

Sustainability Education in Primary and Secondary Schools:

Great Needs and Possible Solutions

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Abstract

Sustainability is a topic that will be exceptionally important to subsequent generations of students, as they tackle the issues of climate change, environmental degradation, and more. Thus, sustainability education should be a vital part of formal education systems worldwide. While there are currently a few successful sustainability educational programs around the world, they are by no means widespread. Programs in the United States are particularly sparse. A research study of my local area showed that primary and secondary students in Knoxville have little to no knowledge of sustainability at all. Thus, there is a great need for sustainability education in the United States. Because sustainability is such an interdisciplinary subject, incorporating it into many different courses may be one of the best options. Thus, I developed four different lesson plans that include both sustainability principles and content standards in meaningful ways. My hope is that these lesson plans prove that sustainability can be incorporated into the classroom without sacrificing the time needed to teach core subjects if teachers are motivated enough to thoughtfully intertwine the two in their lessons.

Introduction

With climate change and other environmental concerns becoming evermore present and cumbersome, there is a necessity for increased education on these issues, especially in the United States. In order for real changes to occur in American society that promote the preservation of the environment and sustainability for future generations, increased education needs to occur at all levels, from preschoolers to adults. Unfortunately, these concepts are not being addressed accurately and appropriately in elementary, middle, or high schools in the United States. Without knowledge of sustainability, it is impossible for students to strive to promote sustainability within their homes and communities. While some may argue that there is not enough time to teach students sustainability at school due to the large amount of material teachers are already required to teach in math, science, social studies, and language arts, I have created sample lesson plans that allow teachers to incorporate the concepts of sustainability into lessons that also cover their required material. Thus, with proper planning and fervent intentions, teachers can begin to inform students about sustainability, which will hopefully inspire them to educate others and actively support sustainability in their homes, communities, and country.

The Need

There is a great need for sustainability education in the world today with the upcoming challenges related to climate change and environmental degradation. Ober & Dipplén (2011) accurately summed up this need: “Time has come to re-assess or revise school curricula or academic curricular in order to ensure that the young generation will be able to cope with future demands of the changes in the 21st century in most aspects of life” (p. 93). While there

are currently some environmental science and ecology classes in primary and secondary education today, few of them actually teach the topics of sustainability in sufficient detail to actually matter in students' lives. "Traditional education appears deficient in its failure to recognize men's relationship to an ecological system of which he is a part, and the need for adjustment of his behavior to rapidly changing conditions" (Bakshi, & Naveh, 1980, p. 43).

Primary and secondary students are the future and will likely bear the brunt of the environmental effects of climate change and environmental degradation. Thus, it is important for us to teach them what practices are harming the environment, advancements in green technologies, and ways that they can positively impact the environment through their own behaviors. In addition, sustainability education promotes the skills that will be necessary for students to embrace and overcome environmental challenges in the future. Flint, McCarter, and Boniwell (2000) accurately summed up this mission:

By providing students with the tools necessary to participate as active members of their communities, having the creative problem-solving skills, social literacy, and commitment to engage in responsible individual and cooperative actions that will lead to ecologically viable, socially just, and economically secure societies for present and future generations...we can instill in them a caring for the environments and citizens...trained to protect and restore their birthright and their legacy (p. 202).

Thus, sustainability education is not only needed to show students how they are connected with the environment and how they can positively impact it, but also to help them develop the skills that will be necessary for them to achieve and maintain sustainability in the future.

Factors for Success

In order for sustainability education to be successful, there are several factors to consider before implementation. The first is that sustainability education is interdisciplinary and does not necessarily fit cohesively into a divided discipline system. Unfortunately, “The divided academic discipline structure in...education creates subject boxes that limit learners’ and educators’ thinking and detach them from the world beyond their disciplines” (Feng, 2012, p. 33). Therefore, sustainability education needs to be implemented through a more interdisciplinary approach. “There is a considerable consensus in the field of sustainability education that systemic thinking offers a ‘holistic approach through recognizing the complex interconnected nature of all aspects of the world around us from an individual to a global level’” (Feng, 2012, p. 36). Not only does an interdisciplinary approach best suit sustainability education, it can have many benefits for students. “Interdisciplinary subject areas such as sustainability education need to be encouraged, so that ‘a learning society’ can emerge in which individually and collectively we can face up to the complex and uncertain challenges that lie ahead with more open, flexible, holistic and creative minds” (Feng, 2012, p. 33). While it is difficult to teach interdisciplinary topics within a discipline-oriented schooling system, it is possible without a complete overhaul of the current system. One way that teachers can support the interdisciplinary nature of sustainability education is to simply incorporate the principles of sustainability into their discipline-specific lesson plans. Sustainability education can easily be incorporated into lessons in economics, history, biology, etc. if teachers take the initiative to include sustainability in their lesson plans. Another way that teachers can support the interdisciplinary nature of sustainability education is to have people who work in different

fields, with the same goal of sustainability, to come and talk to their students. This was shown to be quite successful in an innovative, new sustainability class at a Chinese university, as described by Feng (2012). “In attempting to make the course content interdisciplinary, the Chinese course involved a number of teachers with varied backgrounds including education, geography, chemistry, history, media, economics, administration, engineering and architecture” (Feng, 2012, p. 38).

Additionally, for sustainability education to be effective in primary and secondary schools today, the principles taught need to expand beyond the classroom and the whiteboard. An effective sustainability program not only teaches students the principles of sustainability, but also encourages them through actions. Keqin (2004) provides examples of how this can be done:

In addition to the classroom teaching, the secondary vocational schools should also host various kinds of extracurricular activities, such as classified collection of garbage, recycling of used batteries, noise monitoring, and so on, so as to increase the awareness and ability of the students to be involved in the protection of the environment (p. 38)

One of the main goals of sustainability education is to show students the need for sustainability and then teach them how to act to promote it. Thus, active programs and projects should be incorporated into a sustainability program. This allows students to understand that action is required in order to achieve sustainability and that they will be the ones responsible for it in the future. Thus, a successful program will focus on the interdisciplinary nature of sustainability

education as well as the need for action to ultimately achieve and maintain environmental sustainability.

International Efforts

While countries vary on whether or not they have implemented sustainability education and to what extent, many places internationally have taken large strides toward improving their education systems in this regard. There are some international programs that are worth mentioning because of their high success rates and the possibility for implementing versions of these programs in the U.S. One country that has taken some drastic steps towards promoting sustainability as a whole, as well as in the classroom, is Germany. Kärchner-Ober and Dippel (2011) even stated that “Germany serves as a model in the field of education and technology (p. 93). With Germany’s movement of *Energiewende* (Morris & Pehnt, 2012), or “energy transition,” and history of environmental concern, it is no surprise that it is one of the leaders in the movement towards incorporating sustainability into the formal education system. They have included environmental and sustainability principles into student education from Pre-Kindergarten through secondary school and beyond (Morris & Pehnt, 2012). In addition, they have promoted the interdisciplinary nature of sustainability education by incorporating it into many different classes and from varying perspectives, instead of limiting sustainability just to environmental science. Thus, Germany has implemented a sustainability education that contains researched factors for success as well as exposes students to these principles as soon as they begin formal schooling.

Another country that is successful educating people, both children and adults alike, is Vanuata. Schools in this country are using community theater programs to teach principles of

environmental stewardship and sustainability (Tillbury et al, 2002). Students can choose to participate in this program as one of their arts classes and can become even more involved after school if they so wish. The performances put on by these students all have environmental and sustainability themes and serve to teach the performers themselves, as well as their audience of parents, community members, etc. (Tillbury et al, 2002). What makes this program so unique is that it is a non-traditional form of sustainability education that has been as effective, if not more effective, in teaching people about sustainability. This is because the students are able to express themselves through an art form while simultaneously learning. In addition, the community theatre productions have the potential to teach people the concepts of sustainability that might not hear about them anywhere else. Because it involves the entire community, the education is not confined to the classroom or school, but expands to the community, village, region, etc.

In addition, India has begun implementing sustainability education programs in their primary schools. They started as pilot programs, but their success and wide acceptance have led to more widespread implementation (Tillbury et al, 2002). Their program focuses on the belief that an environmental education course for school children should be local-specific, practical and activity-based” (Tillbury et al, 2002, p.67). The course they constructed focuses on the students completing activities and doing projects that promote sustainability, instead of just learning about what they could do to promote it. In addition, the course focuses on the local needs and concerns of the area where the school is located. They believe that “the village is the laboratory for students to learn and experiment” (Tillbury et al, 2002, p. 68). Thus, the students learn about what environmental efforts are most critical to achieve sustainability of

their own people in their own communities as well as how they can change their behavior to promote it. As a result, this program has been quite successful in engaging students as well as teaching them the principles and behaviors that will help them contribute to sustainability now and in the future.

One of the most striking educational efforts related to sustainability has been occurring in Hungary. In the past few years, Hungary has undergone an education overhaul, which includes the incorporation of sustainability into the curriculum (Tillbury et al., 2012). In fact, they have initiated a three-year initiative to increase the presence of environmental education into the curriculum, integrating environmental education into many different disciplines, increase the experience of teachers in teaching environmental education, and to encourage both students and teachers to become more active in protecting the environment (Tillbury et al., 2012). What is striking about this initiative is that it is being implemented on a large scale, not with a few individual schools. In addition, it is a stepping stone to providing more interdisciplinary education in primary and secondary schools. While it is yet to be seen how successful this initiative will be, it is an excellent example of a country that is motivated to create a successful sustainability education program nationwide as quickly as possible.

The United States

While there are quite a few successful international education programs promoting sustainability, the United States seems to be lagging behind in this area. There have been many governmental and non-governmental discussions about the need for increased environmental and sustainability education, but very few ideas and programs have been successfully implemented. Sustainability education is arguably more important in the United States than in

the majority of other countries because of the predominate culture. “U.S. culture, on a whole, can be characterized as a high mass consumption, mass-production culture with excessive spending and high wastage of resources” (McFarlane & Ogazon, 2011, p. 88). The U.S. is in a unique situation because we are funding and supporting large amounts of research on sustainable practices but continuing to live unsustainably at the same time. McFarlane and Ogazon (2011) accurately summed up the U.S. in relation to sustainability and our responsibility in education:

It could be argued that the U.S., more than most countries, is highly engaged in bettering environment practices, researching, discovering, and applying new and cleaner energy sources, and promoting programs and policies related to sustainability as an umbrella concept. While this is true in many ways, it must not be forgotten that people in the U.S. consume far greater resources than most of the world’s nations and produce far more waste including environmental pollutants and mechanical industrial wastes. Thus, the role of the nation should be significantly greater than many of its counterparts in the sustainability movement and promotion of sustainability education as a vitally important matter to the nation’s ongoing progress and future well being (p. 88).

On a nationwide scale, the U.S. is not pursuing sustainability education with the same pace and with the same enthusiasm as other countries. “Currently, however, the advancement of environmental education nationwide is inconsistent, achieving a high profile where the state-or even individual teachers – have made a commitment to it and being practiced at a minimal level or not at all elsewhere” (pg. 16). The majority of successful programs are being

implemented at the state level. One state that is pursuing environmental and sustainability education is Washington. As a part of the Education for Environment and Sustainability effort, environmental education is mandatory for all public schools in the state (“Education for Environment and Sustainability,” 2016). They are taking the interdisciplinary approach as well, including environmental aspects in many different courses. “Instruction about conservation, natural resources, and the environment shall be provided at all grade levels in an interdisciplinary manner through science, the social studies, the humanities, and other appropriate areas” (“Education for Environment and Sustainability,” 2016).

Another successful environmental and sustainability education program in the U.S. is Northampton County, Virginia. The goal of their environmental education program is not only to teach students about protecting the unique environment around them, but also to “involve them in diverse interdisciplinary collaboration, the creative process, advanced technology, cross-cultural communication, economic development, and environment ethics and values” (Flint, McCarter & Boniwell, 2000, p. 193). One of the main projects that is used in this program is for the students to build their own boats; they then use their boats to explore and measure the coastal marine environment around them and compare this data to previous years (Flint, McCarter & Boniwell, 2000). Additionally, the students learn about the historical culture of the region and how their ancestors depended upon the natural environment and how people continue to depend upon it (Flint, McCarter & Boniwell, 2000). The teachers have found that when “this unique environmental/cultural instruction process is superimposed on an interdisciplinary blend of traditional high school teaching... then the student’s learning experiences are put into a context that is much more aligned to their life experiences” Flint,

McCarter & Boniwell, 2000, p. 196). Thus, the students are more engaged in their traditional classes as they are connected to these environmental and life experiences. Thus, this program is successful in teaching students environmental and sustainability topics, while improving their attention in other classes and allowing them to see the connections between the environment and other topics, such as economics, history, and even art.

While there are examples of successful environment and sustainability education programs in the U.S., they are by no means wide spread or nationally recognizable as they could be. Some states are beginning to implement educational programs, but “there is not one state where environmental education or education for sustainability programming has been fully incorporated into formal education institutions” (President’s Council on Sustainable Development, 1996, p. 13). The good news is that we are heading in the right direction, even if it is at a comparatively slow pace. “Sustainability education is gaining popularity in K–12 schools in the United States as a new solution-based educational paradigm among environmental educators” (Warner & Elser, 2015, p. 2). Unfortunately, there are still some challenges that need to be addressed in order for sustainability education to successfully be incorporated into the formal education system. For example, “The ambiguity regarding assessment tools and metrics for sustainability education has led to the application of many different approaches in U.S. K–12 schools, and we know little about the relative success of these different approaches (Warner & Elser, 2015, p. 2). Therefore, the only way that sustainability education will improve and increase in frequency across the U.S. is if people at the national, state, and local levels advocate for it and implement programs and strategies to make it possible.

Local Needs

In order to investigate the knowledge of students in my own area, I conducted a research experiment involving students in Knoxville, Tennessee. I went to several different private schools in the Knoxville area and surveyed 5th, 8th, and 11th-12th grade students. The survey consisted of several questions about the students' knowledge of sustainability and when they may have gained that knowledge. The main questions that were used in analyzing the results of the survey was, "What is sustainability?" in which the students were required to write a definition of sustainability. It was determined that a student had some knowledge of sustainability if he or she mentioned the environment, or steps to protect the environment, in their definition. It was determined that the students did not have any knowledge of sustainability if they wrote "I don't know" or provided a definition that had no environmental component to it. The results showed that few students in Knoxville have any knowledge of sustainability. The majority of the students responded that they did not know what sustainability was and had never learned about it in school. While the number of students who had knowledge of sustainability steadily increased with each grade level surveyed, the increase was minimal at about 8% per school level (Figure 1). Overall, the amount of students with any knowledge of sustainability was staggeringly low across the board. In fact, less than 17% of students surveyed had knowledge of sustainability by their last years of high school (Figure 1). It is clear that, at least in Knoxville, the idea of sustainability is not being taught in most primary and secondary schools, where students can be influenced the most to change their ideas and behaviors in regards to the environment. Thus, I believe that it is important to educate and equip teachers to teach these concepts now in order to promote a sustainable future through educating and inspiring our youth.

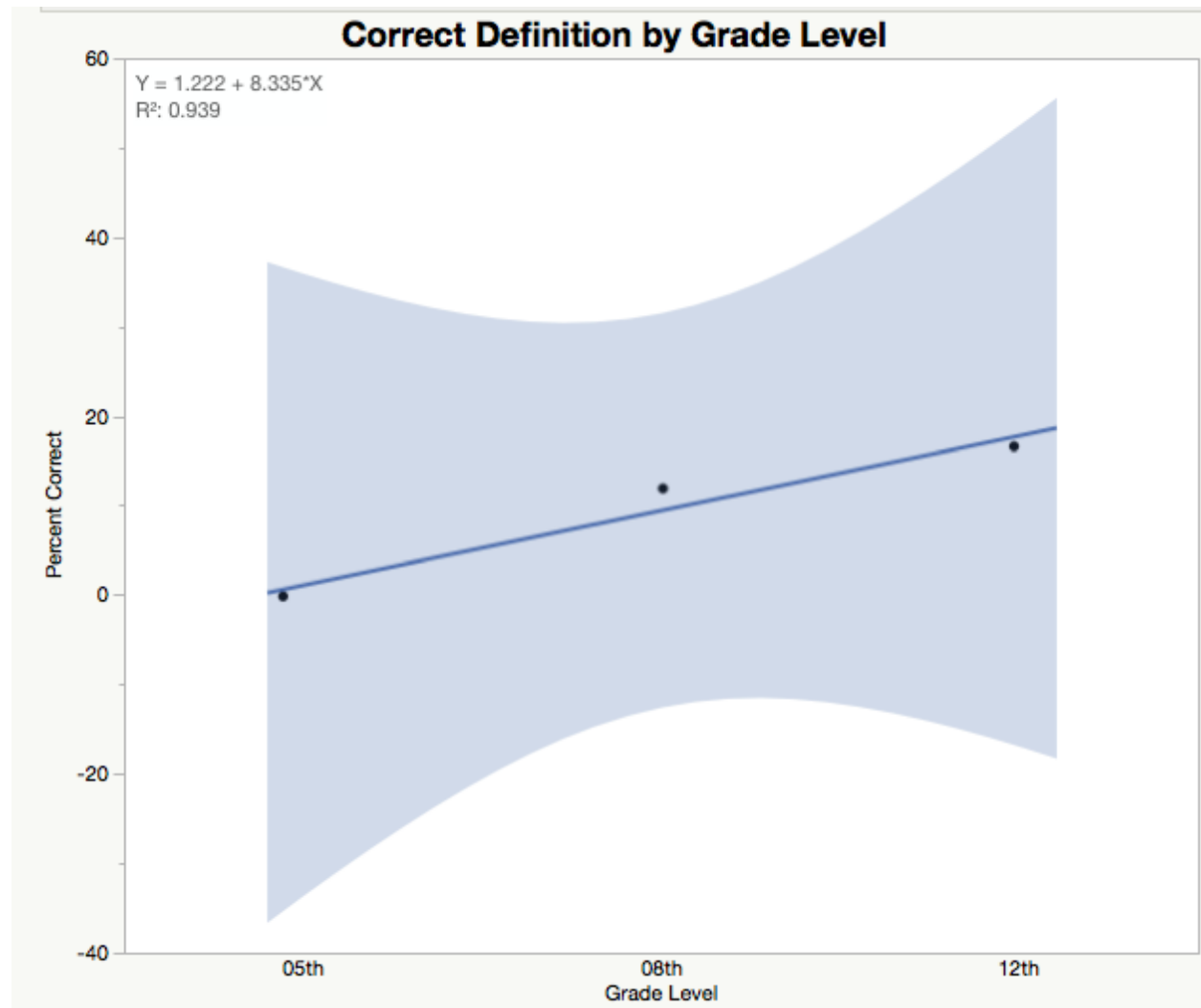


Figure 1. This figure shows the increase in student knowledge of sustainability based on the percentage of students who gave an acceptable definition for sustainability on the survey at each grade level studied.

General Strategies

There are a few different strategies for presenting the topic of sustainability in primary and secondary classrooms that have been suggested by various authors and researchers. One strategy that had been proposed is to include active learning when teaching sustainability.

“Engagement in active learning can promote students’ development of critical thinking skills necessary for addressing issues of sustainability at different spatial scales in varied sociocultural contexts” (Dengler, 2008, p. 482). A specific form of active learning that Dengler (2008) promotes is role playing. This involves having students play different roles in relation to making decisions about sustainability, such as an economist, a business owner, an environmentalist, and a politician. This helps to show students that many factors must be considered when making decisions and entering negotiations about sustainability on a large scale. In addition, “active learning can allow students to experience the complexities of issues of environmental governance in practice as well as the challenges of finding sustainable solutions framed in environmental and social justice” (Dengler, 2008, p. 482).

Another strategy for effectively teaching sustainability is through online project-based learning. Tomkinson and Hutt (2012) describe a program that was implemented at the university level to teach students about sustainability as well as to help them develop critical thinking skills and become immersed in the processes necessary in order for sustainability to be achieved in the future. For this specific project, the students were engaged in a computer simulation of a developing town. They had the original, traditional plans for building the city to reference and were asked to “analyze possible alternative approaches and propose an environmentally sound and sustainable strategy for the construction of buildings” (Tomkinson & Hutt, 2012, p. 303). The students’ decisions about construction and development were actually carried out through the computer simulation and they were able to see the results of those decisions. After the project was completed, the students had to present their city and share their various decisions and the consequences of those decisions throughout the process.

Not only did this teach students some of the principles of sustainability in relation to city planning and construction, but also the decisions people have to make and the options they have to consider when making real-world decisions. Thus, the students learn the complex and interdisciplinary nature of sustainability, providing them with better understanding of sustainability itself.

An additional strategy suggested for teaching sustainability is to simply have class outdoors (Zibell, 2013). One of the simplest ways to show the students the need for sustainability is to let them see the beauty of nature around them and all of the ecosystem services the environment provides, followed by a presentation on how humans are currently destroying these natural resources. One way to expand upon this basic idea of having class outdoors is to create a learning garden. "Filled with blossoming flower and shrubs, ripening plants, and decomposing compost heaps, gardens located on school grounds provide immediate and consistent exposure to natural systems" (Williams & Brown, 2012, p. 12). Oftentimes students, especially in urban areas, are disconnected from nature due to a lack of exposure on a daily basis. Thus, the hope is that learning gardens will help students connect with nature, which, in turn, will inspire them to protect it in the future through efforts of sustainability. Learning gardens can even be incorporated into urban classrooms through rooftop gardens or small gardens inside the classroom itself. Additionally, the incorporation of rain gardens can give students hands-on experience with some of the techniques associated with sustainable living. "In rain gardens and native gardens, students learn other sustainable practices such as rainwater harvesting, landscaping with native plants, and incorporating wildlife into gardens (Williams & Brown, 2012, p. 30). Thus, learning gardens benefit students in

multiple ways, by teaching them the importance of natural systems and sustainability as well as giving them the experience of working with and caring for nature itself.

Integrative Lesson Plans

Because sustainability is such an interdisciplinary topic, I approached creating sample lesson plans including sustainability in the same manner. Thus, I created four different lesson plans for the major content areas in primary and secondary schools: science, math, language arts, and social studies. While these lesson plans are intended to be used in high school classrooms, they can easily be manipulated and adjusted to fit the needs and abilities of middle school and elementary school students in all four content areas. Because I did my research on student knowledge in Knoxville, Tennessee, the content standards included in the lesson plans are those provided by the state of Tennessee on their website (Tennessee Department of Education, n.d.). However, I believe that the major concepts addressed within each lesson are some that are common amongst most educational programs in the United States. Thus, these lesson plans can be adjusted to fit the content standards and grade-level expectation of students anywhere in the U.S.

Because many of the concepts related to sustainability are directly related to science, creating a science lesson plan was the simplest and most straight-forward task. However, I did not want to create a lesson plan for the classes that usually include many of the topics related to sustainability anyway, including earth science and ecology. I chose to write a lesson plan for a biology classroom because climate change and other environmental concerns can have major changes on Earth's biology in the future, highlighting the need for sustainability. Climate change could prove to be a major influence on how species behave, migrate, and even survive in the

future, yet it is rarely discussed in biology classrooms today. Thus, I attempted to create a sample lesson plan that would address the biological concept of interdependence because not only are species often interdependent with each other, but also to their environment. Thus, major changes to the environment, such as climate change, pollution, and toxic waste, will likely impact Earth's biology in a negative way. As a result, I think it is important to explain this connection to students as well as to introduce the topic of sustainability to show students that there are ways that humans can help prevent these negative effects from occurring.

For the beginning of the lesson, I chose to have the teacher review the students' knowledge of ecosystems and ecosystem services to ensure that they are ready to be introduced to the new concepts as well as to provide connections between the material presented in this lesson with that of previous lessons. This provides students with more clarity about the importance of topics as well as encourages them to comprehend the "big ideas" of the course (Bain, 2008). Subsequently, the teacher would introduce the topic of climate change by initiating a discussion on what the students have heard about climate change in the recent past and providing an opportunity for students to make predictions about how climate change could affect Earth's biology. I then chose to include a video that overviews some of the major effects of climate change that are already being observed to provide perspective and motivation for the main component of the lesson. For the main instructional strategy in this lesson, I chose a collaborative learning, inquiry-based activity. This is because collaborative learning promotes student understanding, improved communication skills, and increased probable solving abilities (Bruffee, 1999). In addition, inquiry-based tasks are important in teaching science because inquiry and research are critical in the practice of science itself

(Rutherford, 1964). In the collaborative learning exercise, the students would research a specific effect of climate change and present their findings to the class. Some of the topics the students would research include ecosystem effects, case studies, and remediation strategies (Appendix A). The students will also have the ability to present their findings in any way they choose, following the model of multiple means of expression (CAST, 2011). This allows the students to harness their creativity and improve their communication and presentation skills, while still demonstrating their learning to the teacher. After the students present their findings, the teacher will explain how these effects on Earth's biology can also negatively impact humans. I included this section in the lesson plan because students are more likely to remember information and stay engaged throughout the lesson if it is relevant to their lives (Kember, Ho, & Hong, 2008). The lesson will conclude with a formative assessment of the student's knowledge in the form of an exit ticket. This exit ticket will require students to describe how climate change might affect them personally, make predictions about the effects of climate change, and identify the effects of climate change (Appendix A). The results of this formative assessment will allow the teacher to gauge whether the students have met the goals of the lesson and are ready to expand upon this knowledge in future lessons. The intended result of this lesson is that the students will be able to predict and describe several effects climate change will have on ecosystems (Appendix A). In addition, my hope is that this lesson will give students some exposure to the consequences of climate change and the idea of reducing and preventing them through efforts of sustainability.

Putting mathematics topics into a real-world perspective is usually helpful for students, so a lesson that includes both mathematical concepts and the idea of sustainability would be a

win-win situation. Students can simultaneously realize that seemingly abstract mathematical ideas and processes are actually utilized in the real world and that environmental concerns can be researched and addressed using math. For the beginning of this lesson plan, I chose to have the teacher review the students' knowledge on linear equations to ensure that they have the background knowledge to be able to use linear equations to make predictions using data (Appendix B). The lesson would continue with a video about polar sea ice melting in case the students are not aware of the problem and to provide a broader context to the work they will be doing throughout the lesson (Appendix B). This lesson plan also includes a collaborative learning activity to improve student understanding of the concepts as well as their communication skills (Bruffee, 1999). For this activity, the students will complete a worksheet that requires them to use linear equations to model data of arctic sea ice extent to make generalizations and predictions about the problem of sea ice melting (Appendix B). In addition, the students will research current ice sheet data to compare this data with their predictions generated in the Arctic sea ice worksheet (Appendix B). Finally, the students will create their own real-world problem that could be addressed using linear modeling to discuss with the class (Appendix B). Each student will be responsible for one specific aspect of the overall group project to ensure that all students are engaged and accountable for their own learning and effort (Slavin, 1991). To conclude this activity, the students will compile all of this information and present it to the class in the medium of their choosing (Appendix B). After all of the student groups have presented their processes and findings, each student will be given an exit ticket to complete that requires them to describe how linear equations can be used to solve real-world problems as well as to use a data table to find the line of best fit and make predictions for the

future (Appendix B). The exit ticket will gauge whether students have met the goals of the lesson and will be ready to complete similar tasks using more complex functions, like exponential and quadratic functions, in subsequent lessons. The overall goal of this lesson is for students to be able to generate a linear equation that best represents data as well as to use this equation to make predictions about future data, while simultaneously becoming aware of the problem of global warming and the need for sustainability (Appendix B).

In regards to language arts, I wanted to create a lesson plan that encourages students to develop stronger critical thinking and reading skills, while simultaneously learning about the concepts of sustainability. In order to accomplish this, the lesson mainly consists of a jigsaw reading activity that introduces the topic of renewable energy sources. I selected this instructional strategy because jigsaw reading has been shown to improve students' comprehension of texts as well as to improve their "self-esteem, group relationships, attitudes toward school, and acceptance of and ability to work with others" (Resor, 2008). The lesson would begin with a review of what the students know about informational text and informational essays, as this knowledge will be necessary for them to successfully complete the goals of the lesson (Appendix C). The lesson continues with a video that introduces the students to the topic of renewable energy sources and why they are preferred, environmentally speaking, over traditional, fossil fuel sources (Appendix C). This video will hopefully give students some insight to the "big idea" of sustainability through renewable energy that will put their informational texts into perspective. The students will then complete the jigsaw reading task, in which they will read about renewable energy sources and then discuss the information with group members who read the same text. Subsequently, the students will move into a

different group, which contains students who read different texts, and will communicate the knowledge they gained from the text with their peers (Appendix C). There will then be a class discussion, in which the teacher prompts students to share what they learned from their reading and their classmates as well as how it connects to the concepts addressed in the video (Appendix C). The students will then be given the entire article to read and highlight new vocabulary to prepare them for the next activity in the lesson (Appendix C). Finally, the students will be asked to write an informational essay using the knowledge and vocabulary gained from the article, which will be used as a formative assessment to gauge whether the students met the learning targets. The targets for this lesson are that the students will be able to read informational text and communicate their knowledge using academic vocabulary gained from the text (Appendix C). In addition, the goal is for students to become exposed to the ideas of sustainability, including renewable energy.

Connecting sustainability to history was more challenging, but I chose to make this connection through a lesson about population dynamics. One concept that students are supposed to learn in world history in Tennessee is the demographic changes in populations since the 1980 (Appendix D). Thus, I believe this topic can easily be expanded upon to address population pressures on the planet in the future and how people can minimize them through sustainable practices. This lesson begins with a review of the students' knowledge of the time period that will be investigated in this lesson. Then, the teacher will show a video about census data to give students some perspective on how the data used in creating population pyramids and census data table was actually collected (Appendix D). The lesson will then continue with a PowerPoint presentation on the major demographic changes in the population since 1980 using

a variety of different categories within the census data as well as population pyramids (Appendix D). The students will then complete a think-pair-share activity in which they will use population pyramids and census data to describe three major demographic changes that have occurred since 1980 and discuss them with their partner (Appendix D). I chose a think-pair-share activity because it gives students time to process their thinking, put it into words, receive additional support from their partner, and ultimately provide responses with more breadth and depth to the class (Azlina, 2010). Subsequently, the class will have a brief discussion on how population pressures and climate change will affect the planet in the future (Appendix D). Using the prior knowledge and the knowledge gained from the discussion, students will then participate in the “7 billion – Where do you stand” activity. For this activity the class room will be divided into four quadrants, with each quadrant having a sign for what it represents. The four quadrants will be strongly agree, agree, disagree, strongly disagree. The teacher will read several statements that are related to population pressures and sustainability. The students will then physically move to the section of the room that is labeled. After the students have made their decisions, the teacher will ask a few students to defend their position on the issue. Students will be allowed to move to a different quadrant of the room if their classmate persuaded them to change their opinion, but will need to be prepared to explain why he or she moved. This process will continue until every student has defended his or her position on one of the issues (Appendix D). The lesson will conclude with an exit ticket for which the students will be asked to pick one of the issues discussed in class and defend their position on it as well as to answer a few multiple choice questions based on two population pyramids (Appendix D). The exit ticket will be used to gauge whether the students have met the goals of the lesson,

which are for them to be able to describe demographic changes in the world's population over the last forty years. In addition, the goals of the lesson include the students being able to describe the social and environmental impacts of increasing human populations and express their opinions on issues related to population pressures (Appendix D).

Overall, I think that these four lesson plans demonstrate that the topic of sustainability can be incorporated into lessons without sacrificing the required content of the course. They also emphasize the interdisciplinary nature of sustainability and that it can be incorporated into lessons for almost any secondary level course.

Conclusion

To conclude, there is a great need for sustainability in the U.S. and worldwide. From local research, I discovered that students have little to no knowledge of sustainability. Today's youth will be the ones that have to make the decisions about sustainability in order to survive and thrive. Sustainability is an interdisciplinary topic and should be taught with this in mind. Thus, one of the best ways to teach sustainability is by incorporating it into many different primary and secondary level courses. Through integrative and inspirational lesson, I believe that teachers have the power to teach students the principles and skills necessary to preserve the planet for themselves and future generations.

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Appendix A

TEAM Lesson Plan			
Teacher: -----			
Course: Biology I			
Course Unit: Interdependence			
Lesson Title: Global Warming and Earth's Biology			
Learning Goals: What do you want students to be able to <u>know</u> or <u>do</u> as a result of this lesson?			
The students will be able to describe several effects climate change will have on ecosystems.			
STANDARDS: Reference State, Common Core, ACT College Readiness, ORS Standards and/or State CTE Competencies.			
CLE 3210.2.3 Predict how global climate change, human activity, geologic events, and the introduction of non-native species impact an ecosystem			
Review: How will you build on prior knowledge?	Hook: How will you catch the attention of your students and focus their minds on today's learning goals?	Real World Connection: How is this learning goal relevant to students' lives?	Student Reflection: How will you provide for student reflection?
I will begin the lesson by reviewing what students know about ecosystems. The students will then use this information to make predictions on what would happen to an ecosystem if various human impacts occurred.	I will catch the students' attention by showing them a video of the effects that are already occurring due to climate change in order to get them thinking about future effect. This thinking will allow them to accurately describe and predict the effects of climate change on biology.	This lesson is relevant to the students' lives because climate change will have effects on ecosystems, and many of these effects will then be transferred on to people. Thus, climate change has the potential to affect their lives directly in the future.	Students will be asked to reflect on how climate change may affect them directly in the future based on the topics discussed during this lesson.
Assignments require students to: (Check all that apply) What evidence will you collect that students have mastered the learning goals?			
☐ Organize ☐ Interpret ☐ Analyze ☐ Synthesize ☐ Evaluate information	☐ Writing: ☐ Draw Conclusions ☐ Make Generalizations ☐ Produce arguments	Connection to: ☐ prior learning – ecosystems and ecosystem services ☐ life experiences - food security, news stories Other disciplines - Earth science, History, English	
Assessment: How will performance be measured? (Check all that apply)		Measurement Criteria: How will you define mastery?	
☐ Project ☐ Essay ☐ Experiment ☐ Short Answer ☐ Presentation ☐ Multiple Choice ☐ Other _____		Mastery will be defined by the students listing at least one way in which climate change could affect them individually, predicting at least 2 effects of climate change on biology, and completing the multiple choice questions with at least 50% accuracy.	

Activities and Pacing: What strategies, procedures, and transitions will you use?			Materials	How do they align with learning goals and allow for higher order thinking?
How will you begin? I will begin the lesson by reviewing the students' knowledge of ecosystems and ecosystem services. I will then explain that climate change is one of the biggest threats to ecosystems in the future. The class will then have a discussion about what they have heard about climate change in the news, in other classes, etc. Subsequently, I will show the students a video that gives a brief overview of the effects of climate change that have already been observed. (Video: https://www.youtube.com/watch?v=S7jpMG5DS4Q)	Time	Beginning	Computer with internet access	How do you predict climate change to affect biology?
				What evidence is there that climate change is occurring?
	15 min			What effects are climate change having on biology?
				Do you predict these effects to get better or worse over time?
				What have you heard about climate change in the news? Are all of these stories reliable?
<i>Transition?</i> The video explained some of the effects of climate change that are already occurring. Now we are going to research these effects further and make predictions on what the biological outcomes will be in the future.				
The students will be asked to research a specific effect of climate change (ocean acidification, sea level rise, increased temperatures, etc.). They will research the effect on ecosystems, the predicted outcome, a specific case study, and preventative/remediation strategy related to their topic. The students will then present their findings with the class in whatever medium they choose.	Time	Middle	Computers/IPads	What are some of the specific climatic effects associated with global warming?
			PowerPoint/Poster board/other presentation mediums	How do you expect these climatic effects to affect ecosystems in the future?
			Markers	Is there anything humans can do to prevent or lessen the negative effects of climate change?
	1 hr			Is climate change the same as a disturbance?
<i>Transition?</i> From what we have seen through the group presentations, climate change has the potential to cause major effects on ecosystems and biology as a whole. Now we are going to				

look at how climate change could affect humans, and more specifically, each of you as an individual.				
How will you close the lesson? After all of the groups have presented their findings, I will initiate a class discussion on how climate change can/will affect humans via the biological effects. The students will then be asked to complete an exit ticket in which they will reflect on how climate change could affect them personally in addition to its biological impacts.	Time	End	Exit Ticket	How will climate change affect humans?
	15 min			Will climate change affect you directly or indirectly?
				Do the potential human impacts cause you to think more about preventing climate change?
Texts: Which texts will be used? What is the level of complexity?			Questions: What are some questions you plan, and what evidence will students be required to cite?	
The texts used in the lesson will be based on the students’ online research. Students will be using online literature to further understand their specific topic. The rest of the text will be generated by the students in their presentations.			What are some of the effects of climate change we are already seeing? - Students will cite evidence from the news, other classes, and the video What effects do you predict to climate change to cause in the future? - Students will cite evidence from their research How might climate change affect you in the future? - Students will cite evidence from their research and the class discussion	
Grouping: How will your groups be organized? What roles will students fulfill?			Differentiation: How will you differentiate instruction to accommodate individual students’ anticipated learning difficulties, interests, and/or cultural heritage?	
Students will be heterogeneously grouped into small groups of 3-4 students. Each student will be responsible for a specific part of the project and presenting his/her part. For example, one student will be responsible for researching and presenting about ecosystem effects, while another student will be responsible for the case study portion.			Students will be grouped heterogeneously based on their abilities. Students struggling in the group activity will be given extra support from the instructor via guiding questions, research advices, etc. In addition, students will choose their individualized roles within the group to best fit their interests. The case study portion of the activity also allows students to research plants, animals, regions, etc. that they are most interested in.	
Intervention: How will you use the results of the assessment(s) to inform future instruction?			Thinking: What kinds of thinking will students do, and how will you model this thinking?	
I will use the results of this assessment to gauge whether students understand the effects of climate change on biology and can make educated predictions based on this information. I will use the results of the assessment to determine whether students have an accurate knowledge base to make these predictions, or whether these topics			Students will be predicting what could/will happen in the future based on climate change. I will model this thinking by providing an example of predicting future effects of climate change after watching the overview video. In addition, students will be reflecting on how climate change could/will affect them personally. I will model this	

need to be discussed/covered further in order for the students to master this skill.	thinking by beginning the final discussion describing how I think climate change could affect me as an individual.
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Group Presentation Instructions

You and your group will be researching a specific “side effect” of climate change (that you chose out of the bowl). Each group member will be responsible for researching and presenting one of the four main topics.

These topics include...

- Effect on ecosystems
- Predicted outcomes
- Case Study
- Remediation and adaptation strategies

After researching the topics, your group will come together to create a presentation of the information. You can present the material any way you choose (e.g. poster, PowerPoint, song, skit, etc.) as long as each group member contributes to the presentation.

Exit Ticket

1. How might climate change affect you personally in the future?

2. List at least 2 predictions of how climate change can affect biology in the future?

3. Which of the following is NOT associated with climate change?
 - A. sea level rise
 - B. ocean acidification
 - C. increased temperatures
 - D. increased drought
 - E. increased land fertility

4. Which of the following is a proposed remediation or adaptation strategy for climate change?
 - A. Reforestation
 - B. Increased use of fertilizers
 - C. Increased fossil fuel use
 - D. Monocultures

Appendix B

TEAM Lesson Plan			
Teacher: -----			
Course: Algebra II			
Course Unit: Linear Equations			
Lesson Title: Real World Application of Linear Modeling			
Learning Goals: What do you want students to be able to <u>know</u> or <u>do</u> as a result of this lesson?			
The students will be able to generate a linear equation to best represent data. The students will be able to use a linear function to predict future data.			
STANDARDS: Reference State, Common Core, ACT College Readiness, ORS Standards and/or State CTE Competencies.			
Interpreting Categorical and Quantitative Data			
6a. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models			
Review: How will you build on prior knowledge?	Hook: How will you catch the attention of your students and focus their minds on today's learning goals?	Real World Connection: How is this learning goal relevant to students' lives?	Student Reflection : How will you provide for student reflection?
I will build on students' prior knowledge by beginning the lesson with a discussion about the basics of linear functions, including slope, y-intercept, slope-intercept form, standard form, line of best fit, etc. We will then discuss how to use linear equations to solve real world problems.	I will gain the students attention by showing them a news clip about polar ice melting. This will grab their attention and encourage them to focus on how the accomplishment of today's learning goals would be beneficial for them in solving real-world problems.	This lesson is relevant to student's lives because it shows them that the abstract concept of linear equations can be used to solve problems in their daily lives. It also shows the importance of this concept in understanding and combatting climate change, which will inevitably affect the lives of the students and those around them.	The students will be asked to reflect upon the possible effects of polar ice sheet melting on the Earth and the people on Earth. In addition, the students will be asked to reflect on

			how math can be used to help combat difficult, real-world problems.
Assignments require students to: (Check all that apply) What evidence will you collect that students have mastered the learning goals?			
☐ Organize ☐ Interpret ☐ Analyze ☐ Synthesize ☐ Evaluate information	☐ Writing: ☐ Draw Conclusions ☐ Make Generalizations ☐ Produce arguments	Connection to: ☐ prior learning: linear equations ☐ life experiences: Other disciplines: Environmental science & Biology	
Assessment: How will performance be measured? (Check all that apply)		Measurement Criteria: How will you define mastery?	
☐ Project ☐ Experiment ☐ Presentation ☐ Other _____		☐ Essay ☐ Short Answer ☐ Multiple Choice	
		Mastery will be defined as completing the presentation with correct processes and legitimate sample problem as well as completion of the exit ticket with a well-thought out reflection response and 50% accuracy on the multiple choice portion (with correct work shown).	

Activities and Pacing: What strategies, procedures, and transitions will you use?		Materials	How do they align with learning goals and allow for higher order thinking?
How will you begin? The lesson will begin with a review of previous student knowledge about linear equations. The students will then watch a short video about ice cap melting from a news source. https://www.youtube.com/watch?v=BRWKNF35Jrg	Time	Beginning	Computer with internet access How can linear equations be used to make sense of data sets? How do you think that linear equations could be used to understand

				the arctic ice problem?
	5-10 min			How do you think that linear equations could be used to combat the arctic ice problem?
				What are some of the effects of sea ice melting?
<i>Transition?</i> “Now that we have been introduced to the problem of arctic sea ice melting, we are going to look at data related to this problem and how linear equations can be applied to this problem.”				
The students will work in groups to complete the Arctic Sea Ice worksheet. They will also be researching more recent data on sea ice melting. The students will then create a presentation of their choosing to share their results with the class. This presentation will include how the students completed the given problems, how their predictions compared with current data, and a sample problem that solves a real-world problem with linear equations. (Worksheet from http://www.mathaware.org/mam/2013/sustainability/Arctic%20Sea%20Ice%20and%20Linear%20Equations%20Teacher%20Notes%20Final%203.31.13.pdf)	Time	Middle	Technology for research	Why is the arctic sea ice problem important?
	45 min		Poster board/sticky pads/PowerPoint	Why do your predictions match/not match actual data?
			Markers	
			Sea Ice Worksheet	
			Calculators	
<i>Transition?</i> “You all are going to present how you approached the arctic sea ice problem and how you would apply these same processes to another real-world problem.”				
How will you close the lesson? The students will share their presentations with the class and discuss how they would go about solving their sample problem. The	Time	End	Exit Ticket	Regardless of your final answer, how did you approach the

students will then be given an exit ticket to complete.	30 min		arctic ice problem? What other real-world problems could be addressed using linear equations?
Texts: Which texts will be used? What is the level of complexity?		Questions: What are some questions you plan, and what evidence will students be required to cite?	
The students will use the text on the Arctic Sea ice worksheet to help them understand and approach the problem. This text is on the students' current reading level and does not contain many technical words. Any other texts used during the lesson will come from the internet as the students are researching current data and real-world problems.		How can you use a linear equation to make sense of a data list? -Students will be required to cite the processes they used on their worksheet problem How can linear equations be used to solve real-world problems? -Students will be required to cite evidence form their research. In what fields (other than math) are linear equations used? - Students will be required to cite evidence form their research.	
Grouping: How will your groups be organized? What roles will students fulfill?		Differentiation: How will you differentiate instruction to accommodate individual students' anticipated learning difficulties, interests, and/or cultural heritage?	
The students will be in groups of 3 during this lesson. The students will work on the worksheet collaboratively and will have individualized roles in relation to their presentations. For their presentations, one student will be expected to focus on presenting how the group solved the original problem. Another student will focus on researching current data and including it in their mathematical solution. A third student will focus on generating an original real-world problem involving linear equations. Each student will be responsible for presenting their individual focus area to the class.		Students will be grouped heterogeneously based on their abilities. The students will be able to choose their specific focus area/role to best fit their strengths and capabilities. Groups will be instructed to ensure that every student in the group understands the processes involved in solving the ice sheet problem as well as their sample problem because every student will have an equal chance of being asked about any part of their project.	
Intervention: How will you use the results of the assessment(s) to inform future instruction?		Thinking: What kinds of thinking will students do, and how will you model this thinking?	
The results of the assessment will allow me to gauge whether the students are capable of applying their		The students will be required to think about how the concept of linear	

knowledge about linear equations to a data set. This will inform me whether the students need more practice with this skill in subsequent lessons and/or need a review of the basics of linear equations necessary to master this skill.	equations can be practically applied. I will model this thinking by providing context for data sets that encourage students to think about the concept of linear equation outside of a mathematic “practice problem” scenario.
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Arctic Sea Ice and Linear Equations

Background

European explorers, beginning with Cabot's 1497 attempt to sail to the Orient from England, searched for the *Northwest Passage*, a route through the Arctic Ocean along the coast of Canada. See Figure 1. The Norwegian explorer Roald Amundsen was the first to complete the journey, though it took from 1903 to 1906. In 1957, the U.S. Coast Guard Cutter *Storis* became the first U.S. vessel to circumnavigate the North American continent, a 22,000 mile trek.

The problem is the Arctic Ocean is covered by a sea ice pack nearly all the time---the passage is closed. Since the beginning of the Industrial Revolution, global temperature averages have risen overall causing more of the ice pack to melt in the summer. NASA's *National Snow and Ice Data Center* at the University of Colorado, Boulder, has collected data provided by satellites, over-flights, submarines, and other observations measuring the amount of sea ice in the Arctic Ocean for several decades. The amount of ice is at a minimum in September, the end of summer. Figure 2 shows the September average extent of total Arctic sea ice area in millions of square kilometers versus the year from 1979 to 2011. Clearly the extent of ice is decreasing.

Melting sea ice provides an example of a positive feedback loop (also called non-linear feedback). As the ice melts, it leaves more ocean open. Ice is very reflective giving the arctic region a high *albedo*; ice reflects up to 70% of the sun's energy. The ocean is darker, reflecting only 6% of the sun's energy, so as the ice pack retreats, the area's albedo gets lower. More energy is absorbed by ocean water than by sea ice increasing the temperature, causing more ice to melt leading to more open water, creating a positive feedback loop.

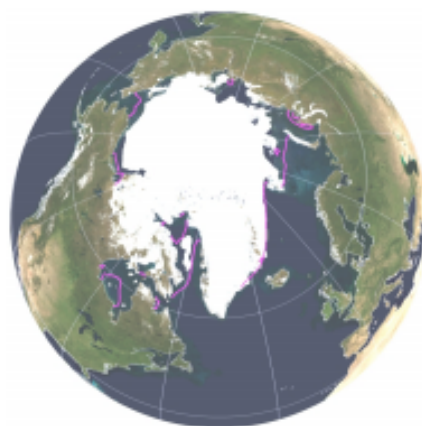


Figure 1: Arctic Sea Ice¹

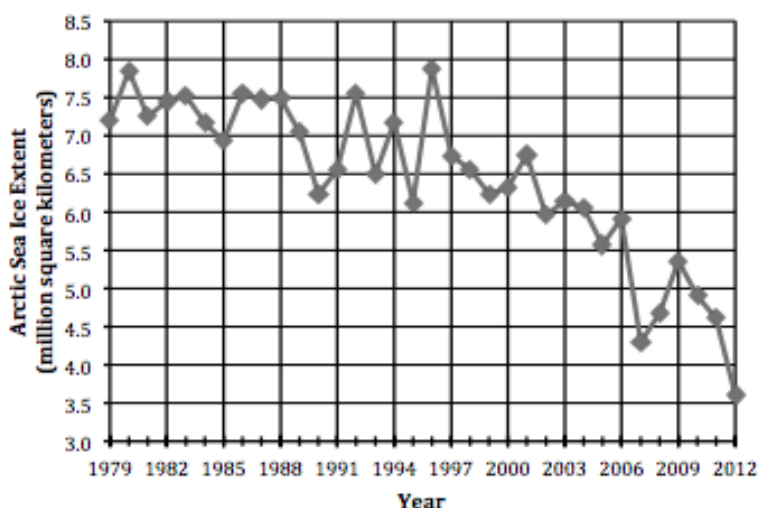


Figure 2: Average September Arctic Sea Ice Extent, 1979 to 2012.

Questions:

1. From the data given in Figure 2, how much ice was in the Arctic in September 1988, September 1998 and September 2008? What are the units? What is the overall trend in the amount of sea ice during this time period?
2. On Figure 2, draw the line that looks to give the best fit to the data.
3. From your drawing, calculate the slope of the line. How does your estimate connect with the overall trend?
4. Figure 3 shows both the equation and the graph of the line of best fit: $y = -0.0921 t + 190.12$. Use this mathematical model (the equation of the line of best fit) to find the amount of ice in September 2003 and in September 2012. How do these values compare to the actual data values?
5. What is the slope of this line? How close was the slope of your line in (2) to the slope of the best fit line?
6. What are the units for the slope? What does the slope tell us about the rate at which extent of sea ice is changing?
7. If present trends continue, how much Arctic sea ice will there be in September 2020? In what year does your model predict that the Arctic will be ice free in September?
8. Looking at the data, do you think this prediction is accurate? Discuss.
9. What do you consider as the pros and cons of having an open Arctic passage?

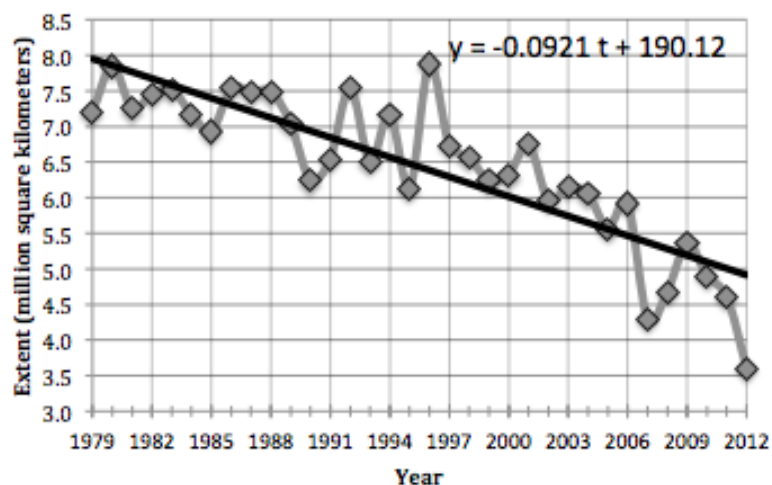


Figure 3: Best fit curve to Average September Arctic Sea Ice Extent

¹ All images courtesy of NASA and the National Snow and Ice Data Center, U.C., Boulder. (<http://nsidc.org>). Lesson plan by William Bauldry, Appalachian State University, Victor Donnay, Bryn Mawr College, and Thomas J. Pfaff, Ithaca College.

Exit Ticket

How can math be used to help combat difficult, real-world problems?

Use the data table to answer the following questions.

COST OF HEALTH CARE

Year	Cost (in millions)
1996	\$482
1997	\$504
1998	\$522
1999	\$560
2000	\$591
2001	\$630

What is the line of best fit for this data?

What would you predict to be the cost of healthcare in 2016?

Appendix C

TEAM Lesson Plan			
Teacher: -----			
Course: English (Secondary)			
Course Unit: Informational Text			
Lesson Title: Green is Great (Derived from https://www.teachingenglish.org.uk/article/green-great)			
Learning Goals: What do you want students to be able to <u>know</u> or <u>do</u> as a result of this lesson?			
The students will be able to read an informational text and communicate their knowledge to others. The students will be able to communicate their knowledge in writing academic vocabulary gathered from the text.			
STANDARDS: Reference State, Common Core, ACT College Readiness, ORS Standards and/or State CTE Competencies.			
Reading Informational Text 1. Cite the textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text 2. Determine a central idea of a text and analyze its development over the course of the text, including its relationship to supporting ideas; provide an objective summary of the text. 4. Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings; analyze the impact of specific word choices on meaning and tone, including analogies or allusions to other texts			
Writing Text Types and Purposes 2. Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.			
Review: How will you build on prior knowledge?	Hook: How will you catch the attention of your students and focus their minds on today's learning goals?	Real World Connection: How is this learning goal relevant to students' lives?	Student Reflection: How will you provide for student reflection?
I will build on the students' knowledge by reviewing what the students know about informational text and vocabulary related to sustainability.	I will catch the students' attention by showing a video about alternative energy sources and introducing the topic before they begin their reading activities.	This lesson relates to the students lives because climate change and renewable energy sources are becoming a major issue in the world today, and many of the students have probably seen these topics on the	The students will be asked to reflect on the importance of incorporating renewable energy sources in the U.S. and the world.

		news. Students should also know that large amounts of energy are necessary for them to live the lifestyles they are currently accustomed to.	
Assignments require students to: (Check all that apply) What evidence will you collect that students have mastered the learning goals?			
☐ Organize ☐ Interpret ☐ Analyze ☐ Synthesize ☐ Evaluate information	☐ Writing: ☐ Draw Conclusions ☐ Make Generalizations ☐ Produce arguments	Connection to: ☐ prior learning – informational text ☐ life experiences - news stories Other disciplines: Life Science, Biology	
Assessment: How will performance be measured? (Check all that apply)		Measurement Criteria: How will you define mastery?	
☐ Project ☐ Experiment ☐ Presentation ☐ Other: Discussion		☐ Essay ☐ Short Answer ☐ Multiple Choice	
I will define mastery as the students writing an accurate and cohesive essay about sustainability and renewable energy, using at least 5 new vocabulary words gained from reading the informational text.			

Activities and Pacing: What strategies, procedures, and transitions will you use?			Materials	How do they align with learning goals and allow for higher order thinking?
How will you begin? I will begin the lesson by reviewing what the students know about informational text and informative essays. I will then show them an overview video about renewable energy sources. (Video: https://www.youtube.com/watch?v=KEeH4EniM3E)	Time	Beginning	Computer with internet access	What have we already discussed about informational text?
	10 min			What is an informational essay?
				What do you know about renewable energy?
				What do you know about

				climate change?
<i>Transition?</i> Now that you have been introduced to renewable energy and climate change, you are going to read more information about it and share it with your group members.				
The students will complete a jigsaw reading task, in which they will read about renewable energy sources and share the information they gathered with their group members. The class will then have a discussion about what they learned from their group members and how it connects to the video. The students will then be given the full text to read and asked to highlight new vocabulary related to the topic.	Time	Middle	Jigsaw Reading Instructions	What new vocabulary did you learn from this text?
	20 min .		Jigsaw Reading	What information did you get from the reading that you can share with your group members?
			Highlighters	
<i>Transition?</i>				
How will you close the lesson? The students will be instructed to write an informative essay on the topic, using the knowledge and vocabulary gained from their previous reading.	Time	End	Essay Prompts	What information from this article would be useful in writing an informative essay?
	1 hr.			What vocabulary words would be useful/necessary when writing an essay on this topic?
Texts: Which texts will be used? What is the level of complexity?			Questions: What are some questions you plan, and what evidence will students be required to cite?	
The selected texts were chosen from http://listverse.com/2009/05/01/top-10-renewable-energy-sources/ . They are complex enough so that the students gain new information and vocabulary but are easily comprehensible for students on a 7 th -8 th grade level.			What is the most important information conveyed in the article? - Students should cite information from the text How would you present this information to others (both in writing and vocally)?	

	- Students should cite information from the text and their knowledge of informative essays What new vocabulary can be found in the reading? How would you use these words to discuss this topic? - Students should cite words from the text and use them in their essays
Grouping: How will your groups be organized? What roles will students fulfill?	Differentiation: How will you differentiate instruction to accommodate individual students' anticipated learning difficulties, interests, and/or cultural heritage?
Students will be heterogeneously grouped into groups of four. Each student will be given a piece of the text that discusses a certain renewable energy source and will be responsible for discussing their piece of the text with their group members.	Students who have difficulty reading and understanding the text will be asked to underline information that they think is important and that they want to share with their group as they are reading. This lesson also allows students to learn and communicate knowledge in several different ways, such as reading, writing, listening, and speaking, to help each student receive some information via their preferred delivery method.
Intervention: How will you use the results of the assessment(s) to inform future instruction?	Thinking: What kinds of thinking will students do, and how will you model this thinking?
The results of the assessment will allow me to gauge whether the students were able to gather information from the text and communicate it through writing. In addition, it will allow me to see whether the students know how to write a proper informative essay with a strong thesis statement. The results of this assessment will allow me to know whether I need to continue teaching about how to gather and communicate information from informational texts. In addition, it will allow me to see whether the students need more practice with writing informative essays and/or strong thesis statements.	Students will be evaluating the text for important and communicable information. I will model this thinking by starting the activity with an example text and showing the students how I would choose what information is most important and identify critical vocabulary.

Jigsaw Reading Assignment

You will be reading one section of an article describing different renewable sources of energy. While you are reading, think about what pieces of information are most important. (You may want to underline important facts).

After time is called, you will be sharing what you learned from your piece of the article with your group members, who read the same piece.

After time is called again, you will return to your table and discuss your portion of the article with your table mates (who read a different portion).

Make sure you thoroughly discuss your piece of the article with your group and listen carefully to the information they share with you (You will need it later).

Jigsaw Reading Passages

Photovoltaic (PV) Solar power is harnessing the sun's energy to produce electricity. One of the fastest growing energy sources, new technologies are developing at a rapid pace. Solar cells are becoming more efficient, transportable and even flexible, allowing for easy installation. PV has mainly been used to power small and medium-sized applications, from the calculator powered by a single solar cell to off-grid homes powered by a photovoltaic array. The 1973 oil crisis stimulated a rapid rise in the production of PV during the 1970s and early 1980s. Steadily falling oil prices during the early 1980s, however, led to a reduction in funding for photovoltaic R&D and a discontinuation of the tax credits associated with the Energy Tax Act of 1978. These factors moderated growth to approximately 15% per year from 1984 through 1996. Since the mid-1990s, leadership in the PV sector has shifted from the US to Japan and Germany. Between 1992 and 1994 Japan increased R&D funding, established net metering guidelines, and introduced a subsidy program to encourage the installation of residential PV systems. Solar

installations in recent years have also largely begun to expand into residential areas. with

Wind power is the conversion of wind energy by wind turbines into a useful form, such as electricity or mechanical energy. Large-scale wind farms are typically connected to the local power transmission network with small turbines used to provide electricity to isolated areas. Residential units are entering production and are capable of powering large appliances to entire houses depending on the size. Wind farms installed on agricultural land or grazing areas, have one of the lowest environmental impacts of all energy sources. Although wind produces only about 1.5% of worldwide electricity use, it is growing rapidly, having doubled in the three years between 2005 and 2008. In several countries it has achieved relatively high levels of penetration, accounting for approximately 19% of electricity production in Denmark, 11% in Spain and Portugal, and 7% in Germany and the Republic of Ireland in 2008. Wind energy has historically been used directly to propel sailing ships or converted into mechanical energy for pumping water or grinding grain, but the principal application of wind power today is the generation of electricity. As of 2008, Europe leads the world in development of offshore wind power, due to strong wind resources and shallow water in the North Sea and the Baltic Sea, and limitations on suitable locations on land due to dense populations and existing developments. Large markets for wind power, including the United States and China focused first on developing their on-land wind resources where construction costs are lower, but population centers along coastlines in many parts of the world are close to offshore wind resources, which would

Hydroelectricity is electricity generated by hydropower, i.e., the production of power through use of the gravitational force of falling or flowing water. It is the most widely used form of renewable energy. Once a hydroelectric complex is constructed, the project produces no direct waste. Small scale hydro or micro-hydro power has been an increasingly popular alternative energy source, especially in remote areas where other power sources are not viable. Small scale hydro power systems can be installed in small rivers or streams with little or no discernible environmental effect or disruption to fish migration. Most small scale hydro power systems make no use of a dam or major water diversion, but rather use water wheels to generate energy. This was approximately 19% of the world's electricity (up from 16% in 2003), and accounted for over 63% of electricity from renewable sources. While many hydroelectric projects supply public electricity networks, some are created to serve specific industrial enterprises. Dedicated hydroelectric projects are often built to provide the substantial amounts of electricity needed for

Geothermal energy is a very powerful and efficient way to extract a renewable energy from the earth through natural processes. This can be performed on a small scale to provide heat for a residential unit (a geothermal heat pump), or on a very large scale for energy production through a geothermal power plant. It has been used for space heating and bathing since ancient roman times, but is now better known for generating electricity. Geothermal power is cost effective, reliable, and environmentally friendly, but has previously been geographically limited to areas near tectonic plate boundaries. Recent technological advances have dramatically expanded the range and size of viable resources, especially for direct applications such as home heating. The largest group of geothermal power plants in the world is located at The Geysers, a geothermal field in California, United States. As of 2004, five countries (El Salvador, Kenya, the Philippines, Iceland, and Costa Rica) generate more than 15% of their electricity from geothermal sources. Geothermal power requires no fuel, and is therefore immune to fluctuations in fuel cost, but capital costs tend to be high. Drilling accounts for most of the costs of electrical plants, and exploration of deep resources entails very high financial risks. Geothermal power offers a degree of scalability: a large geothermal plant can power entire cities while smaller power plants can

Essay Prompt

Using the information and vocabulary you learned from the previous reading, write an informative (expository) essay that compares and contrasts two different sources of renewable energy.

Tips:

- Do NOT directly quote the reading.
- All ideas should be in your own words.
- Make sure you have an introduction, THESIS statement, and conclusion.
- Budget your time (You have ~45 min.).
- Use the rest of this page to brainstorm before beginning your essay.

Appendix D

TEAM Lesson Plan			
Teacher: -----			
Course: World History			
Course Unit: Contemporary World Since 1980			
Lesson Title: Population Dynamics			
Learning Goals: What do you want students to be able to <u>know</u> or <u>do</u> as a result of this lesson?			
The students will describe demographic changes in the world's population over the last 40 years using population pyramids.			
The students will describe the social and environmental impacts of increasing human populations.			
The students will express their opinions on issues related to increasing population pressures.			
STANDARDS: Reference State, Common Core, ACT College Readiness, ORS Standards and/or State CTE Competencies.			
W.100 Using census data and population pyramids, identify and describe the demographic changes worldwide since 1980. (C, E, G, H, P)			
Review: How will you build on prior knowledge?	Hook: How will you catch the attention of your students and focus their minds on today's learning goals?	Real World Connection: How is this learning goal relevant to students' lives?	Student Reflection: How will you provide for student reflection?
I will build on the students' prior knowledge by asking them how many people are currently on Earth. In addition, I will display census data and ask the students what they know about the various categories included within it. Finally, I will display a population pyramid to see what the students already know about them.	After reviewing the students' previous knowledge, I will show a video about the census and population data. I will also show them several different population pyramids.	I will connect the material to the students' lives by beginning our discussion of demographics and population pyramids in the local area.	The students will reflect on their (and their classmates') opinions of issues related to increasing population sizes.
Assignments require students to: (Check all that apply)			
What evidence will you collect that students have mastered the learning goals?			
☐ Organize ☐ Interpret ☐ Analyze ☐ Synthesize ☐ Evaluate information	☐ Writing: ☐ Draw Conclusions ☐ Make Generalizations ☐ Produce arguments	Connection to: ☐ prior learning – census data, population representations, ☐ life experiences – local demographics	

		Other disciplines: Geography, earth science, sociology
Assessment: How will performance be measured? (Check all that apply)		Measurement Criteria: How will you define mastery?
☐ Project ☐ Essay ☐ Experiment ☐ Short Answer ☐ Presentation ☐ Multiple Choice ☐ Other: Oral Arguments		Mastery will be defined as the students completing the exit ticket and discussion with a well thought out descriptions of their opinion on climate change issues based on accurate facts as well as completing the multiple choice portion of the exit ticket with 66% accuracy.

Activities and Pacing: What strategies, procedures, and transitions will you use?			Materials	How do they align with learning goals and allow for higher order thinking?
How will you begin? The lesson will begin with a review of the students’ prior knowledge. I will then show a video (https://www.youtube.com/watch?v=_E78q7szdkM) about census data to give the students perspective on the content we will be learning. I will then present the students with basic information of demographic changes in the population using census data and population. The students will then complete a think-pair-share activity on how demographics have changed over the past 40 years.	Time	Beginning	Computer with internet access	What is the point of a census? What information can we get from them?
			PowerPoint presentation	How have demographics changed worldwide since 1980?
	50 min		Think-Pair-Share worksheet	What are population pyramids and how can they be useful?
Transition? One trend in population in the last 40 years is a huge increase in worldwide population at rapid rates. This has led to a worldwide population of 7 billion people. This amount of people on our planet is causing problems, and we are going to see what your opinion is on these issues.				
The class will then have a brief discussion on how climate change will affect dynamics and the effects of having 7 billion+ people on the planet. The students will participate in the “7 billion – Where Do You Stand?” activity.	Time	Middle	7 Billion – Where do you stand? scenarios	How are population dynamics and sustainability related?

Students will move to the sign that best reflects their viewpoint on the issue. 1-2 students will be randomly asked to explain their decision. Each student will be required to present at least one argument. (https://www.worldof7billion.org/wp-content/uploads/2014/08/7-Billion-Where-do-you-Stand.pdf)	30 min		"Agree," "Disagree," etc. signs	Which issues are the most important regarding sustainability?
				Is your school, community, state, etc. currently promoting sustainability? How? or Why not?
Transition? Now you were going to use your knowledge about changes in demographics, population pyramids, and your own opinions to fill out the exit ticket.				
How will you close the lesson? The students will be asked to complete an exit ticket that requires them to use census data and population pyramids to answer demographic questions as well as to reflect on the issues related to increasing population sizes.	Time	End	Exit ticket	What can you conclude from a population pyramid?
	10 min			How do you predict the population to change in the near future?
				What is your position on issues related to sustainability and population?
Texts: Which texts will be used? What is the level of complexity?			Questions: What are some questions you plan, and what evidence will students be required to cite?	
Texts will be converted to a PowerPoint presentation format for the students to take notes on. It will be the same level of complexity as their textbook (on grade level).			What are some major demographic shifts that have occurred worldwide since the 1980s? - Cite evidence from census data and population pyramids What information can we get from population pyramids? - Cite evidence from real population pyramids How are demographic transitions and population increases related to climate change and sustainability?	

	- Cite evidence from knowledge of demographics and climate change What is your opinion on the issues surrounding increasing population sizes? - Cite evidence from own opinion and supporting information
Grouping: How will your groups be organized? What roles will students fulfill?	Differentiation: How will you differentiate instruction to accommodate individual students' anticipated learning difficulties, interests, and/or cultural heritage?
For the first part of class, students will be grouped in pairs with the person at their table. Each student will be responsible for writing and sharing his/her own ideas as well as those of his/her partner. For the remainder of the class, the students will present their opinions individually but will engage in a class-wide discussion.	Students will be in pairs for the majority of the lesson. They will be allowed to work with their partners to make sure their notes are filled out completely, work on the think pair share, and come up with any questions they might want to present to the class. Students will be allowed to volunteer to present their opinions on each of the climate change issues based on their level of interest (until no more volunteers are found).
Intervention: How will you use the results of the assessment(s) to inform future instruction?	Thinking: What kinds of thinking will students do, and how will you model this thinking?
The results of the assessment will inform me whether the students can accurately describe demographic transitions since the 1980s using population pyramids and data. I will use this information to determine whether students need more practice with this type of information and making inferences based off of it. The assessment will also allow me to gauge whether students can make connections between changes in populations and changes in the environment (i.e. climate change). This will inform me whether I need to make this connection clearer in subsequent lessons and discussions.	Students will be making inferences based on information presented in various forms (e.g. data tables & population pyramids). They will also be predicting future patterns in demographics based on current data. Finally, students will be generating opinions and producing arguments based on their knowledge of increasing populations and climate change. I will model this thinking by providing making inferences and predictions based on example population pyramids as well as by sharing my own opinion on a climate change issue with supporting facts.

Think-Pair-Share

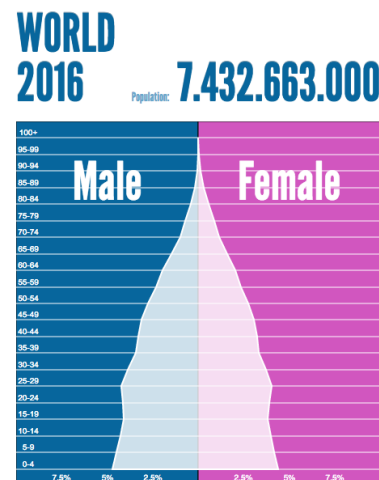
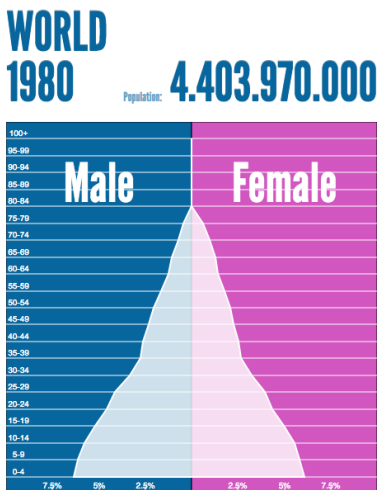
Using the data and population pyramids on the board. Describe at least three major demographic changes that have occurred worldwide since 1980.

List at least one demographic change that your partner described (that you did not already write down).

Exit Ticket

1. Pick one issue related to climate change and population growth discussed in class and defend your opinion on it in paragraph form.

Use the population pyramids (and your knowledge) to answer the following questions.



2. How much has the worldwide population increased since 1980?
 - A. ~ 20%
 - B. ~ 44%
 - C. ~ 57%
 - D. ~ 75%

3. How has the age structure of the world population changed since 1980?
 - A. There is a large percentage of young children (Ages 8 and under)
 - B. There is a larger percentage of elderly people (Ages 80+)
 - C. There is a larger percentage of middle age people (Ages 20-40)
 - D. The population size has decreased dramatically

4. How do you predict the population size to change in the future (under a business-as-usual model)?
- A. Slight decrease in population size
 - B. Sharp decrease in population size
 - C. Increase in population size
 - D. none of the above