book or that illustrates another aspect of the concept this is the right place to do it.

Evaluate: For a wrap-up or culminating part of your unit of instruction, using a book to get students thinking and reflecting about what they have learned is appropriate for this phase of the 5E. Perhaps you could read a book to the class and provide a writing prompt and have students describe hat they learned during the unit. Writing and drawing to illustrate their understanding would give you a better idea of what each student has learned during the unit.

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Energy and Me: Actual Calculations of Individual Carbon Footprints Can Change Individual Actions

BY Erin Oldani, Maxx Marano, Megan Borgeson, Department of Teacher Education, College of Education and Honor College, Michigan State University, and Jane Rice, Science Education Specialist, Department of Geological Sciences and the Center for Integrated Studies in General Science, College of Natural Science, Michigan State University

This project was based on previous work supported by a grant from the National Science Foundation (DUE 0941820).

The last science class these future teachers will ever take – that's the course I teach and coordinate at Michigan State University. That one fact guides all the instructional decisions I make throughout the semester in terms of the science content on which I focus and the science practices I emphasize. What do I want these college students – these future teachers – to walk away with? What do I want them to understand and be able to do a year from now, five years from now, for the rest of their lives?

Informed decision-making – that's what it comes down to. I want this last science course to give these future teachers an understanding of a few foundational science concepts and practices that they can actually use when it comes to making decisions on personal and societal issues. Increasingly, it becomes clear that climate change (global warming) is one such issue that college students must understand and be able to take action on. And, since these students are future teachers, their ability to use science in everyday decision-making related to many issues will have an impact that is multiplied many times over in the lives of their future students.

In this article, my colleagues (three undergraduate students enrolled in Michigan State University's Teacher Education program) and I report on one such project in the course I teach (called Energy and Me) that was designed to foster informed decision-making. The project involved calculating energy usage to determine individual carbon footprints and then communicating to a wider audience the relationship between our collective carbon footprints and global climate change. Before we discuss the actual project, meet my colleagues:

My name is Maxx Marano, and I am currently pursuing becoming an elementary teacher specializing in urban education. I have always known I have wanted to be a teacher ever since I asked my mom to turn our guest room into a "school room" in third grade. Everyday I would beg my two younger sisters to play school with me. I would write up a schedule and craft lessons for my "students". My passion to become a teacher originates from the remarkable and inspiring teachers who I have had the wonderful chance to cross paths with and learn from.

I am Megan Borgeson, and I have wanted to be an elementary teacher since I was in elementary school. My kindergarten teacher, Mrs. Middleton, really inspired me with her dedication to teaching and her passion for working with children, and her influence really made me want to teach. My specializations are language arts and math, and I would like to teach the younger

grades, K-3. My senior year of high school I took a class in which I worked for an hour every day with kindergarteners, and I would love to teach this grade.

My name is Erin Oldani, and I am here at Michigan State University to achieve my dreams in becoming an elementary school teacher. I have always found pride and passion in helping others figure new things out which is when I realized I wanted to do this for a living. The immense payback from students makes all the hard work worth it. My first grade teacher, Mrs. McLane at Isbister Elementary, has been my inspiration for many years now and is the reason I also want to teach first grade. She knew how to keep us engaged in our work while also making it a fun and inviting environment. I always loved going to school during this time and this is what I hope to share with my students. At school my specializations are in mathematics and teaching English to students of other languages (TESOL) along with a specialization in urban education.

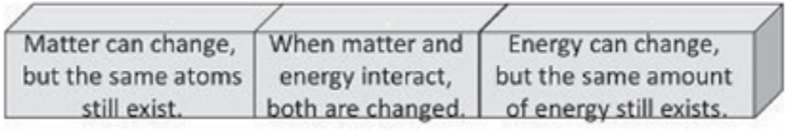
We've written this article in two voices. My voice (Jane Rice) is the teacher and the second voice (in italized font) is the collective voice of the three students. We believe this approach will allow readers to view the project from a teacher perspective and from a student perspective. While this project was done by undergraduate students, we believe it can be modified to be used at different grade levels, ranging from upper elementary through high school. The project primarily integrates disciplinary content across Earth science and physical science, but could easily be broadened to integrate life science (e.g., photosynthesis, cellular respiration in all organisms). The project also integrates science practices and crosscutting concepts with these disciplinary core ideas. Thus, this project can easily be aligned to the three dimensions of the Next Generation Science Standards (NGSS; NGSS Lead States, 2013). We'll discuss each of these three dimensions as we describe the "Energy and Me" student project.

Student Participants

The first part of this project, the actual collection of the carbon footprint data, involved 80 students at Michigan State University (junior level) who were all in the elementary teacher education program. None of these students were science majors; rather they were education majors with a "teaching major", almost always in language arts or social studies. They had already taken the general education science courses required of all non-science majors at MSU. The course they were now enrolled in was a science course for teachers offered by the College of Natural Science. The goal of the project for these students was to collect and analyze their personal energy usage data (for transportation, electricity, and heating) and then use that data to explain their individual contribution to climate change and make decisions about their future energy use. The second part of this project involved a group of five future teachers (drawn from the larger group) who were all Honor College students. The goal of this part of the project was for these students (three of whom are authors of this article) to communicate to the public the science climate change and how individual actions can contribute or minimize the problem. This was done through a large wall display (see below).

Crosscutting Concepts

The science knowledge required to understand climate change includes several crosscutting concepts as well as disciplinary core ideas. One of the most powerful crosscutting concepts in NGSS focuses on the interaction of matter and energy with the conservation of each in physical and chemical changes. This NGSS crosscutting concept is "*Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.*" Rather than stating these principles in science terms, we express them in simple words that have meaning in everyday life. For example, instead of saying matter is conserved in physical and chemical processes, we expressly state what matter is conserved, or "lasts forever" - the atoms, not the molecules as many students believe. We use the idea of foundational building blocks to help students stay focused on this crosscutting concept which serves as the foundational for disciplinary core ideas in all content areas.



Disciplinary Core Ideas

Students need an understanding of some disciplinary core ideas in physical and Earth science in order to understand global climate change to the point of making informed decisions about personal actions. First, students need to apply the crosscutting concept of "matter can change, but the same atoms still exist" to the burning of fuels. An understanding of chemical changes begins in the upper elementary grades and continues through middle school and high school. However, many college students still struggle with what happens to the atoms in a fuel when the fuel is burned. In this course, when these future teachers were asked about burning fuels on a pre-assessment, over 90% said that the atoms in the fuel turned into heat energy. Even for adults, it's hard to believe that when one gallon of liquid gasoline (weighing about 6 pounds) reacts with oxygen (weighing about 21 pounds) the two substances turn into new invisible substances in the air, namely 20 pounds of carbon dioxide and 7 pounds water.

It is commonly mistaken that when an object, like fuel, burns it turns into energy. We can feel the heat and see the light, so why doesn't it? In class we used a model throughout the semester to represent changes like these. Paper clips represent the atoms in the fuel and paper strips represented the energy that was being used, transformed, or transferred. Have you ever heard of a paper clip turning into paper strip? No! So why would it be any different with atoms and energy? There is a universal law in science that both atoms and energy are forever (in physical and chemical changes). The amount that goes into a change will always equal the amount that comes out. Atoms will never change into energy and energy will never become an atom. So, when a fuel burns the atoms are still present but in different forms. It is the energy in the fuel that ends up as the light and heat that we can feel and see.

Do invisible gases have mass? Of course! This is a confusing topic because thinking about an invisible object having mass is unnatural. However, gases are made up of many atoms that are moving at a fast pace bumping and bouncing off of each other. Atoms are the building blocks of our whole world which means that they have to have mass. If atoms have mass and they make up the gases in our air, they too must have mass, invisible or not.

In Earth Science, students need to understand how energy from the sun interacts with Earth's surface to warm the air. We focus simply on light energy being absorbed by the surface and transformed into heat energy, which means the surface is warmed. The warmed surface then transfers heat energy to the atmosphere, warming the air. Certain molecules in the air (namely, carbon dioxide) interact with the heat energy in the atmosphere, with the result that the heat energy remains in the atmosphere longer before eventually radiating to outer space. This, of course, is the natural greenhouse effect that keeps Earth's temperature within a livable range. Once students connect this understanding of the heating of the atmosphere with their understanding of the burning of fuels in cars, furnaces, and power plants (lots of carbon dioxide molecules made and released to the air) they are able to explain global warming.

Climate change can be examined through the framework of the foundational ideas about matter and energy. Many actions requiring energy depend on energy from burning fuels. Burning fuels involves changing chemical energy in the fuel molecule into other forms of energy, such as electrical, heat, or mechanical energy. A fuel is some type of matter that has carbon atoms connected to other carbon atoms and/or to hydrogen atoms. It is necessary for a fuel to interact with oxygen. When this interaction (i.e., burning) takes place, different atom groups are formed (namely, lots of carbon dioxide molecules and water molecules). These atom groups are released into the atmosphere. This amount of carbon dioxide released in the atmosphere is also known as a carbon footprint.

Putting the explanation of global warming in a manageable, easy and visual way makes the concept less daunting. In class we created a visual representation of global warming through drawings that included labels at each area of the drawing. This representation helped us see the energy being transformed and transferred in relation to the different atoms the make up a fuel and the carbon dioxide in the atmosphere.

Science Practices

This project required students to actually do science, not just learn existing science knowledge. In other words, this project integrated science practices with the disciplinary core ideas. Students used models (both sketches and the hands-on paper-clip and paper-strip models of matter and energy). Students conducted their own investigation into their energy use. Students communicated this science knowledge in graphical displays and narrative writings. They constructed explanations and argued from evidence, especially in regards to their selected activities that would reduce their carbon footprint. Here's how the disciplinary core ideas, crosscutting concepts, and science practices were integrated together in our two-part carbon footprint project.

Carbon Footprint Project: Part One

The data for part one of the project was compiled by the 80 students in the course. The students tracked their energy usage for one month, keeping track of how

much they used transportation, heat, and electricity. For transportation, students actually logged the miles they traveled along with the gas mileage of the vehicle they were in. From this data, they calculated how many gallons of gasoline needed to burn each month for their transportation needs. For heat, students looked at their heating bills to find out how much natural gas had to be burned to heat their air (furnace), water (gas water heater), clothes (gas dryers), and food (gas stoves). If students did not have access to their bills, they used the average amount for a Michigan household. For electricity, students chose eight electrical devices they used frequently and looked at the label on each to find out how much electrical energy was needed to run the device. They multiply this number by the number of hours they used the device in one month. Since this method only yielded a partial picture of electrical energy use, students then looked at their electric bills (or used the average for a Michigan resident) to determine their total electrical energy use for the month.

At the end of the month, students calculated their carbon footprint. A carbon footprint is a representation of how much carbon dioxide a person emits into the air due to daily activities, such as heating a house, turning on lights, and driving a car. All of these activities require a fuel to burn, either in a power plant, furnace, or car. When the fuel burns, more carbon dioxide enters the atmosphere. As a result, the excess CO2 in the atmosphere traps even more heat in Earth's atmosphere, which causes global climate change.

After computing these numbers, students then chose one or more daily activities to change in order to decrease their carbon footprint. Examples of these activities included turning down the heat in a house, turning off or unplugging electrical devices, not using the clothes dryer, and driving less. Students calculated the actual decrease in pounds of carbon dioxide that would result from these changes.

Each student used their own data as the basis of a paper (called Energy and Me) in which they explained global warming and discussed their personal decision-making about actions that contribute to global warming. Students also completed objective test questions and answered subjective questions about their beliefs and actions.

The collecting data and calculating part of the project made me very conscious about my impact on the environment through my everyday actions. I was shocked that just driving my car puts 440 pounds of carbon dioxide into the environment every month. Since atoms are forever, this action is part of my carbon footprint that I am leaving on the earth. Also, learning what area of my life (transportation) puts the most carbon dioxide into the atmosphere and what appliances use more energy than others (the clothes dryer) is useful data. It helped me recognize where making changes can be the most effective - riding my bike and letting my clothes air dry. After gaining a strong understanding of climate change, I feel like it was my responsibility to make changes in my life and to educate others so they can decide if they can find their own ways to reduce their carbon footprint.

Carbon Footprint Project: Part Two

The results of the first part of the project were so impressive that I wanted to convey this information visually to a broader audience. This was the goal of the second part of the project, conducted by the five Honor College students. These students decided to make a large wall display showing each student's current carbon footprint and proposed decreased carbon footprint. In order to do this, they had each student make a paper cut-out of her/his footprint on colored paper. These paper footprints represented each student's initial carbon footprint. The honor students then reduced the size of these paper footprints on a copier at a percentage that equaled the percent reduction in carbon dioxide emissions for each individual student. For example, if one student proposed to reduce her carbon dioxide output by 400 pounds (perhaps by driving 400 fewer miles) and this reduction represented a 25% decrease in her baseline energy use, then her paper footprint was reduced in size by 25%.

Each student had written down actual steps they could take to achieve their percentage of decreased carbon dioxide emissions. After recording the percentage of each students' decreased energy use, we then wrote on each footprint the student's action plan for decreasing her/his carbon footprint. Writing out every idea, such as carpooling more or turning off lights, really made this project come to life and seem even more realistic. We also took photos from everyone who was involved with the project and added them to our display as well. This makes reducing carbon emissions seem even more possible, because anyone who looks at the display will see pictures of the actual people who participated and are making a difference. Additionally, we created posters that describe how climate change happens and how everyone can make a difference.

Results: Individual Carbon Footprints

I saw impressive changes in students understanding of disciplinary core ideas and crosscutting concepts. As previously mentioned, most students initially were confused about the crosscutting concept related to matter and energy conservation. Almost all students believed that the atoms in any fuel turned into energy (primarily heat energy) when the fuel was burned. On the objective post-assessment, over 80% of the students now understood that the atoms in a fuel still exist after the fuel is burned, just in a different molecule. In terms of disciplinary core ideas, over 90% of students initially held erroneous beliefs about global warming, with many students thinking ozone depletion was the cause. These beliefs changed by the post-assessment with over 80% correctly answering questions related to the cause of climate change.

I found several interesting patterns to student responses to survey questions they completed at the end of the project. The most enlightening response to me was in student answers to the question of the value of actually looking at the labels on their own personal electrical devices compared with looking up the same data online. Students overwhelming (89%) said that looking at the labels was more meaningful than gathering the data on the internet. In response to the question "Will your energy usage really change in specific ways now that you've completed this project?", the majority of students (82%) responded they were actually making real life energy usage changes. Students responded in one of two ways when asked about the most interesting part of the project. Many students were surprised that they used more energy than they had predicted they would; others were impressed to see how much of an impact an individual can make when taking action to decrease her/his carbon footprint.

Results: Communicating Science Knowledge

Our goal for the display was to communicate with others the power of coming together to create change. Once an individual's attention is on the display, we wanted our message to be clear, informative, and easy for viewers to make a conclusion about. The eighty footprints of the individual participants come together to create a bigger picture. They are an expression of the impact that a group of people have when they all do their individual part to change an issue. We researched and included the results of our project on a bigger scale. If all Michigan State students made similar changes, we would put an estimated 17 million fewer

pounds of CO2 in the air each month, and if all Michigan teachers did this, CO2 emissions would decrease by 37 million pounds.

driving, combining trips, or biking. In terms of energy use for electricity, the most frequent change reported was turning off lights

Completing the actual wall display was a great way for us to get a clear picture on how our daily activities are really affecting the environment. Completing this part of the project was insightful and worthwhile. It clearly shows how many students are already making an impact, and how just a few changes can really make a difference. Through the process of completing the display, we learned that what we are doing can be done by anyone, and reducing our carbon footprints seemed more realistic than ever.

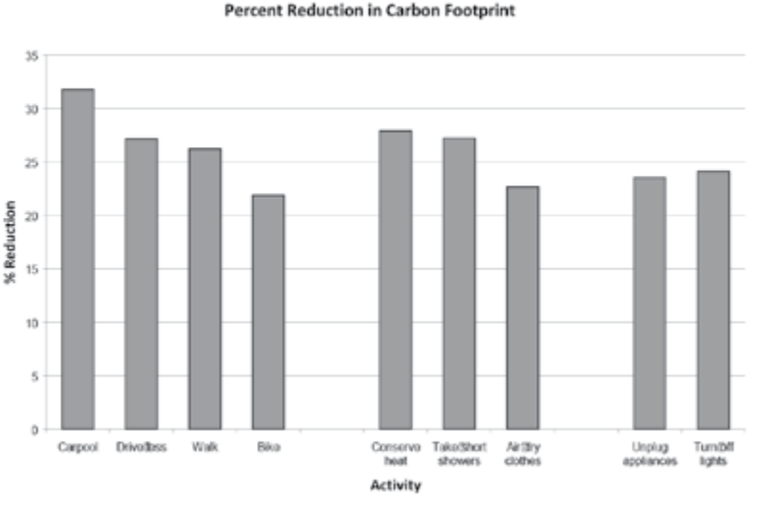
The most frequent change students reported related to transportation energy use. Almost 75% reported that they would use less energy for transportation by carpooling (50% chose this action) or walking instead of

(37%) or other appliances/devices (35%). In terms of energy use for heating purposes, the most frequent change reported was turning down heat (13%), air-drying clothes, and taking shorter showers.

However, not all decisions led to equivalent decreases in carbon footprints. For example, a student who action plan focused on turning off lights only reduced her carbon footprint by 10% (as illustrated by an only slighter smaller projected footprint in the photograph. For another student, carpooling led to a much greater impact on reducing a carbon footprint, in this case by 44% (as seen in the much smaller projected footprint).

The collective carbon footprints shown in the hall display allowed students to see the pattern of which personal actions led to the greatest decrease in their carbon footprint. The projected decrease in carbon dioxide

emissions was the greatest on average for students who chose to carpool (an average decrease of 31% in monthly carbon footprint).



Seeing the pieces of the project come together was nothing like seeing the complete display up on the wall finished. Being able to see the numbers and the drastic difference that we all can make as a collaborative whole was astounding. We knew that if we worked together we would be able to make a difference, but it is more real when the numbers are in front of your face and there are no excuses not to! The display is a true illustration of the power of one. If every individual makes a difference in their lives to fight against the rise in global warming, our world would be changed and for the better.

Discussion: Addressing Misconceptions

My finding that these college students (i.e, future teachers) held some of the same misconceptions of their future students is not surprising. One of these misconceptions was that atoms turn into energy when a fuel burns. This misconception has fundamental consequences when trying to understand climate change. If the atoms in gasoline, or coal, or natural gas are destroyed in burning, then there are no atoms available to make carbon dioxide molecules, and thus no increased heat energy in the atmosphere. My strategy to deal with this belief was to use the crosscutting concept of matter and energy conservation and interactions as the foundation for all the science topics in the course. Thus, when students began to learn about climate change, they had already developed a way of thinking that pushed them to keep track of atoms (and energy units). They knew the atoms had to be present in the molecules of some substance, even if that substance was invisible.

I went into this course with a very unclear concept of matter and energy. These topics had been addressed throughout my school career, but it was very hard to visualize exactly what happened to matter if it did not turn into energy and was not destroyed. This is especially difficult to comprehend when that matter is changing state, especially when it changes into a gas. My idea of burning fuel before this course was that when something is burned, it is destroyed. Therefore, it did not make sense that atoms still remained and entered our atmosphere as a gas after burning. In class, however, we learned how matter is never destroyed and cannot be turned into energy. Gaining an understanding on how matter works with visual representations and models was very beneficial toward my overall understanding of climate change. Once I understood how the process worked, it then became clear how the burning of a fuel does not destroy atoms, and the atoms still existed in different molecules.

A second misconception that actually prevents students from taking personal actions to minimize global warming is the belief that ozone depletion is the main cause. I asked students on the survey where this belief came from. Students said that they had connected global warming with ozone depletion on their own because both phenomena happen in the atmosphere. This misconception is problematic for making informed decisions. How can a person take action to decrease ozone depletion? The cause of ozone depletion has already been address with a ban on the manufacturing and use of chlorofluorocarbons. However, each individual has the power to take action on global warming many times each day in how they decide to use energy.

Discussion: Actually Doing the Science

I also found that many students lacked experience with household energy use, especially in terms of electricity and heating (not so much so with transportation, perhaps because we pay immediately at the point of purchase of the fuel that our vehicle will burn). In terms of electrical energy use, many students were unfamiliar with the fact that different electrical devices require different amounts of electrical energy to run. Initially, many students predicted that charging their cell phones and computers would be among the biggest contributors to their electric bills. Their reasoning, of course, was the number of hours that the device was using electrical energy per month. In the words of one student, "I had everything backwards originally. I thought that the amount of time you used the item held the key to how much energy use it would use." A cell phone charger may require only 10 watts while a microwave may require over 1000 watts.

Here is where actually looking at the energy use labels on electrical devices really helped students' understanding of the energy transformations that occur in household devices. An overwhelming majority of students in this project believed that actually finding energy usage labels on their electrical devices made the project more meaningful. One student commented, "If I had looked up appliances online it would have been less real and easier to say that I don't use that much energy but I can't deny my numbers." Another student commented, "I can excuse the numbers if they could possibly be wrong from the internet but if they are right in front of my eyes on things I use all the time there are no excuses."

In my high school chemistry class we were asked to complete an online calculation of our carbon footprint. We went on a website to answer questions about how long we used certain appliances, how much we drove, and the energy use from a household energy bil . After entering all of the data, the website calculated the number of planets that would be needed if the participant continued to produce that size carbon footprint. This project only reached the surface of the issue for me. I understand that resources are consumed at a tremendous rate, but the online calculation did not leave me with the knowledge of specific science content. I entered some numbers and then a website gave me a number back. Unfortunately, the activity did not involve science practices or actually doing the science.

Discussion: Changing Actions

I asked students on the survey if they would actually implement the change or changes on which they based the reduction in their carbon footprint. The majority of students responded they were actually making the real life energy usage changes. Most of these students provided specific ways they would change their current carbon footprint. While some students brought up their hesitations to actually change their energy use, most responses were similar to this student's: "I think it will change a little bit now that I'm aware of what I'm using. To change in a big way may not be realistic but if everyone changes in a small way it will really add up."

People are very routine based beings. We know how we like to do things, and we do them. This is what makes change so difficult. These changes we have accumulated throughout this project are absolutely necessary. If we want our environment and in turn the whole world to be a better place to inhabit, then it is up to us to do it and no one else. To me, this is a shout out to make a change. Little things like driving less and walking or air drying clothes instead of putting them in a dryer are easy to do. Ultimately, these change your lives very little. But together, making these changes can create a big difference. The difference we want to make.

Discussion: Informed Decision-Making

I also asked students what was most interesting aspect of the project. Students frequently responded that connection to personal decisions and actions was the most interesting and useful aspect of the project. These responses provide me with some evidence that I am making progress on my overall goal of students and future teachers being able to use science knowledge and practices for informed decision-making in their personal lives and in regard

to societal issues. One student summarized this belief with "The most interesting thing was to see my effect on climate change with real data. I have always been told by science teachers that I always have an impact but that didn't mean much because I never really understood how. This project allowed me to actually record and see how I personally impact climate change and how I can reduce my [carbon] footprint." Another student responded with "I think that this made it easy to understand the impact that each of us have on climate change in a tangible way that isn't as abstract."

Students expressed their belief that this sense of personal empowerment could lead to even bigger impacts, especially through their future teaching. I asked students how they would respond to someone who argues that individuals may as well do nothing about climate change since one person would have such a little impact. Student responses focused on the power of collaboration of individuals coming together. This is where the hall display really makes the point.

We scaled up the results of the project to be relevant to MSU students and Michigan teachers. Hopefully our work speaks to the public showing that they can be contributors in efforts made to reduce carbon emissions in a positive way. Climate change is a gigantic, scary concept. Should individuals do nothing about climate change because one person will have little impact on such a big global issue? We don't think so. We hope that the eighty footprints and thousands of pounds of CO2 not put into the air prove that individual actions matter in the larger picture of positively changing the world we all share.

I found this project to be one of the most satisfying ones I have ever done with students. The relevance of the topic as a societal issue lent a sense of urgency to students' learning the science content. Students could then easily make informed decisions about their use of energy. As one student explained, "What if every person individually decided to make a change in her or his life? Then collectively the whole Earth would see immense changes. It starts with one person daring to create change and making an impact. That could be you!"

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Appendix 1. Selected Disciplinary Core Ideas in NSSS that relate to the project

Standard	Grades K-2	Grades 3-5	Grades 6-8	Grades 9-12
ESS2.D Weather and climate	N/A	N/A	N/A	The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior.
ESS3.A Natural resources	Humans use natural resources for everything they do.	Energy and fuels humans use are derived from natural sources and their use affects the environment.	Humans depend on Earth's land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable.	Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits.
ESS3.C Human impacts on Earth systems	Things people do affect the environment but they can make choices to reduce their impacts.	Societal activities have had major effects on the land, ocean, atmosphere, and even outer space.	Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things.	Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
ESS3.D Global climate change	N/A	N/A	Human activities affect global warming. Decisions to reduce the impact of global warming depend on understanding climate science, engineering capabilities, and social dynamics.	Global climate models used to predict changes continue to be improved, although discoveries about the global climate system are ongoing and continually needed
PS1.A Structure of matter	Matter exists as different substances that have observable different properties.	Because matter exists as particles that are too small to see, matter is always conserved even if it seems to disappear.	The fact that matter is composed of atoms and molecules can be used to explain conservation of matter.	N/A
PS3.A Definition of energy	N/A	Energy can be converted from one form to another form.	N/A	The total energy within a system is conserved.

Appendix II. Related Science Practices in the Next Generation Science Standards

Asking questions and defining	We wondered how much of an impact our carbon footprints really had on the environment, and how we could take steps to reduce it. We also wondered how many actual pounds of CO2 were being put in the air by individuals over the course of a month.
Developing and using models	We created the footprint model to represent how much CO2 each person put into the atmosphere.
Planning and carrying out investigations	We had to decide the best way to collect our data and display it.
Analyzing and interpreting data	We took the data we collected from eighty students and analyzed it. We decided which information was relevant and what the results meant.
Using mathematics and computational thinking	We calculated how many pounds of CO2 were put in the air by students in one month, and the projected amount put in the atmosphere by teachers and MSU students in one month. We also calculated our own individual carbon footprints, graphed the individual contributions from heating, electricity, and transportation, and then compared our graphs to other students.
Constructing explanations and designing solutions	We explained how carbon dioxide gets into the air, and the ways in which our daily activities caused this. We also explained how to reduce a carbon footprint. Students designed solutions for lessening their impact on the environment by choosing activities that required less burning of fuels - air drying dishes, ride-sharing, using a radio for noise at night instead of a TV.
Engaging in argument from evidence	If every person makes a change, it can make a huge difference on a global scale. Individual graphs of student use could also be used to have students engage in argument from their own evidence. For example, the graphs might show that students who had large carbon footprints had a huge contribution from transportation while students with small footprints used little energy for transportation.
Obtaining, evaluating, and communicating information	The visual display communicates the information.

Dig into Gardening Using NGSS Science Practices and Crosscutting Concepts

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You can study plants outside with your students AND complete Science Grade Level Content Expectations using the new Science Practices and Crosscutting Concepts of the Next Generation Science Standards This article demonstrates how you can accomplish all of this while "Digging in the Garden". Included are several elementary GLCEs and Disciplinary Core Concepts of the NGSS and activities from some of the best Environmental Curriculum Guides and Activities involving Garden and Plant Activities.

Teaching in a Garden involves new avenues of learning. You are all set to dig in if you have a rain garden, butterfly garden or farm garden on your school property. If not, find a sunny patch, place railroad ties around the perimeter, fill the space with soil, plant wild flowers or vegetable seeds and get ready to watch them grow and study them. Students will relish studying in a new place. Learning will be remembered when students participate and DO LEARNING! Leave the classroom and go outside where the air is fresh and invigorating.

Here are some tips to help you get started with trips outside. Introduce students to garden trips gradually. Take them out 5 minutes at first. Prepare students for the topic prior to your garden tour. Gradually increase your time in the garden and observe growth in detail. 1/2 of the class can be working in the garden and the other 1/2 reading or journal writing. Have them notice the following:

- Why are plant sprouting up? Were seeds planted?
- Why do some plants look differently than others?
- What do these plants need to grow?

Use data sheets and clip boards to collect information. Pick a favorite plant, draw and measure it. Periodically return outdoors to monitor the growth of the garden plants.

Below are 4 GLCEs that can be accomplished using a Garden. Some excellent activities are included that can be used as whole classroom activities to teach biological concepts or to demonstrate whole class experiments. These activities can also continue this outdoor learning with plant experiments and activities inside the classroom. The activities are listed by GLCEs and ,in parenthesis, the new NGSS Disciplinary Core Concepts with the new grade level that will soon be adopted .

1st Grade

E.ES.01.12 Demonstrate the importance of sunlight and warmth in plant growth. (K-LS1-1 Use observations to describe patterns of what plants need to survive.)

1. "A Plant Begins" , ***AIM Primarily Plants,*** p. 18. Observe and record the growth of plants and what they need to survive. Plant the plants in the garden or at home in the spring.
2. Plants and Water", ***AIMS Primarily Plants,*** p. 93. Activities for teaching that sunlight and water are needed for plants.
3. "What Plants Need to Grow", ***AIMS Primarily Plants,*** p. 139. An experiment with variables showing 4 requirements that plants need to grow.Records growth of plants.