the fact that with mandatory curriculum and standardized testing that are a result of No Child Left Behind, many teachers feel that there is little time available to provide hands-on opportunities to their students (Lord, 2009). The benefits of hands-on learning are for all students, regardless of intelligence and age (Lord, 2009).

Hands-on instruction has a long and successful legacy in the sciences and math (Basista & Matthews, 2002; Bredderman, 1983; Haury & Rillero, 1994), and shows promise for teaching social studies, history, English, and other subject areas. By using hands-on instruction, educators are fostering the 21st century skills that students need to be successful: critical thinking, communication, collaboration, and creativity. Hands-on activities encourage a lifelong love of learning and motivate students to explore and discover new things (Bass, Yumol, & Hazer, 2011). "Ultimately, improving science achievement will require coordinated changes in everything from academic standards to labs to teacher training" (Lord, 2009). Hands-on programs can help stimulate these changes.

Science on a Sphere

James Madison University in Harrisonburg, Virginia, is the first university to acquire Science on a Sphere (SOS); this instructional tool is primarily utilized in museums' interactive displays (James Madison University, 2012). SOS is a sphere-shaped, visualization tool that was developed by the National Oceanic and Atmospheric Administration (NOAA), and it uses four projectors to project onto the surface of a six-foot diameter sphere that is suspended from the ceiling (James Madison University, 2012). Many of the current images for SOS use processed satellite data from NOAA (NOAA SOS, n.d.). The observer has the illusion of seeing Earth from an astronaut's perspective in space, regardless of where the observer is seated in the room. The conventional objective of SOS is an educational tool to expose the audience to issues and fundamentals of science. Accordingly, SOS is equipped with dozens of movies and images depicting environmental processes of Earth, such as global climate effects and changes in land formations (NOAA SOS, n.d.).

JMU obtained a three-phase grant to fund the purchase and implementation of SOS. Due to the economy, the third-phase of the grant, evaluation, was not funded (C.J. Hartman, personal communication, November 8, 2013). Dr. Hartman at JMU has experienced challenges in determining the effectiveness of K-12 school groups using SOS. SOS uses state-of-the-art technology, which makes it difficult for educators to use their own curriculum; currently, the school groups that visit the Sphere are only able to use the pre-programmed movies and images with no way of evaluating their effectiveness. Dr. Hartman has expressed interest in working with at least one local educator in designing an outreach program where teachers can begin to learn how to incorporate their curriculum in SOS while properly evaluating the effectiveness of

using this technology. As a result, I was responsible for designing rigorous, hands-on curriculum using this visualization tool.

Statement of the Problem

Can a pilot program with James Madison University's Science on a Sphere allow educators to create problem-solving learning opportunities to help students understand how to work in cooperative learning groups while solving science-related problems?

Purpose of the Project

The purpose of the project is to develop curriculum and make it available to other educators to promote cooperative learning in conjunction with the use of the SOS.

Project Objectives

The specific objectives guiding this project were:

1. Develop cooperative learning curriculum centered on climate change that can be used in conjunction with the SOS;
2. Align curriculum with Virginia's Standards of Learning; and
3. Evaluate the educational effectiveness of the curriculum by receiving feedback from education professionals.

Definition of Terms

Alternative Assessments: interactive ways other than standardized or conventional tests for teachers to determine what students have learned and areas in which they need assistance; examples include oral presentations, projects, and experiments (Stears & Gopal, 2010)

Cooperative Learning: a teaching method in which students work together in small groups to complete a project or an assignment and where each student has a specific responsibility

within the group, students complete projects and/or assignments together, and students typically receive a common grade (Blosser, 1993)

Critical Thinking: an active process in which the thinker considers alternatives, combines ideas, takes risks to find new connections, and evaluates steps to a conclusion (Dixon, 2004, p. 57)

Engagement: a state in which students are actively participating in order to learn new ideas, concepts, and information and feel confident enough to take educational risks (Skinner & Belmont, 1993)

Hands-on learning: a student-centered environment where students are engaged in in-depth investigations with objects, materials, phenomena, and ideas and draw meaning and understanding from those experiences (Haury & Rillero, 1994)

Knowledge: the accumulation of information and the mental structures used to organize that information (Northouse, 2013, p. 51)

Leadership: a process whereby an individual influences a group of individuals to achieve a common goal (Northouse, 2013, p. 5)

Motivation: one's inner drive to accomplish a task (Kirton, 2003; Northouse, 2013)

Rubric: a grading or scoring tool that lists the criteria and expectations of a particular assignment by describing levels of quality for each of the criteria as a means of providing support and guide learning (Carnegie Mellon University, n.d.)

Shared Leadership: an interactive influence process among individuals where they lead one another toward the achievement of collective goals (Pearce, Manz, & Sims, 2009)

STEM: an acronym that signifies education (teaching and learning) in the fields of science, technology, engineering, and mathematics (Gonzalez & Kuenzi, 2012)

Student-Centered Classroom: (also called learner-centered classroom) an educational pedagogy where students and instructors share the focus, students and teachers interact equally, group work is encouraged, and students learn to collaborate and communicate with one another (Concordia University, 2014)

Teacher-Centered Classroom: an educational pedagogy where students focus on the teacher and work independently with little to no collaboration and communication with one another (Concordia University, 2014)

Significance of the Problem

Part of the reason the United States is seeing a decline in students pursuing STEM careers is a result from a lack of public outreach. "A recent poll of scientists found that 42% engaged in no public outreach," (National Science Board, 2004, p. 4) due to time constraints or a lack of desire to do so. As a result, students are not fully aware of the opportunities with STEM related college degrees and subsequent careers. This proposed project will help increase public outreach and, as a result, more interest in science education and STEM-related pathways.

Even though the project will be designed for use with secondary science students, it is plausible that educators of other age groups and subjects can use the knowledge presented to benefit the learning of their students. Through peer-led training opportunities, other educators will have the opportunity to develop their own lessons or activities for incorporation into SOS; they will also feel comfortable doing so using state-of-the-art technology. Eventually, there could be a clearinghouse of educator-designed activities that would be accessible to teachers in multiple areas and across the curriculum.

Chapter Two

Review of Literature

Science Education

American students 15 years of age recently ranked 17th in science knowledge in the world, compared to 31 other countries (Walker, 2013 and National Math and Science Initiative, n.d.), and as such there is obvious room for improvement. In a recent survey (Walker, 2013), nearly half of American students 15 years of age who were surveyed said that they do not plan to pursue math and science degrees after graduating high school because they are too challenging. Fewer American students enroll in STEM courses than their counterparts in other countries (National Science Foundation, n.d.). According to a 2007 study, "only 10% of U.S. 8th graders reach the advanced science level on the international TIMSS [or, Trends in International Mathematics and Science Study] exam. Twenty five percent of 8th graders in China and 32% of 8th graders in Singapore reach the advanced science level on the TIMSS" (National Science Foundation, n.d.). With these statistics, it is understandable that "only 16% of American high school seniors are…interested in a STEM career" (U.S. Department of Education, n.d.). Due to a lack of consistent science education in America's public school system, many high school graduates are not adequately prepared for college-level science; in fact, as of 2012, 69% were deemed as not ready for college-level science (National Math and Science Initiative, n.d.).

Knowledge Acquisition

Alongside teaching curriculum and giving assessments, teachers are also educating students to help develop their leadership skills to become productive members of society. "Knowledge has a positive impact on how leaders engage in problem-solving" (Northouse, 2013, p. 51). Knowledge also allows people to "think about complex system issues and identify

possible strategies" (Northouse, 2013, p. 52) when learning how to solve problems. However, with the current educational system of mandatory curriculum and standardized tests, it is becoming increasingly difficult for students to make cognitive connections and to build upon their neural networks that lead to knowledge acquisition (Weisberg & Reeves, 2013). Students are being tested for benchmarks throughout the school year in each grade, and in order to meet the requirements, students are memorizing information solely for the purpose of passing assessments. Even though "rote [memorization and] repetition can result in some information being retained, it is not a particularly effective method of encoding information into memory" (Weisberg & Reeves, 2013, p. 101).

Critical Thinking

All students benefit from learning basic critical thinking skills, regardless of their age and level, and they can be applied in all content areas (Shaughnessy, Seevers, & Elder, n.d.). The traditional classroom environment, however, is not always conducive for students to develop critical thinking skills because the current curriculum is not designed as such (Shaughnessy et al., n.d.). Additionally, not all teachers understand exactly what critical thinking is (Dixon, Prater, Vine, Wark, Williams, & Hanchon, 2004). "Critical thinking is not typically a significant part of teacher preparation programs" (Shaughnessy et al., n.d., para. 1). There is a real need for teacher training to help address this issue; the lack of training trickles down to the students in the classroom and affects them in unintended ways. Some students do not learn how to become independent thinkers. Without properly incorporating critical thinking skills in the curriculum, some students come to expect instant gratification and struggle to move past the challenges that are present when trying to solve complex problems (Shaughnessy et al., n.d.).

It is the educator's responsibility to create opportunities in the classroom for students to think critically. One of the first steps in accomplishing this is to have a learning environment that encourages critical thinking (Dixon et al., 2004). Some examples include student discussions, hands-on and problem-solving activities centered on real-life issues, and encouraging students to feel confident enough to take a proactive role in their education (Dixon, et al., 2004). This will require a shift from a teacher-centered classroom to a student-centered classroom (Dixon, et al., 2004).

Problem Solving

Organizations value their employees' abilities to solve problems (Lohman, 2002). In order to be successful, employees must rely on their knowledge and skills to help them solve complex and ill-structured problems encountered in their jobs (Lohman, 2002). Without implementing problem solving for students of all ages and levels (Canter, 2004), these students will fail to learn these valuable skills that will be needed throughout their life. Canter (2004) goes on to say, "regardless of state or federal mandates, schools need to change the way they address" student learning in order for students to be college-and-career ready (para. 4).

Even though homework for American students has increased by more than 50% since 1981, their problem-solving skills have continued to lag (Townsend, 2012). The inference can be made that effective problem solving is more than assigning homework problems. When the value is placed on exploration instead of results, students are taught real-world skills; their confidence will also increase, which helps nurture their creative problem-solving skills (Townsend, 2012). Townsend (2012) explained:

> The teacher doesn't need to give any answers, the answers are everywhere. And we know now from years of measurements, that learners who find the answers for themselves, retain it better than if they're told the answer (para. 13).

Therefore, it becomes clear that teachers are doing a disservice to their students by assuming homework problems will teach the problem-solving skills they will need in life; it goes far beyond that.

Shared Leadership

Shared leadership is becoming increasingly more important in today's classrooms and organizations because it allows faster responses to more complex issues (Northouse, 2013). Shared leadership was defined by Pearce, Manz, and Sims (2009) as "a dynamic, unfolding, interactive influence process among individuals, where the objective is to lead one another toward the achievement of collective goals" (p. 234). Avolio, Walumbwa, and Weber (2009) describe shared leadership as reciprocal influence that helps reinforce and develop working relationships between team members; as the relationships are strengthened, team members will experience higher levels of trust and motivation, which will ultimately increase team performance.

Shared leadership allows individuals "to bring a very diverse set of functional expertise and experience together," (Pearce et al., 2009, p. 235); in turn, team members are more likely to find creative solutions to problems. According to Pearce et al. (2009), "teams that demonstrated higher levels of effectiveness were those that engaged in higher levels of shared leadership" (p. 237). No one is an expert in all things. It therefore makes sense, according to Pearce et al. (2009), to incorporate shared leadership when it is necessary for everyone's knowledge and skills to be utilized to achieve success.

Theoretical Framework

Blosser (1993) defined cooperative learning as a teaching method in which students work together in small groups to complete a project or an assignment. Additionally, each student has a specific responsibility within the group while students complete projects and/or assignments together and they typically receive a common grade (Blosser, 1993). "Students encourage and support each other, assume responsibility for their own and each other's learning, employ group related social skills, and evaluate the group's progress" (Dotson, 2001, p. 2). The group's success is dependent upon the success of each group member (Blosser, 1993). Cooperative learning has been studied and successfully used in a many classrooms, from elementary through post-secondary (Magnesio & Davis, 2010; Dotson, 2001; Slavin, 1991), regardless of achievement levels and socioeconomic backgrounds (Slavin, 1991).

Multiple researchers (Slavin, 1991; Magnesio & Davis, 2010; Blosser, 1993; and Johnson & Johnson, 1994) have compared student learning gains in classrooms that employ cooperative learning against classrooms that use traditional instruction. On average, these studies showed that:

- Students engaging in cooperative learning develop better critical-thinking skills.
- Students enjoy cooperative learning more and are more motivated learners.
- Students learn and develop leadership skills as a by-product of cooperative learning.
- Students are better prepared for post-secondary experiences (e.g., college or jobs) because they have learned the skills necessary to work collaboratively with others.

Cooperative learning is more than just assigning students to work in groups; teachers need to provide the proper structure in order for students to be successful (Magnesio & Davis, 2010).

There are five key elements that help differentiate cooperative learning from simply putting students into groups to learn (Johnson & Johnson, 1994). These elements are: positive interdependence, individual accountability, face-to-face interaction, interpersonal and small group social skills, and group processing (Johnson & Johnson, 1994). As a result, students are encouraged to think creatively because cooperative learning allows them to increase the number and quality of ideas (Johnson & Johnson, 1994). Working with other students in a cooperative learning environment helps generate unique ideas and perspective and causes group members to consider a larger number of alternatives than any one member could think of on their own (Johnson & Johnson, 1994; Slavin, 1991). A cooperative learning environment also encourages students to consider and appreciate others' ideas (Johnson & Johnson, 1994). Students are given opportunities to actively participate in their learning, question and challenge each other, share and discuss their ideas, develop leadership skills, and internalize their learning cooperatively (Johnson & Johnson, 1994).

Using cooperative learning to promote shared leadership, problem-solving, critical thinking, and knowledge acquisition can be a powerful means of helping American students achieve at higher levels in all subjects, (Ejiwale, 2012). It is hypothesized that as more students become engaged and motivated in the classroom, and as more teachers utilize these strategies with their students, leadership skills will also improve (Ruiz-Gallardo, Lopez-Cirugeda, & Moreno-Rubio, 2012).

Chapter Three

Program Overview

Target Population

The curriculum was designed for high school Environmental Science and Natural Resources teachers. This group was chosen because they infrequently utilize the SOS, and JMU is interested in providing more opportunities for high school teachers and, subsequently, students of this age group (Dr. Hartman, personal communication, March 31, 2014). This group was also chosen because students will benefit from participating in a rigorous, cooperative learning environment, and utilizing the SOS will give them valuable experience with many aspects of STEM.

Methodology

The first step of the project was to become acquainted with the SOS and to learn how to use it. Several hours were spent reading resources provided by Dr. Hartman, including "Instructions for Operating the Sphere Theater" (James Madison University, 2012), "Science on a Sphere User Manual" (NOAA SOS, n.d.), "SOS Remote App User Manual" (NOAA SOS, n.d.), and "How to Create Original Content" (James Madison University, 2012). Additionally, the different datasets available for use on the SOS (NOAA SOS, n.d.) were analyzed in order to determine the focus of the curriculum.

After much time and consideration, the curriculum (see Appendix A) was developed with the intent that most high school Environmental Science and Natural Resources teachers could use it with little or no modifications. It was determined that the theme of the curriculum should focus on climate change. An informal review (including but not limited to Scholastic and Discovery Education resources) of online lesson plans and activities that focus on climate change

revealed that very few provided rigor for high school students; additionally, climate change curriculum could be easily incorporated with the SOS because nearly 70 datasets pertaining to this topic are currently available (NOAA SOS, n.d.).

The curriculum, titled Climate Change and Human Health, has four learning objectives. Students will: define climate change, describe Maslow's hierarchy of needs and how these needs are impacted by climate change, describe how climate change is predicted to affect humans in terms of natural resources, and describe how climate change is predicted to affect humans in terms of health.is composed of three activities. The first activity is an introduction to the SOS and will allow students to learn important aspects about climate change while becoming familiar with using the Sphere. The second activity is a large-scale project that utilizes cooperative learning and shared leadership among students. At the conclusion of this activity, students will create and upload original content to the Sphere and present their findings to other students. The final activity allows students to reflect on what was learned by finding a recent news report or research paper and sharing their ideas and reflections on a public forum, such as a classroom blog.

After the curriculum was developed, the activities were simulated on the SOS to determine their feasibility and reliability; students were not involved at any time during the simulation. Multiple modifications were made based upon this simulation. Special attention was given to aligning the curriculum with Virginia Standards of Learning (SOLs). This was done by carefully evaluating each activity and determining what students would expect to learn in each content area. Because the focus of the curriculum is upper-level high school students, only SOLs associated with high school courses were considered. The SOLs are listed on the curriculum, and they include Life Science, Earth Science, Biology, Chemistry, World Geography, Computers

and Technology, and English. The curriculum was developed in order to be as cross-curricular as possible; this integration will increase the likelihood that multiple teachers could utilize the curriculum.

A way to evaluate the effectiveness of the curriculum is important. Therefore, there are two evaluation methods that were developed. The first evaluation method is used to gauge what students know prior to beginning the curriculum and compare that to what they have learned after completing the curriculum. Known as a pre-posttest approach, students are given the opportunity to reflect on what has been learned, and teachers have tangible documentation to assess their students' learning. This data was not collected for the purposes of this project; rather, it is included with the curriculum for teachers to use with their students when using the curriculum. The second evaluation method is to receive feedback from educational professionals as to the effectiveness of the curriculum. Because this curriculum is new, feedback will be imperative in order assess what works well and what should be modified to make it more effective. Data was collected for this evaluation method and will be discussed in greater detail in the next section.

Data Collection

A panel of professionals, including teachers and administrators who have expertise in curriculum design and implementation, reviewed the curriculum and provided feedback about its effectiveness. The data collected from the evaluation provided guidance as to how the curriculum should be modified to impact student learning. Seven professionals were contacted to inquire about their interest and availability in reviewing and providing feedback. Three of the teachers were unavailable during the timeframe of this project. As a result, only four professionals were able to review and provide feedback; two are teachers and two are

administrators, and all are employed by the same school division. The curriculum was sent to the evaluators electronically, and they were given two weeks to review it. At the end of two weeks, a Google form with evaluation questions pertaining to the curriculum was sent to each evaluator, and they were given up to two weeks to provide feedback. Because this was done on a Google form, their feedback was easily captured, and data were immediately updated.

Chapter Four

Project Outcomes

A professional panel of teachers and administrators reviewed the Climate Change and Human Health curriculum prior to completing an evaluation of its effectiveness. Evaluation questions were in the form of a 5-point Likert scale; the responses were coded accordingly: strongly disagree = 1, somewhat disagree = 2, somewhat agree = 3, agree = 4, strongly agree = 5. Respondents also had opportunities to provide optional, open-ended responses for each activity. In the tables that follow, the frequency along with the percentage is given for each scaled question. Unedited responses are also provided for the open-ended questions. For the evaluation questions, respondents could only select one response; they were, however, not limited in the number of responses they could give for open-ended questions.

Table 1.

Activity 1, Responses to Evaluation Questions

	Do Not Agree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
The content of the lesson provided depth of the concept.				3 (75%)	1 (25%)
The lesson was coherent and logically structured.				2 (50%)	2 (50%)
The lesson provided hands-on learning opportunities for students.			3 (75%)	1 (25%)	
The target teacher audience could use the activity as presented with little or no modifications.		1 (25%)	2 (50%)	1 (25%)	

When asked "What specific components worked well with Activity 1?" the evaluators said:

- I think the script is very beneficial to show how to present the information. I also like how the Sphere datasets are listed; it takes away all the guesswork.
- The lesson is a great way to introduce the topic of climate change and human health.
- I appreciate that questions to encourage discussion were included. They will be helpful in facilitating discussions with students during the activity.

- I like that this particular concept is being taught using something as cutting-edge as the Science on a Sphere. I think students will make a connection to what they are learning and will remember it.

When asked "What specific components could be improved to make Activity 1 better?" the evaluators responded:

- I suggest offering training on the technology. Since I have never used the Science on a Sphere before, I'm not sure I would be able to navigate it effectively based on the information in the activity.
- Learning how to use the Science on a Sphere seems time consuming, and I'm not sure I would feel comfortable using it without proper training.
- I suggest that teachers participate in some type of training on the Science on a Sphere prior to teaching the activity.
- I suggest adding more background information for those teachers who don't have expertise in climate change or human health.
- Would there be a way to incorporate more hands-on opportunities for the students with this activity? If so, I think that would be beneficial for students.

Table 2.

Activity 2, Responses to Evaluation Questions

	Do Not Agree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
The content of the lesson provided depth of the concept.				1 (25%)	3 (75%)
The lesson was coherent and logically structured.				1 (25%)	3 (75%)
The lesson provided hands-on learning opportunities for students.					4 (100%)
The target teacher audience could use the activity as presented with little or no modifications.			2 (50%)	2 (50%)	

When asked "What specific components worked well with Activity 2?" the evaluators said:

- I am glad that the handout and grading rubrics were included; as a teacher who may potentially use this curriculum, this will save me a lot of time.
- The activity seems interesting, and I think students would enjoy it and learn a lot.
- I like the collaborative nature of this activity. Students will be actively participating throughout the activity – it's very hands-on.
- This activity is well-structured, but it gives students the freedom to make the outcome of the project their own.
- Evaluation from peers is important, and I'm glad to see this incorporated as part of the overall grade.

- I like how each group will be focused on different diseases. Students will learn from each other because each group is presenting on something different (and I won't have to listen to the same presentation multiple times!).

When asked "What specific components could be improved to make Activity 2 better?" the evaluators responded:

- Since I haven't used the Science on a Sphere before, I don't know if I could teach students how to upload their own content. It would be helpful if this could be included in any pre-activity workshops for teachers.
- I'm unsure of how I will be able to help students upload content to the Sphere. More information on how to do this would be good.
- It may be difficult for teachers to check out the laptop carts or reserve time in the computer lab for the duration of this activity. Perhaps the length of the activity could be reduced to account for this.
- It would have been helpful if copies of exemplary, good, fair, and poor projects had been included to use as illustrations for grading.

Table 3.

Activity 3, Responses to Evaluation Questions

	Do Not Agree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
The content of the lesson provided depth of the concept.				4 (100%)	
The lesson was coherent and logically structured.				2 (50%)	2 (50%)
The lesson provided hands-on learning opportunities for students.			1 (25%)	3 (75%)	
The target teacher audience could use the activity as presented with little or no modifications.				3 (75%)	1 (25%)

When asked "What specific components worked well with Activity 3?" the evaluators said:

- I think personal reflection is important, and I'm glad to see this activity included in the curriculum.
- I don't have a classroom blog, but I can still use this activity with my students in their journals.
- I like the grading rubric for the blog entry; that is very helpful.

When asked "What specific components could be improved to make Activity 3 better?" the evaluators responded:

- I think an option should be available for students if they are unable to find a recent article about the disease chosen for the reflection.

- It would be helpful if examples of blog posts could be included so we could see an exemplary, good, fair, and poor for grading purposes.
- An extension to the blog (or journal) could be to read and respond to someone else's post.

Table 4.
Overall Curriculum, Responses to Evaluation Questions

	Do Not Agree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
The objectives of the curriculum were met successfully.				1 (25%)	3 (75%)
The content of the curriculum provided depth of the concept.				4 (100%)	
The curriculum was coherent and logically structured.			1 (25%)	3 (75%)	
The target teacher audience could use the curriculum as presented with little or no modifications.			2 (50%)	2 (50%)	

When asked "What specific components worked well with the curriculum?" the evaluators said:

- All the activities provided very thorough information for teachers.
- The activities were hands-on for students, and they allowed for discussions and collaboration with other.
- The handouts and rubrics were helpful.
- I'm glad to see the pretest and posttest questions; they are much needed to show what students learned.
- Using such new technology as the Science on a Sphere is beneficial for students interested in pursuing STEM degrees in college.
- Well done! I think this curriculum is interesting, and students will not only enjoy it, they will learn a lot from it.

When asked "What specific components could be improved to make the curriculum better?" the evaluators responded:

- I think some kind of training opportunity should be made available to teachers to teach them how to use and interact with the Science on a Sphere.
- I would like to be trained on how to the Sphere before even attempting to use it as described in the curriculum.
- It will be important to offer training or tutorials to teachers about the Sphere. One way to do this could be to create and share a video tutorial. Teachers would then have access to it anytime.

Chapter Five

Conclusions

Objective one was to develop cooperative learning curriculum centered on climate change that can be used in conjunction with the SOS. This was accomplished by creating rigorous curriculum where students can work together to learn about climate change and human health using the SOS. The panel of reviewers thought the curriculum worked well for creating a collaborative space among students and especially liked how it allowed students autonomy to make the outcomes of the projects their own. All respondents (of which the two teachers have a background in climate science) felt that the content of each activity provided depth of the climate change concept; all three activities were ranked as either "agree" or "strongly agree" for this evaluation category. The consensus was that the scripts included in the curriculum were beneficial as were the discussion questions, handouts, and grading rubrics.

All respondents also felt that each activity was coherent and logically structured; this category was also ranked as either "agree" or "strongly agree" for all three activities. Those who responded appreciated that even though the activities were well-structured, they were not so rigid that they could not be modified based on instructors' needs. When asked about hands-on learning opportunities, all respondents indicated that they "strongly agreed" that Activity 2 did just that. This is not surprising, as this activity utilized cooperative learning and shared leadership. With Activity 1, 75% of the respondents "somewhat agreed" that students had opportunities for hands-on learning, and 25% "agreed" that students had hands-on learning opportunities. With Activity 3, only 25% "somewhat agreed" that students had hands-on learning opportunities while 75% "agreed" that students had these opportunities. Overwhelmingly, most respondents stated that the activities were well thought-out and would be

beneficial for increasing students' learning. The reviewers commented that the curriculum was successful in providing problem-solving learning opportunities for students as they worked in cooperative groups while solving science-related problems. The curriculum was developed with high school Environmental Science and Natural Resource classes in mind, but it can be used with other subject areas with some modifications.

Objective two was to align curriculum with Virginia's Standards of Learning (SOLs). The SOLs are listed on the curriculum, and they include Life Science, Earth Science, Biology, Chemistry, World Geography, Computers and Technology, and English. The curriculum was developed in order to be as cross-curricular as possible; this integration will increase the likelihood that multiple teachers could utilize the curriculum. In total, 30 SOLs can be addressed with the developed curriculum.

Objective three was to evaluate the educational effectiveness of the curriculum by receiving feedback from education professionals. A panel of professionals reviewed and provided feedback about the effectiveness of the Climate Change and Human Health curriculum. For each activity, each individual of the review panel answered evaluation questions in the form of a 5-point Likert scale; respondents also had opportunities to provide optional, open-ended responses for each activity. Overall, the panel concluded that the curriculum would be beneficial for high school Environmental Science and Natural Resources teachers and would provide collaboration and hands-on learning opportunities for their students; modifications were also recommended to make the curriculum as effective as possible.

When reviewing Activity 1, 25% selected "somewhat disagree" when asked if the target teacher audience could use the activity as presented with little or no modifications. The reviewers responded that they did not feel comfortable using and interacting with the SOS

without first participating in some form of training. Because the SOS is such an integral part of the curriculum, learning how to first use it will be imperative. Therefore, prior to making this curriculum available to other teachers, it will be important to provide professional development opportunities to teach educators how to use and interact with the Sphere. Part of the training will need to show the basics of using and interacting with the Sphere. It will also be important to provide teachers the opportunity to develop an activity they could use on the Sphere with their students; doing so will increase the likelihood that they will use it with their students. Lastly, those participating in the training will learn how to upload original content to the Sphere. One of the evaluators suggested "It will be important to offer training or tutorials to teachers about the Sphere. One way to do this could be to create and share a video tutorial. Teachers would then have access to it anytime."

Finally, one evaluator was concerned about students' access to computers for Activity 2. In many schools, students do not have computers assigned to them, and teachers are required to reserve a laptop cart or time in a computer lab in order to conduct online research; some schools have restrictions on how frequently these can be reserved. Therefore, this activity would need to be modified as deemed necessary to account for these situations.

Discussion

The curriculum uses cooperative learning by providing students with opportunities to actively participate in their learning, question and challenge each other, share and discuss their ideas, develop leadership skills, and internalize their learning. The curriculum has the five key elements commonly used in cooperative learning environments: positive interdependence, individual accountability, face-to-face interaction, interpersonal and small group social skills, and group processing. With the curriculum, students are engaged in problem solving and critical

thinking, and as a result, it is anticipated that they will learn the science-related content in a much deeper way. Activity 1 provides the introduction to the SOS, a novel instructional tool. Students will have opportunities to conceptualize how climate change impacts human health using real data collected by NOAA. While working on the project associated with Activity 2, students will collaborate with their peers in cooperative groups. In these groups, as students express their own ideas and listen to the ideas of others, they will be able to apply, analyze, and synthesize information in order to successfully complete the goals of the activity. Activity 3 allows students to evaluate and reflect on their learning; this goes beyond mere discussion, as students will be able to critically think about and articulate what they learned. The curriculum promotes shared leadership, which will motivate students to find creative solutions to the problems presented and identified in the curriculum. Lastly, the curriculum is hands-on in nature, which will help students connect ideas and motivate them to succeed in cooperative learning groups.

Multiple SOLs can be addressed with the curriculum. Reviewers were not asked to evaluate the curriculum for proper use of the 30 identified SOLs because it was initially outside the scope of this project. However, it would beneficial for the SOLs to be evaluated in future studies to determine if they are properly used.

Recommendations

A limitation of the study is that only four professionals evaluated the curriculum. Although efforts were made to include other teachers and administrators in the evaluation process, it was not feasible due to conflicting schedules and time constraints. It is recommended that additional teachers and administrators be given the opportunity to review and evaluate the

effectiveness of the curriculum. It is also recommended that future reviewers be given the opportunity to evaluate the curriculum for proper use of SOLs.

Creating a pilot program with James Madison University's Science on a Sphere in order to allow educators to create problem-solving learning opportunities, which will help students understand how to work in collaborative, cooperative groups while solving science-related problems, is of utmost importance for the success of this project. Due to the hands-on, collaborative nature of the curriculum, students will have many opportunities to actively participate in their learning, question and challenge each other, share and discuss their ideas, develop leadership skills, and internalize their learning. There are, however, ways to improve the curriculum. To this end, recommendations are as follows:

Recommendation One: Use this program to help other teachers incorporate more hands-on, cooperative learning in their classrooms by offering professional development training opportunities.

Recommendation Two: Train and facilitate high school students to create activities for upper elementary students (4th and 5th grades); doing so will provide an excellent opportunity for students to incorporate what they have learned while mentoring younger students and laying the foundation for STEM curriculum.

Recommendation Three: A comprehensive professional development seminar/workshop to train teachers how to use the SOS. Additionally, a video tutorial to train teachers how to use the SOS should be developed for those who are unable to make the training or need additional support after the training.

Recommendation Four: Incorporate more background information and resources for teachers who may not have expertise in climate change or human health.

Recommendation Five: Provide examples of students' exemplary, good, fair, and poor deliverables that teachers can use for grading illustrations in a teacher's manual.

Recommendation Six: Provide updated curriculum to include these recommendations to those who originally evaluated it for the purposes of this project to determine if the curriculum has improved.

References

Avolio, B. J., Walumbwa, F. O, and Weber, T. J. (2009). Leadership: Current theories, research, and future directions. *Annual Review of Psychology, 60*(1), 421–49. doi: 10.1146/annurev.psych.60.110707.163621

Basista, B. and Mathews, S. (2002). Integrated science and mathematics professional development programs. *School Science and Mathematics, 102*(7), 359-370.

Bass, K. M., Yumol, D., and Hazer, J. (2011). The effect of RAFT hands-on activities on student learning, engagement, and 21st century skills. *RAFT Student Impact Study.* Retrieved from http://www.raft.net/public/pdfs/Rockman-RAFT-Report.pdf

Blosser, P. E. (1993). Using cooperative learning in science education. *The Science Outlook*. Retrieved from http://ezproxy.lib.vt.edu:8080/login?url=http://search.proquest.com/docview/62859878?accountid=14826

Bredderman, T. (1983). Effects of activity-based elementary science on student outcomes: A qualitative analysis. *Review of Educational Research, 53*(4), 499-518.

Canter, A. (2004). A problem-solving model for improving student achievement. In *Principal Leadership Magazine, 5*(4). Retrieved from www.nasponline.org/resources/principals/naasp_probsolve.aspx

Carnegie Mellon University. (n.d.). *Teaching excellence and educational innovation.* Retrieved from http://www.cmu.edu/teaching/designteach/teach/rubrics.html

Concordia University. (2014). *Journal of news and resources for educators.* Retrieved from http://education.cu-portland.edu/blog/classroom-resources/which-is-best-teacher-centered-or-student-centered-education/

Dixon, F. A., Prater, K. A., Vine, H. M., Wark, M. J., Williams, T., and Hanchon, T. S. (2004). Teaching to their thinking: A strategy to meet the critical-thinking needs of gifted students. *Journal for the Education of the Gifted, 28*(4), 56-76.

Dotson, J. M. (2001). Cooperative learning structures can increase student achievement. *Kagan Online Magazine, Winter*. Retrieved from http://www.kaganonline.com/free_articles/research_and_rationale/increase_achievement.php

Ejiwale, J. A. (2012). Facilitating teaching and learning across STEM fields. *Journal of STEM Education: Innovations & Research, 13*(3), 87-94.

Gonzalez, H. B. and Kuenzi, J. J. (2012, August 1). *Science, technology, engineering, and mathematics (STEM) education: A primer.* Retrieved from http://fas.org/sgp/crs/misc/R42642.pdf

Haury, D. L. and Rillero, P. (1994). Perspectives on hands-on science teaching. *Pathways to School Improvement.* Retrieved from http://www.ncrel.org/sdrs/areas/issues/content/cntareas/science/eric/eric-toc.htm

James Madison University. (2012, October 15). *JMU*. Retrieved November 12, 2013, from https://www.jmu.edu/stewardship/soshome.shtml

Johnson, R. T. and Johnson, D. W. (1994). An overview of cooperative learning. Retrieved from http://teachers.henrico.k12.va.us/staffdev/mcdonald_j/downloads/21st/comm/BenefitsOfCL/OverviewOfCoopLrng_Benefits.html

Kirton, M. J. (2003). *Adaption-innovation: in the context of diversity and change*. London: Routledge.

Lohman, M. C. (2002). Cultivating problem-solving skills through problem-based approaches to professional development. *Human Resources Development Quarterly, 13*(3), 243-261.

Lord, M. (2009). Hands and minds. *ASEE Prism 18*(7), 34-37.

Magnesio, S. and Davis, B. H. (2010). A novice teacher fosters social competence with cooperative learning. *Childhood Education,* 86(4), 216-221. doi:10.1080/00094056.2010.10523152

Murrells, D. (2013). Hands-on = brains on. *Journal of the Association of Mathematics, 235*, 40-43.

National Association for Gifted Children. (n.d.). *What is giftedness?* Retrieved from http://www.nagc.org/index.aspx?id=574

National Math and Science Initiative. (n.d.). *The STEM crisis.* Retrieved from http://nms.org/Education/TheSTEMCrisis.aspx

National Science Board. (2004). Science and Technology: Public Attitudes and Understanding. In *Science and engineering indicators* (Chapter 7). Retrieved from http://www.nsf.gov/statistics/seind04/pdf/c07.pdf

National Science Foundation. (n.d.). *Specialized STEM secondary schools.* Retrieved from http://successfulstemeducation.org/resources/specialized-stem-secondary-schools

NOAA SOS. (n.d.). *Home*. Retrieved November 30, 2013, from http://sos.noaa.gov/What_is_SOS/index.html

Northouse, P. G. (2013). *Leadership: Theory and practice* (6th ed.). Thousand Oaks, CA: Sage Publications.

Pearce, C. L., Manz, C. C., and Sims, H. P. (2009). Where do we go from here? Is shared leadership the key to team success? *Organizational Dynamics, 38*(3), 234-238. doi: 10.1016/j.orgdyn.2009.04.008

Ruiz-Gallardo, J. R., Lopez-Cirugeda, I., and Moreno-Rubio, C. (2012). Influence of cooperative learning on students' self-perception on leadership skills: A case study in science education. *Higher Education Studies 2*(4), 40-48. doi:10.5539/hes.v2n4p40

Shaughnessy, M. F., Seevers, R. (Interviewers), and Elder, L. (Interviewee). (n.d.). *An interview with Linda Elder about critical thinking and gifted education* [Interview Transcript]. Retrieved from http://www.criticalthinking.org/pages/an-interview-with-Linda-Elder-about-critical-thinking-and-gifted-education/476

Skinner, E. A. and Belmont, M. J. (1993). Motivation in the classroom: Reciprocal effects of teacher behavior and student engagement across the school year. *Journal of Educational Psychology, 85*(4), 571-581.

Slavin, R. E. (1991). Synthesis of research on cooperative learning. *Educational Leadership, 48*(5), 71-82.

Smith, K. A., Sheppard, S. D., Johnson, D. W., and Johnson, R. T. (2005). Pedagogies of engagement: Classroom-based practices. *Journal of Engineering Education, 94*(1), 87-101.

Stears, M. and Gopal, N. (2010). Exploring alternative assessment strategies in science classrooms. *South African Journal of Education, 30*(4), 591-604.

Stoner, S. C. and Fincham, J. E. (2012). Faculty role in classroom engagement and attendance. *American Journal of Pharmaceutical Education, 75*(5), Article 5.

Swanbrow, D. (2011). *U.S. public's knowledge of science still has a long way to go.* Retrieved from http://phys.org/news/2011-02-knowledge-science.html

Townsend, J. C. (2012, December 14). *Education for problem-solving, not factories*. Retrieved from http://www.forbes.com/sites/ashoka/2012/12/14/educate-for-problem-solving-not-factories/

U. S. Department of Education. (n.d.). *Science, technology, engineering and math: Education for global leadership.* Retrieved from http://www.ed.gov/stem

Walker, T. (2013). *Survey: U.S. students better at science today than public realizes.* Retrieved from http://neatoday.org/2013/06/03/survey-u-s-students-better-at-science-than-public-realizes/

Weisberg, R. S. and Reeves, L. M. (2013). *Cognition: From memory to creativity.* Hoboken, NJ: John Wiley & Sons, Inc.

Appendix A

CLIMATE CHANGE & HUMAN HEALTH CURRICULUM
- Developed for use on the Science on a Sphere -

The lesson plans that are a part of this curriculum were developed for gifted high school students in 11th/12th grade. This curriculum is designed to assist teachers in guiding the learning process in students as they learn about climate change. The curriculum was designed with the assumption that those who will mostly use them are Environmental Science and Natural Resources teachers; as such, every concept is not provided in extreme detail because these teachers already have the expertise and knowledge about those topics. As with lessons that are not prepared by the teacher who uses them, these plans serve only as guides. Teachers must adapt, supplement, and alter the suggestions according to their expertise and to the needs, interests, and expected outcomes of the students in their classroom. Only in this way will the instruction given meet students' needs as well as the needs of the school and community.

CLIMATE CHANGE AND HUMAN HEALTH

Virginia SOLs

Life Science
LS.1, LS.11

Earth Science
ES.1, ES.2, ES.10, ES.11

Biology
BIO.8

Chemistry
CH.1

World Geography
WG.2, WG.12

Computers/ Technology
C/T 9-12.1, C/T 9-12.2, C/T 9-12.3, C/T 9-12.9, C/T 9-12.12, C/T 9-12.14, C/T 9-12.15, C/T 9-12.16

English:
9.1, 9.2, 9.8, 10.1, 10.5, 10.8, 11.1, 11.2, 11.8, 12.1, 12.5, 12.8

Summary

Climate change is an important topic that affects all systems on Earth. The purpose of this curriculum is to teach students important aspects of natural resources and[1] human health as they relate to climate change.

Objectives

After the outlined activities, students will be able to:

1. Define climate change.
2. Describe Maslow's hierarchy of needs and how these needs are impacted by climate change.
3. Describe how climate change is predicted to affect humans in terms of natural resources.
4. Describe how climate change is predicted to affect humans in terms of health.

Materials

Science on a Sphere ® - optional
Computer
Projector
Flip chart paper and markers - optional
Handouts

Pretest

The pretest is designed to evaluate students' knowledge of climate change; as such, students should do this prior to any of the activities outlined. The results can be used to determine how much time is needed to devote to the introductory activity. The questions listed below could be disseminated various ways, including a slide on the screen/wall, a handout, or a Google form. It is recommended to allow students no more than 8 minutes to complete the pretest.

1. Define climate change.
2. Describe Maslow's hierarchy of needs.
3. How is climate change predicted to affect humans in terms of natural resources?
4. How is climate change predicted to affect humans in terms of health?

[1] From this point forward, any these changes that were made post panel evaluation are shown in green.

Pretest Answers:

1. "Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns, among others, that occur over several decades or longer." (Source: http://www.epa.gov/climatechange/glossary.html#C)
2. Maslow developed a pyramid to explain and illustrate human needs. At the bottom of the pyramid are the most basic human needs: air, food, water, shelter, warmth, and sleep. As people are able to fulfill these needs they can then move to the next layer of the pyramid. This pattern continues until people reach what Maslow called "self-actualization." (Source: http://www.simplypsychology.org/maslow.html)
3. Climate change is predicted to impact our water resources, energy supply, transportation, agriculture, and ecosystems. (Source: http://www.nrdc.org/globalwarming/climatebasics.asp)
4. Climate change is predicted to impact human health in the following ways: significant increases in the risk of illness and death related to extreme heat and heat (e.g., heat stroke), some diseases transmitted by food, water, and insects are likely to increase, and certain groups, including children, the elderly, and the poor, are most vulnerable to a range of climate-related health effects (e.g., asthma and upper respiratory illnesses). (Source: http://www.nrdc.org/globalwarming/climatebasics.asp)

Posttest

The posttest is designed to document students' knowledge of climate change; as such, students should answer the same questions after completing all activities outlined in the same amount of time given for the pretest. As an additional posttest question, you may also ask students to write a brief response (approximately 100-200 words in length) to this prompt: "Describe how your knowledge of climate change has changed since taking the pretest." This will allow them to tell you what they learned in their own words.

Activity 1: Climate Change and Health, an Introduction to Science on a Sphere

Notes
The Science on a Sphere (SOS) is an innovative type of technology that many have never experienced before. If the teacher has never used the SOS before, it is advisable that he or she take time prior to teaching this lesson to become familiarized with its features. Accessing http://sos.noaa.gov will give teachers the opportunity to become more familiar with its features. The teacher should make plans to travel with their students to a nearby SOS. As a modification, if it is not feasible to travel to a nearby SOS, it is possible to use this introductory activity using a computer, projector, and screen; datasets may be accessed by going to http://sos.noaa.gov/Datasets/index.html.
This lesson plan is organized in the following way: "Dataset Title" signifies which dataset to select on the SOS; "Script" signifies a sample of what the teacher can say, and "Special Notes" serve as reminders to the teacher to make the lesson as effective as possible.

Time to complete
1 hour (estimated)
Student interaction and discussion is important for this activity as it will increase understanding of the relationship between human health and climate change. As such, the time listed is an estimate.

Dataset Title	Script	Special Notes
Blue Marble, 23° tilt	Science on a Sphere is a great way to view the world. Using complex data from NOAA (the National Oceanic and Atmospheric Administration), we are given the opportunity to visualize how Earth changes over time.	It is a good idea to have this image on the Sphere as students enter the room.
	This first image is called Blue Marble; it was created by images collected from satellites orbiting Earth. This is a very good representation of what Earth looks like to an astronaut on a space shuttle.	Direct students' attention to the Sphere.
	Today, you will have a chance to explore the relationship between climate change and human health. According to the World Health Organization, human health is and will continue to be affected by climate change.	
	QUESTION: How would you define climate change? How can climate change negatively impact us?	Give students time to answer.
	Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, or wind patterns,	Source: http://www.epa.gov/climatechange/glossary.html#C

	among others, that occur over several decades or longer. Climate change will ultimately impact such things as clean air to breathe, safe water to drink, enough food to eat, and reliable shelter. QUESTION: What do people need to survive? What do people need to be happy? Abraham Maslow (1908-1970) was an American Psychologist who developed a pyramid to explain and illustrate human needs. This is called Maslow's hierarchy of needs. At the bottom of the pyramid are the most basic human needs: air, food, water, shelter, warmth, and sleep. As people are able to fulfill these needs they can then move to the next layer of the pyramid. This pattern continues until people reach what Maslow called "self-actualization."	 Give students time to answer. Overlay Maslow's Hierarchy PIP (Picture in Picture). Point to each level with the arrow annotate feature as you discuss the hierarchy.
Earth with Vegetation	First, before we start investigating health, it is important to explore the relationship between humans and the environment. QUESTION: How does the environment impact humans? What patterns do you notice? Look at the vastness of the Sahara desert, the dark green of the Amazon rainforest, and the tundra of the arctic and Greenland. These environments are very different and each one will have some kind of impact on the people who live there. QUESTIONS: How have humans impacted the environment? Do you believe this has been done on a small scale or a large scale? Are these impacts positive or negative? Let's investigate human impacts further. First, we'll use the *country names with population* overlay. The larger the font of the country name, the larger its population is. QUESTION: Which countries are the most populated? As you can see, India, China, United States, and Indonesia (among many others) are quite populated. When a lot of people live in the same geographic region, they are going to impact their environment with buildings and structures, emissions from vehicles, garbage, human waste, and other similar issues. Human health can be traced geographically. We'll now	Transition to the Earth with Vegetation dataset. Give students time to answer. Direct students' attention to the Sphere. Give students time to answer. Overlay *Country Names with Population* from the overlay menu. Give students time to answer.

	explore how humans impact the environment and in turn how the environment impacts humans and our health.	
Global Average Temperature Anomaly 2012	One major factor of the climate change and health connection is rising global temperatures. This dataset shows the monthly averages as well as the overall average global temperatures in 2012. Let's practice using the Sphere to gather data. Pair up with another student and: 1) Select a country (no repeats) 2) Observe changes over the year 3) Discuss your responses to these questions with the rest of the class: What color is the majority of the selected country and what does it mean? QUESTION: Overall, would you say that the world is warmer or cooler than it has been in the past? Why? 2012 was the 10th warmest year on record since 1880. Worldwide temperatures have risen over the past 100 years with a dramatic acceleration since the 1950s. 2005 and 2010 tied for the warmest years on record.	Play the *Global Average Temperature Anomaly 2012* dataset. A temperature anomaly is the difference between the long-term average temperature and the temperature that is actually occurring. A positive anomaly means that the temperature was warmer than normal; a negative anomaly indicates that the temperature was cooler than normal. Source: http://ete.cet.edu/gcc/?/globaltemp_anomalies/#sthash.RP7ko6tu.dpuf This dataset is animated but does not rotate as the previous ones have; you will need to pause and rotate it so students have a chance to observe changes over time. This dataset contains thirteen frames, the average temperature anomaly map for each month, plus the average temperature anomaly map for the entire year. Give students 5 minutes to complete this, and give each group enough time to report their findings. The darker the red, the warmer is has become. Give students time to answer. Source: NOAA
Global Epidemic and Mobility Modeler – H1N1 Scenario	Now, we are going to begin looking at how the spread of disease is changing as a result of climate change. An outbreak of H1N1, or swine flu, began in La Puebla, Mexico, on February 18, 2009. It was quickly determined to be a pandemic, and by the beginning of 2010, approximately 17,000 worldwide died as a result of H1N1.	H1N1 is a flu virus. When it was first detected in 2009, it was called "swine flu" because the virus was similar to those found in pigs. The H1N1 virus is currently a seasonal flu virus found in humans. H1N1 spreads between people in the same way that seasonal flu viruses spread.

	QUESTION: What predictions can you make about what impacted the spread of H1N1? The dataset you are seeing now was a model researchers used to determine how infectious diseases spread. The red lines illustrate airplanes that carry infected individuals into a previously unaffected area. Once those individuals arrived to a new location, the disease spread and the color for the area turned red. Let's watch this again. You can see where H1N1 began in Mexico. As infected people travel around the world, we can see the disease spread. The color bar indicates an infection rate of 0 to 10,000 people. QUESTION: Looking again at November of 2009 when the number of people with H1N1 peaked, what patterns do you see? As you can see, H1N1 is not like most influenzas. Most influenzas peak in January or February, but H1N1 peaked in the fall of 2009.	Give students time to answer. Ultimately, students will be seeking out answers to this question with Activity 2. However, it is important to understand that changing precipitation patterns, increased temperature, and extreme weather events can all help increase the geographic spread, number of people infected, and the speed of transmission. Play the dataset and let students observe the changes. Replay the dataset. Point to the region with the arrow. Give students time to answer. Refer to the note associated with the previous question. Go back to November 2009 to show the peak in both Europe at U.S. at this time.
Global Average Temperature Anomaly 2012	As we finish using the Sphere today, let's look at the Global Average Temperature Anomaly one more time. We are going to look deeper into the transmission of diseases and how humans will be impacted these diseases with climate change. Tomorrow, we will begin a project to investigate this in greater detail. EXIT PASS: (Option 1) Taking turns, each student will discuss 1 important concept they learned without repeating someone else. (Option 2) Ask students to answer this question: How is Maslow's hierarchy of needs impacted by climate change?	Replay this dataset and let it run as you conclude the lesson. An exit pass is a great way for students to share what they learned with the teacher and each other prior to leaving the classroom. For Option 2, students can be paired up and discuss the answer to the question. If flip chart paper and markers are available, each group can take turns writing their ideas down as they share them with the class. If this option is used, it would be beneficial to have the completed list of answers displayed in the classroom during the rest of the activities associated with this curriculum. Invite students to add to the list and modify the list as they learn more about climate change as it pertains to Maslow's hierarchy of needs.

Activity 2: Climate Change and Health Project

Notes
It is important that Activity 1 be completed before starting this activity.
Activity 2 is a collaborative group project. Handouts and grading rubrics are provided for your convenience. This lesson plan is organized in a similar fashion to the first activity: "Script" signifies a sample of what the teacher can say and "Special Notes" serve as reminders to the teacher to make the lesson as effective as possible.

How you structure the cooperative learning groups will be dependent upon the maturity level of your students. The following are guidelines to help get you started; it will be important to modify these guidelines in order to best suit the needs of your students:

1. There will be up to three students per group. Therefore, it would helpful to organize groups so that students can draw on the strengths of others in their group.
2. It will also be important to try and avoid placing students in a group that will distract each other and others in the group.
3. As the teacher, it will be important to lay the groundwork for this kind of learning environment. It is not merely assigning students to group work; they must understand the expectations. Remember, the success of the group rests in the success of the individuals in the group.
4. It may also be beneficial to assign roles and tasks to each student. For example, it would be helpful to have "a lead researcher," "a lead scribe," and "a lead data organizer."

If you have used cooperative learning in your classroom prior to this project, and your students are intellectually mature, it is also acceptable that they be allowed to choose with whom they will work. The expectations and goals remain the same.

Time to complete
4 to 5 classes (estimated)

Student interaction and collaboration is important for this activity. As such, the time is listed above is merely a suggestion; you may find your students need more or less time, depending on how long your classes are and the level of your students.

Script	Special Notes
Yesterday, we used the Sphere to investigate the correlation between human health and climate change. Today, we are going to begin a project that will allow us to look deeper into the transmission of diseases and how humans will be impacted by these diseases with climate change.	
QUESTION: What questions or comments do you have from yesterday?	Give students time to answer.

For this project, you will have the opportunity to work in small groups (up to 3 students per group, please). Your group will choose from a list of diseases (no repeats), and you will be responsible for investigating certain aspects. The handout (attached) highlights the mandatory components your group must investigate; you are welcome to include other components as your group sees fit. You will be given 3-4 days to collaborate with your group on this project to complete the task outlined in the handout. On the 4th or 5th day, each group will be responsible for presenting the pertinent information and Public Service Announcement to the rest of the class. The Sphere will also be available for your presentation.	The handout has a list of 8 diseases; with no more than 3 per group, this would work for a class size of 24. You can modify the list according to your needs. Students can select their groups, or you can select who will comprise each group. Provide the project handout to students. The time frames listed here are estimated.
As a part of this project, each group will be responsible for using the Science on a Sphere to present one aspect of the project.	Not all students may have the ability to complete this part of the project. Likewise, teachers may not feel comfortable leading this part of the project. Therefore, this should not be a mandatory requirement. If this will not be used with your students, the handout and rubric will need to be modified to reflect the change. For information on how to create original content, please review page 25 of the SOS Training Manual.

- Handout -

Climate Change and Human Health Project Description

For this project, you will work in small groups (no more than 3 students per group, please) to investigate various aspects of how a particular disease is correlated with climate change; you will also be responsible for creating a Public Service Announcement to inform others about the disease. Each group will present their findings and PSA to the class.

After you get into groups, each group will be responsible for choosing 1 disease from the list below – no repeats (that's boring)! The master sign-up sheet is under the document camera.

List of Diseases

- Dengue Fever
- Ebola
- Malaria
- Cholera
- Lyme disease
- Rift Valley Fever
- West Nile Encephalitis
- Yellow Fever

Here is what each group will need to investigate:

- How the disease spreads
- What the effects of the disease are (i.e., symptoms in humans)
- How the disease is/can be controlled
- How the disease is/can be treated
- How climate change will change/has changed the disease's worldwide distribution

Your Task:

- Determine a way to present this information to everyone in the class. You may use Power Point, Prezi, or another type of presentation.
- At least 1 aspect must be presented using the Science on a Sphere.
- Create a Public Service Announcement using the following premise:
  - Select an area in the world where an outbreak of the selected disease has not occurred but is more likely to occur due to climate change.
  - Determine the best way(s) to disseminate information to the people in that area about the disease. Examples may include a TV and/or radio commercials, magazine advertisements, social media posts, or even public meetings.
  - Your PSA should focus on 2 scenarios: (1) how the disease can be prevented and (2) what people should do if they think they have contracted the disease
- Each group will be given up to 10 minutes to present ALL of the above information to the class.

Please see the corresponding rubric to determine how you will be graded on this project.

Date Assigned: _____ **Due Date: _____**

- Handout -

Climate Change and Human Health Project Grading Rubric

The project's overall grade will be broken down the following ways:

ORAL PRESENTATION (INCLUDING PRESENTATION'S VISUAL AIDS): 50%

Criteria	*A (excellent)*	*B (above average, good)*	*C (minimal expectations)*	*D or F (below expectations)*
Preparedness	Students are completely prepared and have obviously rehearsed.	Students seem prepared, but they might have needed a few more rehearsals.	Students are somewhat prepared, but it is clear that rehearsals were lacking.	Students do not seem at all prepared to present.
Time-Limit	The group's presentation is 8-10 minutes long.	The group's presentation is 7 minutes long.	The group's presentation is 6 minutes long.	The group's presentation is less than 6 minutes long OR is more than 10 minutes.
Enunciation	Students speak clearly and distinctly all (95-100% of the time.	Students speak clearly and distinctly most of the time (85-94%).	Students speak clearly and distinctly some of the time (75-84%).	Students speak clearly and distinctly less than 75% of the time.
Content	Students show a full understanding of the topic and address all of the requirements.	Students show a good understanding of the topic and address most of the requirements.	Students show a good understanding of parts of the topic and address half of the requirements.	Students do not show a good understanding of the topic and address less than half of the requirements.
Posture and Eye Contact	Students stand up straight, look relaxed, and are confident. They establish eye contact with everyone during the presentation.	Students stand up straight and establish eye contact with everyone during the presentation.	Students sometimes stand up straight and establish eye contact.	Students do not look confident and do not establish eye contact with anyone during the presentation.
Organization	Information is organized in a logical manner.	Information is mostly organized in a logical manner.	Information is somewhat organized in a logical manner.	Information is not organized in a logical manner.
Appearance of Visual Aid(s)	Visual aids have appropriate graphics that are easy to read and understand. There are no misspellings.	Visual aids have appropriate graphics that are easy to read and understand. There are very few misspellings.	Visual aids have inappropriate graphics that are difficult to read and understand. There are some misspellings.	Visual aids have inappropriate graphics that are very difficult to read and understand. There are many mistakes.

USE OF THE SCIENCE ON A SPHERE: 10%

Criteria	*A (excellent)*	*B (above average, good)*	*C (minimal expectations)*	*D or F (below expectations)*
Content	Students select at least 1 aspect of the disease to present on the Sphere, and the graphics that are used are accurate and reliable.	Students select at least 1 aspect of the disease to present on the Sphere, and the graphics that are used are mostly accurate and reliable.	Students select at least 1 aspect of the disease to present on the Sphere, but the graphics that are used are inaccurate and unreliable.	Students do not select at least 1 aspect of the disease to present on the Sphere.
Appearance of Graphics	Graphics are appropriate and easy to understand.	Most graphics are appropriate, but 1 or 2 may be hard to understand.	Some of the graphics are appropriate, but more than 2 are hard to understand.	Few, if any, of the graphics are appropriate, and most of them are hard to understand.

PUBLIC SERVICE ANNOUNCEMENT(S): 30%

Criteria	*A (excellent)*	*B (above average, good)*	*C (minimal expectations)*	*D or F (below expectations)*
Research/Statistical Data	Students include 4 or more high-quality examples or pieces of data to support their campaign.	Students include at least 3 high-quality examples or pieces of data to support their campaign.	Students include at least 2 high-quality examples or pieces of data to support their campaign.	Students include at fewer than 2 high-quality examples or pieces of data to support their campaign.
Campaign/Product	Students create an original, accurate, and interesting PSA that adequately addresses the issue.	Students create an accurate PSA that adequately addresses the issue.	Students create an accurate PSA but do not adequately address the issue.	The PSA is not accurate and therefore does not address the issue.
Sources, Quality	Students include 4 or more highly-reliable sources.	Students include 2-3 highly-reliable sources.	Students include 2-3 sources, but they are not all reliable.	Students include fewer than 2 sources, or all of the sources that are included are not reliable.
Effectiveness	The PSA, as presented, is highly effective and realistic.	The PSA, as presented, is mostly effective and realistic.	The PSA, as presented, is somewhat effective but not very realistic.	The PSA, as presented, is not effective nor realistic.

PEER EVALUATIONS: 10%

Upon completion of the project, each students will be given a Peer Evaluation Form (see the example below). Each student should complete this form for each team member. The actual feedback form will be confidential; only an average of the evaluations will be provided to each team member. For each question, provide a rating based on this scale: 0 = no participation, 1 = poor participation, 2 = below average to average participation, 3 = excellent participation, 4 = above and beyond. After each question, you will be asked to provide rationale for the rating you provided. (Note: This will be done via a Google form.)

Enter the name of the team member you are evaluating. _____

1. Participation and communication during team meetings

Was prepared for team meetings; read appropriate materials/resources and understood how to incorporate subject matter in the final project; attended and was on time for team meetings; articulated ideas effectively when speaking or writing; listened to others; encouraged others to talk; was persuasive when appropriate.

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4

What is the rationale for the rating you selected?

2. Contributions to team project

Ideas were incorporated into the final project; submitted assigned tasks on time and without errors.

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4

What is the rationale for the rating you selected?

3. Team Player

Knew when to be a leader and when to be a follower; kept an open mind; compromised when appropriate; handled criticism well; respected others.

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4

What is the rationale for the rating you selected?

4. Helped team excel

Expressed great interest in team success by evaluating ideas and suggestions; initiated problem solving; influenced and encouraged others to set high standards; didn't accept just any idea but looked for the best ideas; stayed motivated from beginning to end of the project.

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4

What is the rationale for the rating you selected?

Your name (for recording purposes only): _____

Activity 3: Climate Change and Human Health Reflection

Notes
Activity 3 is an individual assignment that is designed to allow students to reflect on the information learned. Because this is an individual reflection, this could be assigned for homework, which would not require any additional class time. However, it may be beneficial to allow students to reflect on what they have learned with their peers. Therefore, prior to assigning this activity, it is suggested that the teacher spend 10 to 20 minutes of class following Activity 2 to debrief, answer questions, and give students the opportunity to discuss what was learned. This lesson plan is organized in a similar fashion to the previous activity: "Script" signifies a sample of what the teacher can say and "Special Notes" serve as reminders to the teacher to make the lesson as effective as possible.

Time to complete
20 minutes of class discussion (estimated) plus at least 1 week (outside of class)

Script	Special Notes
As we wrap up the unit on Climate Change and Human Disease, you will be given the opportunity to reflect on what has been learned. QUESTION: What is the most striking thing you have learned about climate change and human disease? How has this changed how you look at climate change? As you reflect, tie in your observations with Maslow's hierarchy of needs.	Give students time to answer. 20 minutes (estimated) would be an appropriate amount of time to spend on this class discussion.
As a way to personally reflect on what you have learned, each of you will select one of the diseases presented; you are not permitted to select the disease your group researched. Next, find a recent article (5 years old or less, if possible) pertaining to that disease. Your article can be a news report or research paper; it needs to be from a reputable source. Create an original post on the classroom blog following this format: What? So what? Now what? You will be given a week outside of class to complete this assignment.	Provide the following handout for students so they understand the expectations of the assignment. The handout describes what their post should entail as well as how it will be graded. If students do not have access to the internet at home, it is appropriate to give them some time in class to find a suitable article and to allow them to post their blog post. If you do not have a classroom blog, this reflection can be done in the students' journals or other acceptable way.
(After the posts have been made) Lastly, you will now be given the posttest to show what you have learned about climate change and human health.	Give students the same amount of time as you did for the pretest. Please see posttest notes.

- Handout -

Climate Change and Human Health Blog Assignment and Rubric

This assignment is to be completed individually. As a way to personally reflect on what has been learned, each of you will select one of the diseases presented; you are not permitted to select the disease your group researched. Next, find a recent article (5 years old or less, if possible) pertaining to that disease. The article you select can be a news report or research paper; it needs to be from a reputable source. Provide a hyperlink to the article and create an original post on the classroom blog.

List of Diseases

- Dengue Fever
- Ebola
- Malaria
- Cholera
- Lyme disease
- Rift Valley Fever
- West Nile Encephalitis
- Yellow Fever

Your blog entry must follow a "What?", "So what?", "Now what?" format. Please use hyperlinks, photos, videos, and other graphics for added depth to your post.

Your blog entry will be scored on completeness and demonstration of critical thinking. The scoring rubric used for evaluating it is as follows:

Criteria	*Maximum Points Possible*
What? Discussion (Introduction)	4
So what? Discussion (Interpretation/Importance)	4
Now what? Discussion (Plan)	4
Connection to concepts	4
Overall impression (including writing quality)	4
Total for each entry	*20*

Date Assigned: _____ **Due Date: _____**