

Benefits and Methods of Integrating Geospatial Technology in both
Educational and Professional Realms of STEM Education

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Abstract

In the ever-present search for betterment, technology offers many benefits that have never been seen before, namely accessibility and engagement. Technology is accessible to almost anyone, anywhere in the world. The proper use of technology can capture the interest of the student and ensure engagement. This can be accomplished without regard to location, time-zone, political standing, even language barriers are becoming less impenetrable. With the rise of mobile device usage, a person can access information from the middle of a farmer's field, to the middle of an elementary classroom and everywhere in-between. This project examines how global positioning technology systems including standard GPS and Google mapping technologies can be used to enhance understanding of the physical and natural world. The present work is based on several current educational theories including Place-based education, Citizen Science, and 21st Century Science Skills. Close scrutiny of current policy and research documents around STEM (science, technology, engineering and mathematics) teaching and learning standards inform this project. A website was developed to collate and share geospatial technology resources for teachers and learners in academic (middle school appropriate) and professional settings. The site: <http://eldergoff.wix.com/gps-gps> is a repository of links to teaching helps and informational pages on education in science, notably geospatial technology for classroom and practical use. A full literature review is available on the website which also includes many interactive tools.

Introduction and Background Statement

“Three major technology revolutions [broadband connections, social media and mobile connectivity] have occurred during the period the Pew Research Center has been studying digital technology –15 years—and yet more are on the horizon” (Pew Research Center, 2014).

This work comes at a time when the world is undergoing major change. “Three technology revolutions” have changed the way the world processes information for daily understanding. As technology continues to usher in dramatic changes in computing, relating and processing of information, teachers and consumers of this information must also change the way they access and use it. The present work is designed to contribute resources to everyday users of information and technology obtained from and for simply exploring the natural world. A theoretical framework based on place-based education, 21st century skills and citizen science has been used to shape a website—the major tool/medium presently used to collect information—that contains resources for users.

Positional Statement

I am a trained and certified Physics and Mathematics teacher. I have eight years teaching experience in middle school, high school, and university. I am no longer a classroom teacher. I am in government service, leading and training some of our nation’s most promising young men and women. This unique situation allows me two vastly different perspectives to draw from – my educator role and my professional role.

As an educator, my main focus was on bringing students to understand how to look at a problem productively, draw on prior knowledge to understand the problem, and how to effectively implement learned methods to solve the contrived problem. Bloom’s Taxonomy labels these levels as Knowledge and Comprehension. According to Krathwohl (2002) Bloom’s original 1950s era taxonomy was much more complex and useful for determining congruence with larger ideals of learning than is currently being projected. Knowledge itself was described as specific, universal, based on abstract ideas

and very concrete conventions and goals. Comprehension could be measured through translation, interpretation or extrapolation. Unfortunately, learning goals and objectives in today's landscape of thinking about school and schooling are not that detailed. Somehow, knowledge and comprehension are discounted when perhaps this sterile environment allows students to experiment with their learnings and try their ideas in a setting with little to no risk. Many educators ignore these foundations in pursuit of higher-order thinking (application, analysis, synthesis and evaluation) outcomes. Building knowledge and comprehension in the ways that Bloom (and his contemporaries) originally intended are appropriate and worth revisiting.

As a professional outside the classroom, my main focus is to capitalize on the learning that my comrades gained in the classroom and bring them to higher levels of understanding. This includes applying their knowledge in new and creative ways, analyzing and understanding why what they did either succeeded or failed, synthesizing their efforts and knowledge with other teams and continually evaluating their methods to identify areas of potential improvement. This project is directed to the effective teaching of and beneficial use of the Global Positioning System (GPS). I have created a website with information for both educators and learners to better understand not only what GPS is, but where it comes from, how to teach it, and how to use it in varying situations.

As you read this paper you will begin to identify ways your classroom and your life can benefit from this area of technology. You will be introduced to several paradigm-shifting ideas regarding the use of technology in and out of the classroom. In the next section, I will review scholarship related to my theoretical framework, and open your view to the leading researchers on this topic.

Literature Review and Theoretical Framework

I have enjoyed extensive research into the world of Global Positioning Systems, Education, and how the two can be harnessed for the benefit of all. I learned a lot about GPS and how it works, and even more about how to share that knowledge with others. The big questions are why is this knowledge important and why should someone care about it? The simple answer is that knowledge is power, and having that power in your hand via a GPS unit can be the difference between success and failure, even life and death. A brief overview of Bloom’s deconstructed views about knowledge is important. Table 1. (adapted from Krathwohl, 2002, p. 213) provides a description of knowledge based on Bloom’s 1956 taxonomy.

Table 1 Structure of Knowledge based on Blooms' 1956 Taxonomy

Knowledge of specifics	Knowledge of ways and means of dealing with specifics	Knowledge of universals and abstractions in a field
<ul style="list-style-type: none"> • Terminology • Specific facts 	<ul style="list-style-type: none"> • Conventions • Trends and sequences • Classifications and categories • Criteria • Methodologies 	<ul style="list-style-type: none"> • Principles and generalizations • Theories and structures

A study of pre-service teachers in Turkey noted the benefits of using a revised version of Bloom’s Taxonomy in their lesson planning (Bümen, 2007). *Knowledge of ways and means of dealing with specific information* has particular relevance to 21st century learning around the globe. Successful learning in today’s world depends on one’s ability to choose from a wide array of tools, methods and information quickly. In the years since it was first introduced as a tool to outline learning objectives, knowledge has been further deconstructed to distinguish factual, conceptual, procedural and metacognitive components for cognitive processes. Specific tasks associated with each type of knowledge help learners identify for themselves which aspects of a new field they understand. “Based on examination of knowledge and cognition, teachers can decide where and how to improve the

planning of curriculum and the delivery of instruction” (Krathwohl, 2002, p. 218). For this reason, I posit that knowledge is an acceptable starting point for work with teachers and professionals around geospatial technologies. Furthermore a website of resources that can be used to build knowledge for teachers and students in both academic and professional contexts makes sense for practical use of theory and tools.

Technology in the Classroom

Many studies have been accomplished showing strong correlation between training teachers to effectively use technology for the purpose of increasing student engagement and performance in science. In the ever-present search for betterment, technology offers many benefits that have never been seen before, namely accessibility and engagement. Technology is accessible to almost anyone, anywhere in the world. The proper use of technology can capture the interest of the student and ensure engagement. This can be accomplished without regard to location, time-zone, political standing, even language barriers are becoming less impenetrable. With the rise of mobile device usage, a person can access information from the middle of a farmer’s field, to the middle of an elementary classroom and everywhere in-between (Patterson, 2007; Pew Research Center, 2014).

Harnessing this global audience and feeding mankind’s desire for knowledge, a resource website was created that can guide both educators and learners to a more beneficial experience with GPS. As I studied science standards and teaching trends, I realized that there is much to be done to improve student engagement in the classroom. One way to enhance this is to educate the educators so they are not timid in sharing information and techniques about the proper and beneficial use of technology in everyday use (McClurg & Buss, 2007). A teacher that does not have the knowledge about the subject cannot teach with power. In order to equip the learner with a thirst for learning, this education must take place at the earliest levels. Based on their sample of students in grades 5 through grade 12, not only did students have an increased desire to improve, but they learned more effectively and more

completely. In this instance, as well as in my own experience as a teacher, it has been shown that comprehension, retention and engagement were markedly improved when technology was not only available but encouraged and taught.

Standards for Teaching and Learning Science

Recognizing the ever-evolving world of education and the necessary inter-twined nature of it with technology, there have been several movements to reform the standards governing teaching in general but also science teaching more directly. Beginning with the National Academies Press' Framework for K-12 Science Education (Framework), moving to the Next Generation Science Standards (NGSS) and the International Society for Technology in Education's Standards for Students (ISTE-S) and Teachers (ISTE-T), the reform has been universal in voice – technology is here to stay and must be properly managed to promote learning and success (Stage, 2013).

The Framework is based on three key areas called dimensions. First there are core ideas, or ideas and information for each specific content area. Then there are Science and Engineering practices, encouraging and enabling more than just learning content but expecting students to understand the methods of scientists and engineers. Finally there are cross-cutting concepts or ideas that are found in more than one of the topics (Keller, 2012). The NGSS, based on the Framework, breaks out the ideas introduced in the Framework and formally forms standards for science education (Krajcik, 2012). ISTE-T focuses on integrating the available technology into the learning environment with standards being Student Learning and Creativity, Digital Age Learning Experiences and Assessments, Digital Age Work and Learning, Digital Citizenship and Responsibility, and Professional Growth and Leadership. The Student version describes the skills and knowledge they need to learn effectively and live productively in an increasingly global and digital society (Crompton, 2014).

To facilitate students' learning of concepts and content identified in the standards, teachers all over the world find themselves striving to integrate technology into their classrooms (Gatrell, 2004).

Focusing on the use of Geographic Information Systems (GISystems or GIS) in and out of school can extend borders to encompass the entire planet. GoogleMaps is a tool that can be used both at home and at school with similar benefit. A well-prepared teacher can encourage and demonstrate the many facets of and tools found within GoogleMaps, leading students to find interest in the world around them. Custom maps can be prepared and shared with the class, and everyone can contribute. These maps are constantly being updated with new information collected by satellite, city planners, and even end-users. The utilization of these tools requires an internet connection, which can be a limiting factor in some places. Being such an accessible medium requires a heightened level of wariness, because much of the information provided is not necessarily verified or filtered (Patterson, 2007). Nevertheless, if a major goal of teaching and learning is to engage students more often and to enable broader participation as citizens of science, it makes sense that the level of caution that might otherwise be exercised in the classroom could be reasonably diminutive.

Taking education out of traditional classrooms and into a dynamic, applicable setting is being accomplished all over the world with measured increase in engagement, comprehension, and retention. Based on data from 1999, the percent of public school teachers in the United States who reported using computers in the classroom is high when there are multiple computers in the classroom. While it is beyond the scope of the present project to more closely scrutinize these data, it is highly likely that there is a positive trend in computer use in the classroom for the purpose of engagement given the ubiquity of technology tools available, including mobile connectivity (Pew Research Center, 2014).

Table 2 Percent Public School Teachers Using Computers for Classroom Assignments (1999) from National Center for Education Statistics

Activities	Number of computers available in the classroom		
	One	2-5	More than 5
All public school teachers	43	45	12
Solve problems/analyze data			
Not at all	59	40	23
Small extent	20	26	29
Moderate extent	16	26	27
Large extent	5	9	21
Word processing/spreadsheets			
Not at all	45	33	14
Small extent	19	20	21
Moderate extent	21	24	23
Large extent	15	23	42
Drills/practice			
Not at all	61	37	21
Small extent	21	20	23
Moderate extent	14	26	26
Large extent	4	18	30

Critical juncture: Place-based education & Citizen Science

Place-Based Education is used when speaking of learning ideas that are personally relevant to the student in a setting that is native to the content being taught. Teaching GPS by lecturing is far less effective than teaching GPS by allowing students to use the technology to solve real-life problems in real-life situations. Joining in large projects that extend far beyond the reach of the school, school district, or even country is the idea of Informal or Citizen Science. There are thousands of research projects available for people of any age, education level, and interest to take part in. Engaging citizens allows scientists to have a much further reach in their research and makes it possible for regular people to participate in the act and discovery of science. Conducting research either for yourself or in conjunction with a larger project requires knowledge of modern technology and methods. Twenty-first Century Science Skills encompass what is necessary for a student to become able, contributing members

of the science community. These are: Information Literacy, Collaboration, Communication, Creativity and Innovation, Problem Solving, and Responsible Citizenship.

Given all of the standards and skills available for teachers and learners, there is no reason that the up-and-coming generation of scientists will not be ready for the challenges they will face. As long as the pursuit of knowledge remains the focus of all instruction and guides every lesson, we will be enabling the future to be a bright, wonderful place.

Description of Plan B Product (Teaching and Learning Website)

<http://eldergoff.wix.com/gps-gps>

Rationale

To provide a useful and information-packed tool for educators and learners, I felt I needed a medium that was accessible to anyone, anytime, from anywhere – including mobile devices. With this in mind, I created a website entitled “Goff’s Practical Solutions – Global Positioning Systems” found at <http://eldergoff.wix.com/gps-gps>. Having designed several websites both for my classroom and businesses of friends and family, I looked for a website host that would meet my design needs and be cost effective. I decided to use Wix.com as my host because of the many integrated user improvements they provide and the fact that their services are free. These include easy to instigate mobile-friendly layouts, drop-down menus, flash-loaded picture galleries, integrated linking to social media, and a variety of applications to make the building of and final look of the site more appealing.

Organization of Site

The site begins with a simple Home page stating the purpose of the website as “Making GPS easy and effective for teachers and learners alike,” with the description “A compilation of GPS related websites, research, and information to help teachers teach GPS, and learners understand why GPS is so integrated in our world and how they can harness it for their benefit.” Immediately one understands

the two visions of the website: To provide resources to better enable teachers to present GPS, and to provide interesting learning activities enabling learners to gain a useful understanding of GPS. The menu at the top is equally simple with links entitled: 'Home', 'For Educators', 'For Learners' and 'More Info'.

Following the 'For Educators' link you are led to the Educator Resources page, with links to Educational Research, information about GPS, and all about Google Maps. Under the 'Educational Resources' page you are presented with a brief introduction to Place-Based Education, Informal/Citizen Science, and 21st Century Science Skills. Each of these sections includes a brief description of the educational practices, and a short list of key websites. The 'All About GPS' link leads you to a trove of information classified into groups entitled What is GPS, How to Teach GPS, and GPS Teaching Tools. Finally, the 'Google Maps' page includes all you ever wanted to know about Google Maps and more – with links. I chose to make Google Maps a main focus of the site because of the many different ways that Google Maps can share information with you. There are several types of base maps available such as Political, Satellite, and Picture maps. There are also many different layers of information you can add to each map, including terrain, current and trending traffic, transit routes with current locations of busses and trains as well as daily schedules, bicycling and hiking trails shown, and of course boundaries of neighborhoods, cities, states, forests, countries and more.

Diving into the 'For Learners' links you find an 'All About GPS' link as well, along with the 'Google Maps' page, but you also find a page with activities to help one learn and enjoy using GPS. This page offers links to GeoCaching sites, articles on engaging games to play using your GPS, interesting ideas to do on a date involving GPS, and more.

In the 'More Info' section you will find a list of the websites that I referenced in building the website as well as links to education standards. The 'References' page is categorized into six sections: Place-Based Education, Citizen Science, 21st Century Science Skills, GPS Information, GPS Teaching, and

Using GPS. I researched not only websites but publications and articles, including a video lecture, all of which are linked to here. On the 'Standards' page I share links to the Next Generation Science Standards, National Academies Press' Framework for K-12 Science Education, and International Society for Technology in Education's Standards for Students and Teachers. I offer some personal information on the 'About Me' page along with a link to my in-progress web-site featuring my travels in Turkey. There is a 'Contact' page where you can send an email message to me, and finally there is a 'Terms of Use' page releasing me from copyright liability of any information found on my site or any of the sites that are linked on my page.

This project is accessible to anyone with an internet connection, either on a computer, phone, tablet, or Smart TV. The information that I share can help teachers and learners better understand the full capabilities of GPS and be able to apply it in new areas, analyze the benefits of their GPS usage, synthesize their new-found skills with others to better the education community as a whole, and evaluate how GPS is enhancing their work.

The website will be updated as new resources are identified and methods recognized. Appendix B is the slideshow that was presented during the Plan B Project Defense. At the end, there is a copy of much of the website as it was on 23 April, 2015.

Lesson Plan / Resource for Students

Below is a copy of a lesson plan stemming from many ideas presented in the paper.

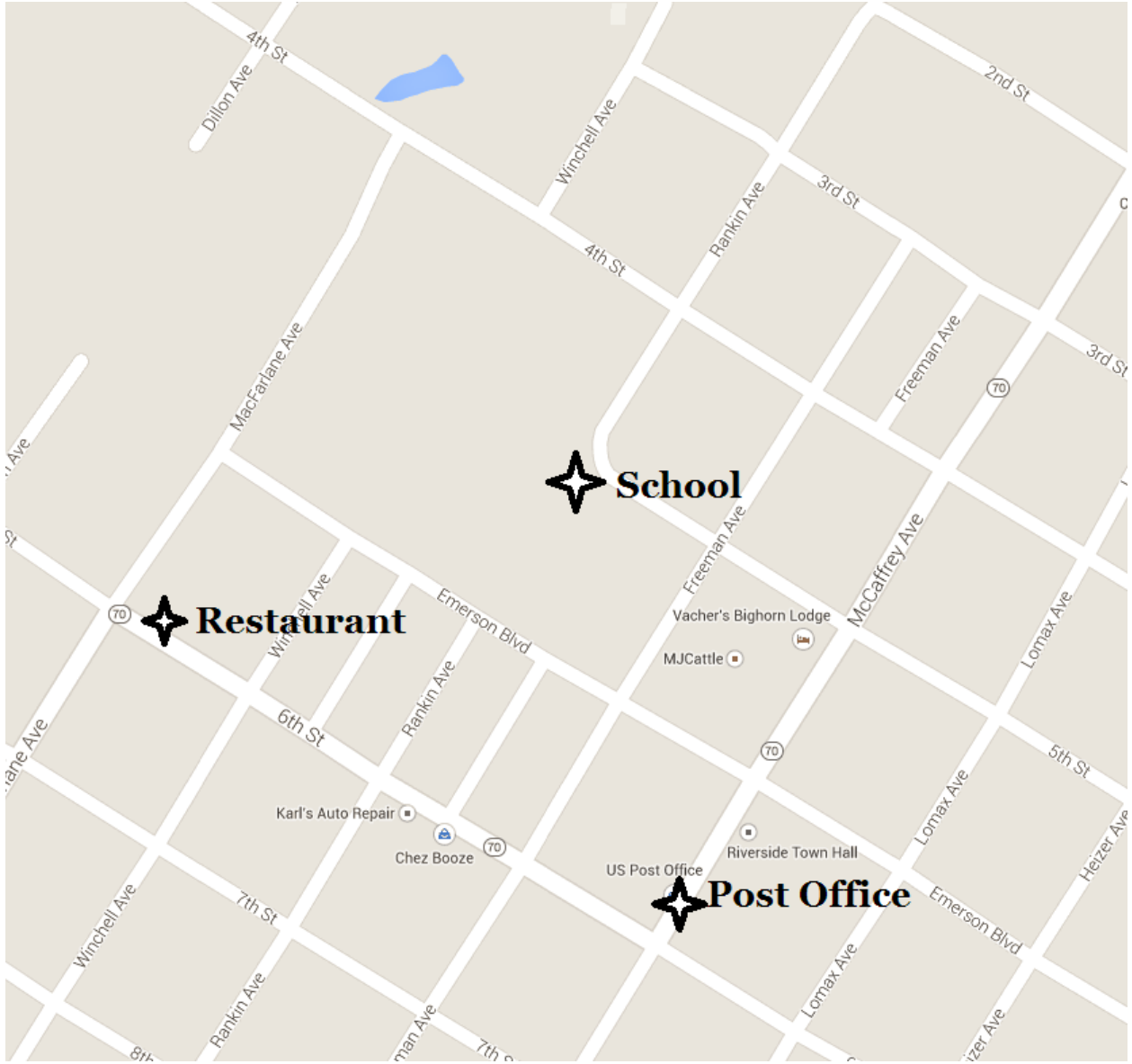
Course Title 7th Grade Physical Science	Lesson Date 05/01/2015
Unit Measurement	Specific Topic Linear measurement
NGSS Objective MS-ETS1-2,	
Daily Objective(s) 1. Using a GPS, verify estimated distances 2. Place coordinates on an online map 3. Measure distances on an interactive map	Rationale 1. (Compare 2. Tactile 3. Measure)
Lesson Content – Pages in book N/A	
Instructional Procedures	Minutes
Starter: Perimeter of a box with given dimensions	2
Quiz: Approximately place 8 cities given only their GPS coordinates on a world map	10
Introduction: With a GoogleMap of Encampment on the Smart Board, map the approximate distances between the school, the Post Office, and the Cathouse Restaurant	5
Instruction: How could we find out exactly? Range finder, wheel, measuring tape, pacing, GPS	5
Learning Activity: Let's discover how far it really is, using only GPS - Given a city map of Encampment Wyoming, and a GPS device with which they are already familiar, the task is to record coordinates as precisely as the instrument allows and place the information on the map. - Students are in groups of two or three - chosen by the teacher - One runs the GPS, one records, and one directs - changing roles at each stop - Once returned, transfer information to GoogleMaps -- Placing and labeling pins at each point recorded on their walk -- Using the "Measure" tool, draw lines between each pin and record the distance	40
Change of Pace Activity: N/A	
Learning Activity: N/A	
Evaluation Quiz: Tomorrow - What does GPS mean? Name 5 ways it is used in your life Homework: Try it again at home, do your fence line, your access road, your irrigation ditches, etc... Test Prep Questions:	
Materials Needed <ul style="list-style-type: none"> ● 6 Hand-held GPS devices (Phones, Garmin, etc...) 1 per group ● Map of Encampment for each student (attached) ● Student worksheet 	

Student Worksheet

Encampment GPS measurements

Group members

1. What is the estimated distance determined in class in meters?
 - a. School to Post Office
 - b. Post Office to Cathouse
 - c. Cathouse to School
 - d. Total
2. Which device are you using?
3. Record the following GPS coordinates
 - a. School front steps
 - b. Post office front step
 - c. Cathouse front sign
4. Mark and label the GPS coordinates on your GoogleMap
5. Calculate the distance via GoogleMaps using the 'Measure' function in meters
 - a. School to Post Office
 - b. Post Office to Cathouse
 - c. Cathouse to School
 - d. Total
6. What is the difference between the estimated distances and the measured distance?
7. Explain the difference



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Appendix A: Literature comparison notes

Study Info (Author, Year, Title) / Publication Info	Research Question Explored by Study	Relationship to present study	Participants	Methods	Findings
Alexander, Bryan. "Web 2.0: A new wave of innovation for teaching and learning?" <i>Educause review</i> 41.2 (2006): 32.	Web 2.0 is a new, social media-centric application of the internet	21 st c. skills	n/a	Theoretical	<ul style="list-style-type: none"> - Social media has reshaped the use of the internet - The access to so much information so easily is hard to compete with - The evolving nature of being able to share your information with the world leads one to share and read others work - The microcontent – one-line headlines – makes it easy to gather information quickly - Sharing information via the internet is much easier than presenting it in person - The web will continue to become more prevalent in everyday life, social life, business life, and education - Grasping on to this technology driven freight train and learning to harness its power to your advantage can make or break your project or lesson
Study Info (Author, Year, Title) / Publication Info	Research Question Explored by Study	Relationship to present study	Participants	Methods	Findings

<p>Wilson, Scott, et al. "Personal Learning Environments: Challenging the dominant design of educational systems." <i>Journal of e-Learning and Knowledge Society</i> 3.2 (2007): 27-38.</p>	<p>Identify strategies for implementation of educational systems emphasizing symmetric connections.</p>	<p><i>Bloom's taxonomy</i></p>	<p>n/a</p>	<p>Theoretical</p>	<ul style="list-style-type: none"> - Learning Management Systems are not being built to fulfil the needs of the classroom - Many personal information systems (wikis, blogs, social software) are not being utilized constructively, and many are not accessible on the school computer systems - Very clear distinction in the capabilities of the learners and the teachers -- Teachers are encouraging innovation, but don't accept or understand the technology available for this -- Students are hesitant to go full throttle because if a teacher doesn't understand the methods, they won't understand the content - As we move forward, LMS will have to follow trends in internet use and maintain a strong component similar to that which is being used in mainstream society to remain a viable option for education
Study Info (Author, Year, Title) / Publication Info	Research Question Explored by Study	Relationship to present study	Participants	Methods	Findings

<p>Patterson, Todd C. "Google Earth as a (not just) geography education tool." <i>Journal of Geography</i> 106.4 (2007): 145-152.</p>	<p>Show the utility of Google Earth as a tool for geography education</p>	<p>Place-based education 21st c. Skills</p>	<p>South Carolina 7th Graders</p>	<p>Lesson plan</p>	<ul style="list-style-type: none"> - Geographic Information Systems (GISystems) are underutilized in the classroom due to lack of: <ul style="list-style-type: none"> --- time --- training ---desire to change method of teaching --- access to appropriate hardware --- separation of disciplines in schools that make it hard to integrate GISystems into teaching schedule - Advantages to Google Earth in the classroom <ul style="list-style-type: none"> -- Extend borders of classroom all around the world -- Can be used at home -- Many layers are available and can be customized to the lesson -- Continuously updated information and platform - Disadvantages <ul style="list-style-type: none"> -- Requires internet access and good bandwidth -- Content not verified -- Time consuming – easily distracting especially for students not in the classroom
Study Info (Author, Year, Title) / Publication Info	Research Question Explored by Study	Relationship to present study	Participants	Methods	Findings

McClurg, Patricia A., and Alan Buss. "Professional development: Teachers use of GIS to enhance student learning." <i>Journal of Geography</i> 106.2 (2007): 79-87.	Will teachers value the technology tools enough to warrant the time required to learn the skills	21 st c. Skills	5 th through 12 th grade classrooms	Professional development (PD) exercise	<ul style="list-style-type: none"> - GIS is important for -- Complete in-depth studies of local issues and phenomena -- analyzing conditions and changes in environment and drafting solutions -- deepening student interest in geography through the technology used and information gathered via GIS -- introducing technology at an early age promotes continued use later in life
Terri Teal Bucci, Susan Cherup, Ann Cunningham & Anthony J. Petrosino. "ISTE standards in teacher education: A collection of practical examples." <i>The Teacher Educator</i> 39.2 (2003): 95-114.	A guide to integrating technology into teacher education	21 st c. Skills	4 ISTE Award-winning programs	Teacher development guide	<ul style="list-style-type: none"> - ISTE standards give guidelines on how teachers can be effective in integrating technology in the classroom - These standards have been used to reform countless teacher education programs by making use of technology - Training teachers how to use technology before entering the classroom can be practical and effective
Study Info (Author, Year, Title) / Publication Info	Research Question Explored by Study	Relationship to present study	Participants	Methods	Findings

<p>Nilay T. Bümen. "Effects of the Original Versus Revised Bloom's Taxonomy on Lesson Planning Skills: A Turkish Study Among Pre-Service Teachers."</p> <p><i>International Review of Education</i> 53.4 (2007): 439-455</p>	<p>The revised version of Blooms Taxonomy has a beneficial difference in lesson planning</p>	<p><i>Bloom's taxonomy</i></p>	<p>Pre-service Turkish teachers</p>	<p>Lesson planning skills with old and new systems utilized</p>	<ul style="list-style-type: none"> - Blooms Taxonomy is evolving and a revised system exists - This revised edition has a number of advantages
<p>Sinem Iskeceli-Tunc, Diler Oner. "Use of webquest design for in service teacher professional development."</p> <p><i>Education and Information Technologies</i> (2014-04-02): 1-29.</p>	<p>Will teaching teachers to use WebQuest improve their technological and pedagogical skills?</p>	<p>21st c. Skills</p>	<p>6 in service teachers</p>	<p>PD module</p>	<ul style="list-style-type: none"> - Web searching and evaluating skills - Develop/improve definition for higher-order thinking Web design - Training improved teachers' skills in all areas and a working definition for higher-order thinking adopted - Teachers produced activities and lessons to promote students' HOT - In service teachers should participate in well-designed PD
<p>Study Info (Author, Year, Title) / Publication Info</p>	<p>Research Question Explored by Study</p>	<p>Relationship to present study</p>	<p>Participants</p>	<p>Methods</p>	<p>Findings</p>

Denise Tatar, Mike Robinson. "Use of the Digital Camera to Increase Student Interest and Learning in High School Biology." <i>Journal of Science Education and Technology</i> 12.2 (2003): 89-95	Does the use of technology in classroom motivate students to take greater interest in lab work and increase learning?	21 st c. Skills Citizen Science	Two urban high-school biology classes	Control group and test group – one group with digital cameras and one without	<ul style="list-style-type: none"> - Technology can radically change what and how we do it, and can amplify or extend that - Digital camera use increased learning of process skills - Tech-enabled group took more care to set up experiment than other group - Tech-enabled group made fewer mistakes in lab procedures
John M. Ritz, Szu-Chun Fan. "STEM and technology education: international state-of-the-art." <i>International Journal of Technology and Design Education</i> (2014-10-08): 1-23.	How are different countries perceptions of STEM education discussions effective?	21 st c. Skills	20 international technology education scholars' papers	Survey research	<ul style="list-style-type: none"> - Some countries believe STEM education is best done by separating the four subjects - Some feel they should be integrated - Many believe it is a combination - Researching STEM education because it is a means to improve performance - Little action has been made to modify educational systems to better deliver - Countries are providing PD to teachers
Study Info (Author, Year, Title) / Publication Info	Research Question Explored by Study	Relationship to present study	Participants	Methods	Findings

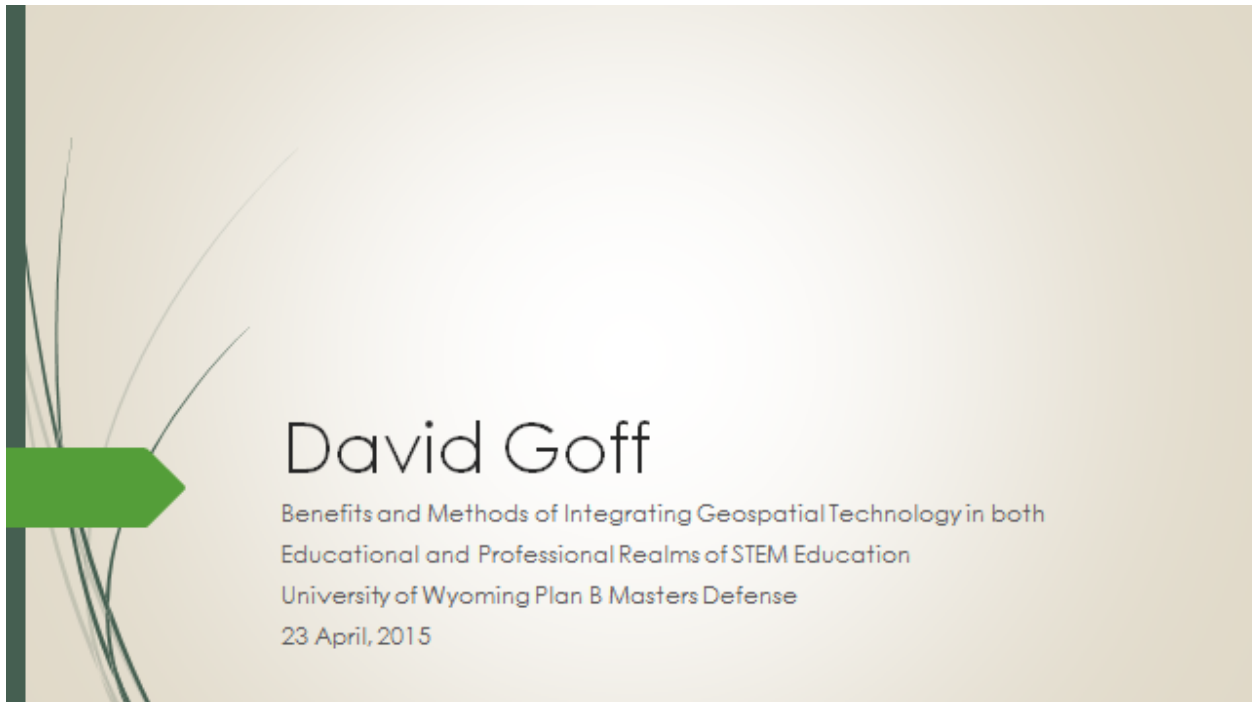
Jay D. Gatrell. "Making Room: Integrating Geotechnologies into Teacher Education." <i>Journal of Geography</i> 103.5 (2004) 193-198	Integrating ISTE NETS for Teachers should complement and support current efforts	21 st c. Skills	n/a	Theoretical	<ul style="list-style-type: none"> - Using existing standards like 1994 Geography for Life standards as content standards for new teachers is essential - Alternate framework is proposed infusing GIS and GIScience into teacher education programs - ISTE NETS used to modernize teacher education and standards
Crompton, Helen. "KNOW THE ISTE STANDARDS." <i>Learning & Leading with Technology</i> (2014).	Knowing the standards: How do we learn them?	21 st c. Skills	n/a	Theoretical	<ul style="list-style-type: none"> - Giving three different "Activities" at different quality of delivery - Exercising creativity is one of the best ways to gain a deep understanding of concepts
Nicole D. LaDue, Cheryl Brown Manning. "GROUNDWORK: Next Generation Science Standards: A call to action for the geoscience community." <i>The Geological Society of America</i> 25.2 (2015): 28-29.	How to ensure university geology departments continue to receive a steady stream of majors?	21 st c. Skills Citizen science	n/a	Theoretical	<ul style="list-style-type: none"> - NGSS are critical, but require support of geoscientists nationwide - State-level support needed to implement NGSS successfully - NGSS emphasize earth-science topics more than ever before - Up-to-date topics - Increased rigor and prominence of earth-science content in K-12 classrooms
Study Info (Author, Year, Title) / Publication Info	Research Question Explored by Study	Relationship to present study	Participants	Methods	Findings

<p>Tamara J. Moore, Kristina M. Tank, Aran W. Glancy and Jennifer A. Kersten. "NGSS and the landscape of engineering in K-12 state science standards." <i>Journal of Research in Science Teaching</i> 52.3 (2015) 296-318</p>	<p>What is the extent and quality of the engineering that is present in state science standards and the NGSS?</p>	<p>21st c. Skills</p>	<p>Academic State Standards and NGSS</p>	<p>Compare and contrast</p>	<ul style="list-style-type: none"> - NGSS and Framework for K-12 Science Education are shaping the future of science education - In-depth look into the suggestions given by the new standards
<p>Okhee Lee, Emily C. Miller, Rita Januszyk. "Next Generation Science Standards: All Standards, All Students." <i>Journal of Science Teacher Education</i> 25.2 (2014) 223-233.</p>	<p>Are the NGSS without bias and applicable to all students?</p>	<p><i>Science, technology, society</i></p>	<p>Seven case studies of diverse student groups</p>	<p>Case studies, reviews of standards, written appendix</p>	<ul style="list-style-type: none"> - Ensures all standards are equitable and without bias - Suggestions and directions on how to make the standards accessible to all - As the nation accepts NGSS, diversity will continue to be an important issue

Study Info (Author, Year, Title) / Publication Info	Research Question Explored by Study	Relationship to present study	Participants	Methods	Findings
<p>Nargund-Joshi, Vanashri, et al. "Understanding meanings of interdisciplinary science inquiry in an era of Next Generation Science Standards." annual meeting of National Association for Research in Science Teaching, Rio Grande, Puerto Rico. 2013.</p>	<p>A framework for understanding Interdisciplinary Science Inquiry for science teaching and learning in the K-12 classroom</p>	<p>21st c. Skills Citizen Science</p>	<p>Scientists from varied disciplines</p>	<p>Interviews and lit review</p>	<ul style="list-style-type: none"> - Integrate ideas of science and engineering practices - Interdisciplinary inquiry teaching with focus on engineering in the classroom - Built to support teachers w/ a framework for understanding - Science and Engineering Practices - Crosscutting Concepts - Disciplinary core ideas - Drivers of Interdisciplinary Research
<p>Subramaniam, Mega, et al. "Crosswalk between the "Framework for K-12 Science Education" and "Standards for the 21st-Century Learner": School Librarians as the Crucial Link." <i>School Library Research</i> 16 (2013).</p>	<p>How can a librarian facilitate the learning of standards, skills, dispositions, and responsibilities w/r to the Standards and the Framework?</p>	<p>21st c. Skills</p>	<p>4 School librarians</p>	<p>Design-based research</p>	<ul style="list-style-type: none"> - Librarians are a key link between information and students - Shows links between the Framework and Standards - Analyzed librarian's work and their study, and how they serve as a link between students and information - Focuses on many roles that librarians play

Study Info (Author, Year, Title) / Publication Info	Research Question Explored by Study	Relationship to present study	Participants	Methods	Findings
Stage, E. K., et al. "Opportunities and challenges in next generation standards." <i>Science</i> 340.6130 (2013): 276-277.	How do the new Common Core State Standards, English Literacy Standards, and the emerging NGSS coincide with and complement each other?	21 st c. Skills Citizen Science	n/a	Theoretical	<ul style="list-style-type: none"> - Showing interdependency of NGSS, Common Core, and English standards - Stresses integration of all standards - Includes Venn Diagram w/ Math, Science, and English Literacy
Keller, Thomas E., and Greg Pearson. "A Framework for K-12 Science Education: Increasing Opportunities for Student Learning." <i>Technology and engineering teacher</i> 71.5 (2012): 12-18.	How can understanding the process leading to the Framework improve education?	21 st c. Skills	Various STEM teachers	Teacher education	<ul style="list-style-type: none"> - Delve into framework - Offers steps for teacher improvement - Articulates vision for science education
Krajcik, Joseph, and Joi Merritt. "Engaging students in scientific practices: What does constructing and revising models look like in the science classroom? Understanding a framework for K-12 science education." <i>The Science Teacher</i> 79.3 (2012): 38.	What does constructing and revising models look like in the Science Classroom?	21 st c. Skills Citizen Science	n/a	Theoretical	<ul style="list-style-type: none"> - Review of new NGSS - What does the model making mean for classroom teaching? - Models are external representations of mental concepts - Diagrams, 3-D structures, mathematical formulations, computer simulations...

Appendix B: Plan B Project Defense Slideshow



David Goff

Benefits and Methods of Integrating Geospatial Technology in both
Educational and Professional Realms of STEM Education
University of Wyoming Plan B Masters Defense
23 April, 2015

The slide features a light beige background with a dark green vertical bar on the left. A green arrow-shaped graphic points to the right, containing the number '2'. The text is centered on the right side of the slide.



2

Introduction

- About Me
- My research
- My product – eldergoff.wix.com/gps-gps
- Lasting Benefits
- Questions

The slide features a light beige background with a dark green vertical bar on the left. A green arrow-shaped graphic points to the right, containing the number '2'. The text is centered on the right side of the slide.

3

About Me

- Family
- Education and Certificates
 - Physics and Mathematics
 - Teaching
 - SMTC
- Teaching Career
 - Middle and High School
 - University
- United States Air Force
 - Officer Corps (Trainers)
 - Enlisted Corps (Trainees)
- Future Plans

2

Introduction

- || My research
 - || Abstract
 - || Theoretical Framework
 - || Literature Review
 - || PBE, Citizen Science, 21st Century Science Skills
 - || Standards
- || My product – eldergoff.wix.com/gps-gps
- || Lasting Benefits

5

Place-Based Education

- Taking teaching outside the classroom
 - Utilizing the community to add meaning to education
 - Engaging students in hands-on, beneficial projects
 - Supporting PBE with classroom instruction
 - Supporting classroom instruction with PBE
- Moving from static to dynamic teaching realms
 - Broaden teacher base
 - Capture interest of more students
- Increase learning
- Decrease discipline issues

6

Citizen Science

- Integrating classroom instruction with world-wide research projects
 - Student centered data collection
 - Real results
 - Bigger picture vision
 - Meaningful activities brings engagement
- Benefits to researchers
 - Many more points of data collection available
 - Different points of view available
- Students can create own projects to share

7

21st Century Science Skills

- Skills necessary for 21st Century success
 - Information Literacy
 - Collaboration
 - Communication
 - Creativity & Innovation
 - Problem Solving
 - Responsible Citizenship
- Ever-evolving and adapting

8

Science Standards

- A Framework for K-12 Science Education
 - Cross-cutting Concepts
 - Practices
 - Core Ideas
- Next Generation Science Standards
 - Stemming from the Framework
- International Society for Technology in Education
 - Teachers
 - Students

My Product

<http://eldergoff.wix.com/gps-gps>

- Why wix.com?
- Educator Resources
 - Methodologies
 - What is GPS
 - All about Google Maps
- For Learners
 - What is GPS
 - Google Maps
 - Fun with GPS
- More Info
 - References
 - Standards
 - About Me / Contact / Terms of Use

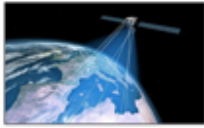
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Making GPS easy and effective for teachers and learners alike

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Straight Forward, Understandable, Useful.
A compilation of GPS related websites, research, and information to help teachers teach GPS, and learners understand why GPS is so integrated in our world and how they can harness it for their benefit.


GPS



GPS - Global Positioning System, using the world-wide group of satellites to find any position using a GPS-enabled device. Used everywhere by consumers, companies, and governments for guiding people anywhere.

[MORE](#)


Google Maps



Google Maps - Using satellite imagery, government supplied plans, and Google imagers, Google Maps provides several views: Political, Terrain, Simple, Street view, and many other valuable flavors.

[MORE](#)

Proven Research



GPS technology has been around a long time, and has proven to be the most useful technology in getting from point A to point B, and many other points in between, since the invention of the compass.

[MORE](#)

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All about GPS - for the Educator

This page will give you some essential resources on teaching GPS to students of all ages. You will find links and articles that will increase your knowledge of GPS as well as interesting and effective teaching tools.

01 What is GPS?

Global Positioning Systems (GPS) technology and dependency is found in nearly every mobile device from phones to cars to airplanes. It allows one to pinpoint a location on the globe using information relayed from a network of satellites. You need to know what it is and how it works in order to teach how to make the best use through its' use.

Links to GPS sites:

<http://www.gps.gov/what-is-gps/> - All about GPS from GPS.gov

<http://www.usgs.gov/edu/gps/gps.html> - Airway Apprend's GPS explanation

<http://www.norad.ca/edu/edu/understand/gps/> - Understanding the Global Positioning System

02 How to Teach GPS

Teaching GPS successfully will require use of non-traditional teaching techniques, many of which are found at my [Teaching Strategies](#) page.

Links to Teaching GPS:

<http://www.julypennsylvania.gov/edu/gps/teach.html> - July Geography's teaching ideas for GPS

<http://www.americancamp.org/edu/gps/teach.html> - American Camp Association's ideas for teaching GPS

<http://www.gps.gov/edu/teaching/gps.html> - Resources for Teachers/Classroom Activities/Classroom Activities/Classroom Activities - A great web resource for teaching GPS.

03 GPS Teaching Tools

The following tools can help you use GPS in the classroom and bridge the gap between classroom and real-world.

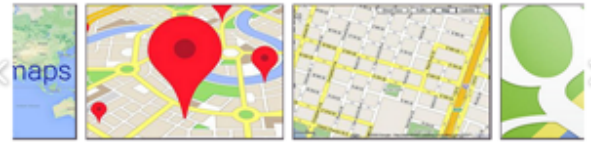
<http://www.google.com> - Google's map site that allows you to chart a course using GPS coordinates.

<http://www.gpsvisualizer.com> - An interactive map website including coordinates in several formats and many tools to explore

<http://www.gpsvisualizer.com> - Find, follow, and create GeoCaches

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based cameras in the hands of citizens and Google vehicles alike.



01 Political Maps - maps that are drawn

Explore the following tools based on Google's political maps:

The simplest view is the political map <http://www.google.com/maps>. This view shows political boundaries, main roads, even businesses as you zoom in. If you click on a name, you will be shown the boundaries of that area, be it neighborhood, city, state, or country.

Try clicking on the ["Show Terrain"](#) option to increase the information given visually. This view allows you to see topography and elevation. Some may call this a 3-D top-down view. This view is quite boring over Kansas.

You can also click on ["Show Traffic"](#) option to show current traffic along larger roads. There are the options of live traffic and typical traffic to be shown. This can be helpful in planning a trip so as to take the best routes at the best time.

A new addition to the Google maps is the ["Bicycling"](#) option (only available in certain areas). This shows bicycle and hiking routes, allows you to plan your commute, to plan an outing, or to design an exercise route.

Another commuter aide is the ["Transit"](#) view. This shows train, bus, and subway routes and stations. You can even click on a station to learn which lines serve that station and when the next vehicle arrives.

Finally, the most popular ["Directions"](#) map that shows you how to get from Point A to Point B, C, D or wherever you need to go. You can choose between several routes, modes of travel, and even add in a [stop for lunch](#). Clicking the details on your Directions map gives you a turn by turn narration on your trip, giving distances and approximate times for each leg of your journey.

02 Satellite Maps - pictures from space with map info

All of the options available in political mode are available in Satellite mode. The benefit to Satellite maps are obvious - you can actually see a top-down (and in many places, a nearly head-on) view of where you are researching. You can tilt the view from a top-down to different angles. You can even rotate the view to look at your destination from a different point of view.

Did you ever wonder what the [Pyramid of Giza](#) really looks like? Or how about the top of [Mount Everest](#)?

<http://www.google.com/maps/earth/outreach/suborbital/images>

03 Picture Maps - photo additions to augment map info

To add to the experience, there are millions of photos linked to Google Maps. Some are provided by Google, and others by citizens [using StreetView](#).

[Street View](#) is Google's repository of billions of photos taken from the famous Google Camera cars. This view allows you to virtually

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GPS Activities

This page offers links to GeoCaching sites, articles on fun games to play using your GPS, interesting ideas to do on a date using GPS, and more.



01 GeoCaching Sites

GeoCaching is a popular activity where you use a GPS to locate a hidden "treasure". There are levels of difficulty from beginner to expert and ranging in complexity between a single coordinate geocache and multiple check-points each with encrypted messages on how to proceed to the next.

Links to Geocache sites:

[GeoCaching.com](#) - The world's largest repository of GeoCaches on the internet, with a top-rated mobile app.

[GeoCaching.org](#) - A free Geocache repository.

[GeoCachingToolbox.com](#) - A comprehensive list of tools to help the Geocacher use any device, including both on-coordinates, understanding text, breaking encryptions / codes / ciphers, conversion tools to and from different alphabets and number systems, and more.

[Original Creative Geocaching Sites](#) - A compilation of creative ideas for geocaches to up the level of difficulty when designing a geocache.

02 Other Creative Ideas for GPS Use

So you know that GPS can be used for navigation, mapping, and GeoCaching, but below are links to activities and ways that GPS can be used in many other ways as well.

Links for Various uses of GPS:

[10 Ways to use your GPS \(by TheStreetSmack.com\)](#) - A list of ideas to use your GPS for more than just driving directions.

[Creative Ideas using GPS \(by Magnet4U.com\)](#) - Including geocaches, parties, treasure hunts, conferences/hunting and more.

[10 Fun Outdoor Games to Play Using GPS \(by Magnet4U.com\)](#) - Including GeoCaching, GeoHunting, GeoScavenger, GeoScrubbing, and many more activities to keep you entertained while learning more about the capabilities of GPS.

[How GPS can be used for businesses \(by The New York Times\)](#) - An interesting article about how GPS is being integrated into many devices, including tracking and control of their inventory, as well as how businesses are improving operations based on information provided by GPS devices.

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Making GPS easy and effective for teachers and learners alike

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References for this project

I referenced all of the following articles, websites, books, and knowledge bases to shape my understanding of the many topics and ideas involved in this exciting area. Please follow the provided links to gain more insight for yourself.

[Place-Based Education](#) / [Citizen Science](#) / [21st Century Science Skills](#) / [GPS Information](#) / [GPS Teaching](#) / [Using GPS](#)



Place-Based Education

[http://www.atacarnotia.org](#) - Enriching lives through Place-Based Education

"Promotes of Place provides a myriad of PBE resources for the educator. There are stories of successful PBE projects, links to research and reports, a professional network of PBE-interested educators, curriculum help, and much more. I learned about the every day applicability of PBE and how it is really feasible in the modern classroom. A teacher that only teaches from a book is not teaching. They are only sharing information."

[http://www.asapac.org/index](#) - Place-based Education Evolution Collaborative (PEEC)

"PEEC is a partnership between many organizations and projects listed on the website. This resource provides in-depth studies, many references to other websites, and several tools to help educators successfully implement PBE into their curriculum. It is organized in a very simple, but easy fashion, providing the maximum information with the least amount of fuss."

[http://www.anschoon.edu/wp-content/uploads/2012/08/pbeexcerpt.pdf](#) - "Place-based Education: Connecting Classroom and Community" by David Sobel

"An excerpt from David Sobel's book, giving a glimpse into the possibilities for PBE. You read several "Aha moments" in this short excerpt, and gain an appreciation for the benefits of PBE."

[www.youtube.com/watch?v=0G0t8Kz7aI](#) - David Sobel on Place-Based Education (28 minutes)

"David Sobel, a Core Faculty Member at Antioch University, New England, is recognized as one of the leaders in the PBE movement. With many years of experience and an extensive repertoire of books and articles published on the matter, he speaks in this lecture about the benefits of, and the mechanics required to successfully use PBE™ in your classroom."



Citizen Science

[http://edutechwiki.unige.ch/en/citizen_science](#) - EduTech Wiki on Citizen Science


"A wiki page with definitions of citizen science, breaking down how it works and can be done effectively. Makes a few great connections such as wikipedia.com being, in essence, a citizen science project. Includes a good graphic of a conceptual model of citizen science and the inter-related nature of this discipline. Of course, there are many links to other sites about citizen science, and some big projects to study and possibly emulate. Rich bibliography included."

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Science Standards

Throughout my project, I referenced the following Nationally recognized standards:

NGSS - Next Generation Science Standards
New science standards prepared for the ever-evolving world of science education. Taking the place of, and improving on old standards from the National Research Council and American Association for the Advancement of Science.

I referenced most specifically the standards:
 * **MS-LS Ecosystems, Interactions, Energy, and Dynamics**
 * **MS-LS Ecosystems**

National Academies Press - A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012)
 Proposing a new approach to K-12 science education that will capture students' interest and provide them with the necessary foundational knowledge in the field. Breaking down the approach into three dimensions: crosscutting concepts (concepts applicable across the science spectrum), scientific and engineering practices, and disciplinary core ideas (in physical science, life science and earth and space science); making it more accessible to everyone with the goal of producing well-rounded, scientific minded citizens.

International Society for Technology in Education (ISTE)
 * **ISTE Standards for Teachers** - Empowering the teacher with skills to facilitate learning with technology.
 * **ISTE Standards for Students** - Setting essential actions and mindsets that a student must embody to be successful in today's educational system - tools to help them learn about technology and to make technology facilitate learning.

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