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Geo-awareness, Geo-enablement, Geotechnologies, Citizen Science, and Storytelling: Geography on the World Stage

Joseph J. Kerski*
Education Manager, Esri, 1 International Court, Broomfield, Colorado USA

Abstract

Five converging global trends – geo-awareness, geo-enablement, geotechnologies, citizen science, and storytelling– have the potential to offer geography a world audience – attention from education and society that may be unprecedented in the history of the discipline. Issues central to geography are now part of the global consciousness. Everyday objects are rapidly becoming locatable, and thus able to be monitored and mapped. Many tools and data sets that were formerly used and examined only by geographers and other earth and environmental scientists are now in the hands of the general public. Citizens outside academia are becoming involved in contributing data to the scientific community. Multimedia and cloud-based Geographic Information Systems (GIS) have greatly multiplied the attraction that maps have had for centuries to tell stories. But despite these trends bringing opportunity to geography, is geoliteracy becoming increasingly valued? How can educators, researchers, and practitioners seize the opportunity that these trends seem to present to actively promote geographic content knowledge, skills, and perspectives throughout education and society?

Introduction

My aims in this document are three fold. First, I make the case that five converging global trends are exerting great impact on geography, on education, and on society. Second, in light of these trends, I consider whether geoliteracy is becoming increasingly valued. Third, I offer practical suggestions to the geography educator, researcher, and practitioner to be able to seize the opportunities that these trends offer for developing geographic knowledge, skills, and perspectives in education and society.

FIVE CONVERGING GLOBAL TRENDS

Five converging global trends may present geography with world attention that may be unprecedented in the history of the discipline (Figure 1). These include geo-awareness, geo-enablement, geotechnologies, citizen science, and storytelling. Each of these recent trends is transforming the audience for geography and how geography is taught and perceived.

GEO-AWARENESS

The world faces complex challenges that are global in nature but also are increasingly affecting individuals' everyday lives. Few hours pass without the impact of seismic or weather-related hazards on human populations. Disasters resulting from these hazards affect communities, countries, and sometimes, entire continents. Changing birth rates and immigration are global issues that impact the politics and economics of nations and the social fabric of local communities. The supply of energy resources is fundamental to enable the use of technology and has been

Fig. 1. Five converging global trends that present geography with new global opportunities.

linked to standards of living and educational attainment. Epidemics and diseases affect specific segments of society and impact the entire planet in significant ways. Sustaining agriculture and fisheries is critical to food supplies. The transportation of people and products consumes massive amounts of human time and energy. Issues of water quality and quantity are fundamental to the very existence of humanity. Political instability and violence displace whole populations.

These challenges have long been some of the fundamental issues that geographers studied. Yet in the past decade, these challenges have become a part of the public consciousness. The themes that have driven geographic thinking and research have in large part become topics of everyday conversation. There is a heightened awareness that these issues affect individuals' everyday lives, that they are serious, and that they need to be solved. There is also growing realization that they all occur *somewhere*, at multiple scales, with specific spatial distributions, patterns, and linkages; and with temporal and spatial components.

GEO-ENABLEMENT

Societies are rapidly moving to an era where most everything in everyday life will be able to be located on a map, or "geo-enabled." From smartphones to tablets and laptops, from webcams recording traffic or bird counts to whether car parking lot sensors, from orbiting Earth-imaging satellites to surface or underground sensors recording water quality, seismicity, and weather, these sensors and devices transmit a latitude–longitude signal, enabled by the coupling of Global Positioning Systems (GPS), smartphone towers, and Wi-Fi transmitters. As geo-enabling extends to thermostats, light switches, and appliances in ordinary homes, it contributes to "the internet of things" (Wasik 2013) and "smart cities" (Al-Hader and Rodzi 2009). As these measurements become mapped within Geographic Information Systems (GIS) and remote sensing environments, they become a "nervous system" for the planet (Dangermond 2002). This geo-enablement is taking place at different rates in different areas around the world, leading to a more uniform access to technology in some areas, and increasing inequalities because of access to devices, bandwidth, and data in other areas.

GEOTECHNOLOGIES

Until recently, satellite imagery, digital maps, aerial photographs, 3D profiles, geodatabases, spatial statistics, and related tools, methods, and data were used largely by those in GIS and scientific fields. Today, millions of maps and satellite images are viewed hourly. Like music, graphics, office tools, and other technologies, GIS has been migrating to a cloud-based "Software as a Service" (SaaS) model. Not only have geographic tools, maps, and spatial data become instantly available, they can be downloaded, streamed, embedded, changed, and reformatted on devices from smartphones to tablets, in the field, in vehicles, in research labs, in classrooms, and just about everywhere. These digital maps are used in newscasts, web pages, videos, and news feeds, becoming among the most common type of 21st Century media. Geodatabases map and synthesize data coming in from geo-enabled devices and objects, and through these objects, the public has become extremely conscious of the value of maps in their everyday lives.

CITIZEN SCIENCE

The largest part of the "internet of things" sensor network is not electronic sensors, but the general public themselves. In fields such as phenology and bird monitoring, the public has been engaged for decades in contributing their own observations, but web-based GIS makes it easier for the general public to contribute data. The general public is also voluntarily and involuntarily providing information about their location through the use of cloud-based smartphone and web applications. Information being fed to cloud-based services offers to make life more efficient, comfortable, and interesting. Examples include connecting with others through fitness apps, recommending products matching a person's purchasing history, and feeding individuals' current speed and location to a regional real-time traffic map so that motorists can avoid snarls. Information about the location of things are of high interest to those providing Internet services. However, even more interesting to service providers are the movements of people, who make up a seven billion strong sensor network – providing information about the planet as has never been gathered before.

STORYTELLING

For centuries, maps have been valued because they provide a large amount of detail in a small amount of space, and because of their capacity for telling a story. Telling stories through maps began with describing explored lands in great detail against *terra incognita*. Today, geographic tools, data, and multimedia on the web expand the ability *and* audience for storytelling through maps. Any person with a smartphone or computer can use maps to tell his or her story.

Platforms that enable citizens to tell stories through maps include Esri Story Maps (http://storymaps.arcgis.com), Map Story (http://mapstory.org), and other tools. Today's story maps range in scale, theme, and purpose. From Napoleon's march to this year's hurricanes, from China's new highways to where food originates, educators, students, researchers, and the public can create their own story maps, through the use of live web maps with text, video, audio, sketches, and photographs. Teaching about the dynamic Earth with dynamic maps seems particularly appropriate to many (Hong 2014).

This is not the first time when geography was afforded great opportunity. During World War II and again during the Cold War and Space Race, a heightened awareness of global affairs translated into calls for increased frequency and quantitative rigor in geography and Science, Technology, Engineering, and Mathematics (STEM) education. However, these periods tended to be short-lived, and were accompanied by setbacks, such as the closure of many geography departments in the USA (Dobson 2007). Will the five trends occurring today be enough to generate and sustain the interest of the general public, as well as policymakers and educational administrators? Will this enable the recognition of geography and the geographic perspective and cement geography as a fundamental, funded, respected subject throughout education and in decision making throughout society?

GEOLITERACY

Each of today's issues of concern to the public is fundamentally tied to space and place – they are geographic issues. To grapple with these issues requires a population that can assess and use geographic information to make wise decisions—in short, a *geoliterate* population. Pattison (1964) defined geoliteracy as including four traditions, or foundations: spatial, area studies, man-land, and earth science. Researchers from two geography associations (Natoli, et al., 1984) identified five themes—movement, region, human-environment interaction, location, and place. Edelson (2012) stated that it should include how our world works, how our world is connected, and how to make well-reasoned decisions, or interactions, interconnections, and implications. I believe that geoliteracy requires cultivation in each of what I consider to be the essential "three legs" of the stool of geographic literacy: (i) core content, (ii) skills in using geographic tools, and (iii) the geographic perspective (Figure 2).

The first leg of the stool is core content. While core content is important, it is often maligned, perhaps because it is often equated with memorization of facts for examinations. Geography's core content is richer than mere facts: Much of the core content is systems thinking: ecosystems, and systems of climate, culture, watersheds, oceans, land use, governments, and Earth-Sun relationships. Core content focuses include learning about natural phenomena such as how ocean currents affect climate, and cultural phenomena, such as sense of place.

The second leg of the stool is the development of skills, including the effective use of geographic tools. Many geographic tools and skills are focused on maps, such as analyzing

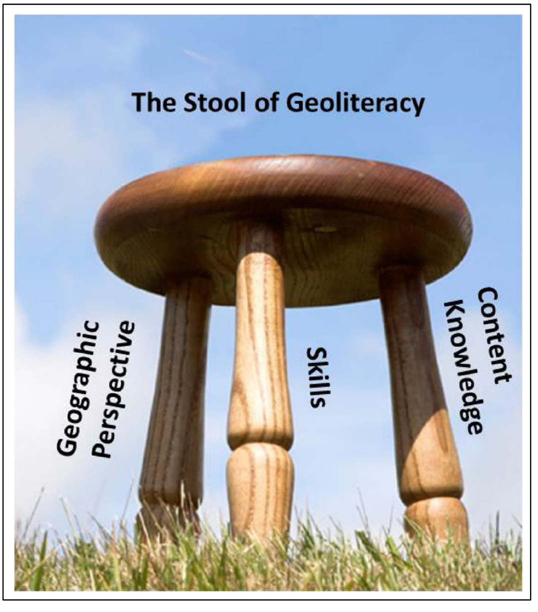

Fig. 2. Geoliteracy can be conceptualized as being supported by content knowledge, skills, and the geographic perspective.

remotely sensed imagery, using GPS and geolocation, representing the Earth as map layers, and using 2D and 3D data in GIS environments. Others, including assessing data quality, graphing and charting, classifying, collecting, analyzing, and mapping field data, and communicating geographic content, are important skills as well.

Fundamental to skill building is the geographic inquiry process. This process includes asking geographic questions, acquiring geographic data, exploring geographic data, analyzing geographic information, and acting on geographic knowledge gained. Despite the "geographic" words used to describe this inquiry process, the process can and should occur in any discipline. Thus, the geographic inquiry model reflects and supports scientific inquiry. Researchers and practitioners advocate that geography should be taught often and deeply, in problem-based and project-based learning environments (Capraro and Slough 2013), with "wicked problems" that are difficult to solve. The focus on inquiry translates into minimizing fact-based worksheets while maximizing hands-on work, discussion, and communication. Inquiry includes tackling issues--landfills, urban greenways, and traffic, pros and cons of energy extraction, and the implications of rapid growth in specific ecoregions and population decline in others. In each case, mapping is seen as the key to understanding patterns, relationships, and trends.

The third leg of the stool—the geographic perspective—begins with "spatial thinking". The geographic perspective represents a certain way of seeing the world. Geographers see the world working through a series of interwoven and changing spatial relationships, operating from the level of chemical bonds in soil, to the distribution of macro invertebrates in a river, to commuting patterns in a metropolitan area, to the ebb and flow of seasonal variation in the temperate latitudes, to how ocean currents affect land climates, and beyond the Earth itself, to Earth-Sun relationships. The geographic perspective seeks to discover why processes and phenomena occur where they do, and includes themes of scale, region, diffusion, patterns, and spatio-temporal relationships. The geographic perspective also includes critical thinking—questioning and investigating where data come from, how to manage uncertainty, how problems are framed, and the scale at which problems are addressed.

Is Geoliteracy Becoming Increasingly Valued?

Each of the five global tends identified offer geographers unique opportunities to advance the core tenets of the discipline. But is this advancement occurring? Some evidence points to increased attention and funding for geoliteracy, such as the National *Science* Foundation (NSF) funding the "geography roadmap" project in the USA (Bednarz et al. 2014). NSF also funded the GeoTech Center, a community college-driven effort to strengthen GIS education. The GeoTech Center was instrumental in the creation of the Geospatial Technology Competency Model (GTCM), which defines the expertise that distinguishes geospatial professionals and skills. The GTCM has been widely used to reinforce the notion that successful use of geospatial technologies does not rely merely on the acquisition of software skills, but upon personal effectiveness competencies, such as integrity, initiative, and lifelong learning, on academic competencies, such as communications, geography, mathematics, science, and engineering, and on workplace competencies, such as teamwork, creative thinking, problem solving, working with technology, and business fundamentals. Finally, the National Academy of Sciences, in their *Learning to Think Spatially* (2006) report, stated that intentional teaching of spatial thinking was valuable in education, that spatial thinking needed to start with young students, and that it taught often and in deep ways.

As geography aligned itself with Science, Technology, Engineering, and Mathematics (STEM) in the USA in recent years, geography has been the recipient of attention and funding. To bring together scientists and educators from cognitive science, psychology, computer science, education, geoscience, and neuroscience, the Spatial Intelligence and Learning Center (Grossner 2012). Internationally, the Spatial Literacy in Teaching (SPLINT) initiative in the UK focuses on the pedagogy of geospatial technologies and the enhancement of spatial literacy in higher education (Janelle et al., 2009).

Geo-awareness is also gaining attention for geography. As decision makers increasingly engage in geographic tools, educators advocate that there is an increased need to understand how to wisely use these tools. Coupled with this is media attention on "big data" and a growing awareness that much data exist in mappable forms. Data fluency (Jukes et al. 2010) means to understand the capabilities but also the limitations of data. Maps are incredibly useful, but contain distortions and limitations, such as map projections, scale, resolution, and attribute completeness. Those with the geographic perspective and skills must be included in the discussions about the wise use of the ongoing deluge of data, such as issues of copyright, privacy, data aggregation, interpretation, and communication of that data. Because geographers are tasked to understand the whole world, those with the geographic perspective are well-suited to understand when connections exist between data and the implications. They are well-suited to separate the trivial from the important, to consider the implications of information on society, and counsel society on the interpretation of the data about people and the built and natural environment.

More significant evidence, however, exists in the adoption rate of what many consider to be foundational tools of geography--geotechnologies. Educators are adopting geospatial tools more rapidly now, prompting observation that GIS adoption is moving past "innovators" and "early adopters" to the "early majority" of educators (Kerski, 2015). The likeliest causes are (i) the advent of web-based GIS tools and (ii) a renewed focus in education on inquiry. The advent of web-based GIS flattens the learning curve for educators and students, enables analysis and exploration to take place on the web without large software packages to install, and can be used on any device. That maps and geographic data have become one of the most popular resources on the Internet comes as no surprise. People have always been fascinated with investigating their home – the Earth. For centuries, maps have stirred imaginations and inspired explorations of the unknown. Maps provide a rich source of information in a small amount of space, showing spatial relationships between climate, vegetation, population, landforms, river systems, soils, natural hazards, and much more. In education, maps have always done more than locate "where" places are – they enable students to investigate the "whys of where" – the essence of scientific and geographic inquiry.

SEIZING THE MOMENT: STEPPING FORWARD IN PRACTICE

How can geography educators, researchers, and practitioners seize the opportunity that these trends offer to actively promote the inclusion of geographic content knowledge, skills, and perspectives throughout education and society? I offer the following recommendations and welcome a dialogue on the topic.

Tie Geo-Awareness to the Need for Geography Education. A growing awareness of the geographic nature of problems from local to global scales is evident, yet a realization that these issues can be better understood using the geographic perspective seems lacking. The geography community could take this opportunity to explain to the public what geography really is, why it is important, and how it can help society grapple with these issues. As the geographic perspective, content, and skills are becoming more valued by other disciplines on the university campus (Sinton 2006), geographers can open the dialogue to interdisciplinary pathways of research.

Contribute to the Dialogue About Issues Surrounding Geo-enablement. Geographers should actively contribute to the discussions that are in the public consciousness about the implications of geo-enablement, such as location privacy and crowdsourcing. They should also demonstrate how geography education can help foster skills in handling and interpreting the deluge of data that ensues from geo-enablement.

Emphasize that maps are not just reference documents. Many regard maps largely as reference documents. Geographers must demonstrate how maps can be a doorway to discovery about the physical and cultural world and local communities in which we live.

Emphasize that digital maps are usually more useful than paper maps. Because of these changes and the increased demand for base data for use in GIS, paper maps are limited; they have been converted into digital form to expand their use for new applications. Geographers can discuss with their students the advantages and challenges of paper maps and digital maps.

Maps are not just for geographers. Maps are useful to broad sectors of society, such as an epidemiologist studying the spread of diseases, climatologists studying climate change, and businesspersons siting new franchises. Maps are essential tools for studying these issues and for solving real problems.

Model effective use of geotechnologies in teaching, research, and other applications. Geographers can use the democratization of geotechnologies to explain why and how skills in using these tools are essential to many careers and everyday tasks.

Engage the Citizen Science Community. Geographers can use the energy, expertise, and size of the citizen science community to illustrate why phenomena can be understood more completely when it is mapped. GIS provides a framework that enables the management of the large volume of data generated by the citizen science community.

Promote Civic Engagement. Geographers can use citizen science, fieldwork, and geotechnologies to cultivate a culture of civic engagement, where volunteer efforts are made more visible and local, including students want to contribute to their own community.

Tell Stories with Maps. Geographers can take advantage of the longstanding interest that people have had with maps, and the equally rich tradition of telling stories, to use web-based dynamic mapping tools engage the general public.

Focus on Change. Nearly all issues and problems have a change component. Because the Earth is changing, a platform to map that change that also is dynamic is the perfect complement, and that is what web based mapping offers.

Focus on Connections to Educational Content Standards. For the trends identified above to be embraced in educational systems around the world, the activities based on them need to be firmly and demonstrably anchored in content standards.

Focus on Workforce Needs. Focusing on workforce needs helps make education more relevant to society. The *Geographic Information Science and Technology's Body of Knowledge* (Dibiase et al., 2007) and the Geopatial Technology Competency Model help guide course planning. The *Partnerships for 21st Century Skills* (www.p21.org) documents can help ensure that relevant skills are taught in these programs.

Focus on Career Skills. Geotechnologies were identified by the US Department of Labor (Gewin 2004) as one of three major growth fields for the 21st Century. The use of GIS and web mapping technologies builds skills in technology, organization, communication, critical thinking, and other skills needed by government agencies, the private sector, academia, and nonprofit organizations.

Help Students to Engage with the Tools. The bulk of geotechnology training in secondary and university education over the past 20 years has been geared towards educators, rather than students. While this has the advantage of working with professionals who in turn could impact thousands of others, educators must realize that it is even more important for the *students* to learn how to use these tools.

Engage the Research Community. For educators and policymakers to be convinced that it is worth their time and finances to invest in geographic perspectives, geography content, and geospatial technologies for teaching and learning, a research base needs to be solidly developed. While some studies have investigated the effectiveness and implementation of geographic perspectives, content, and skills, much remains to be studied. Research is needed in the development and evaluation of assessment instruments, and in the most effective strategies for teaching and learning with geospatial technologies, particularly web-based tools.

Don't Neglect the Educational Policymakers. To effect change in education, it is important that policymakers are convinced that teaching and learning geographic concepts, skills, and tools bring value, substance, and interest into education. They also need to be convinced that it will help them achieve their policy goals, including increased student performance, retention and graduation rates, critical thinking, and problem-solving ability.

TEACHING AND LEARNING WITH WEB MAPPING TOOLS

The advent of today's geotechnologies affords numerous opportunities for the educator and student to analyze diverse phenomena – from population distribution to biomes – at scales from local to global, over many time periods. However, determining which resources and tools are most valuable for instruction can be confusing. Let us focus on a few excellent places to start, and model how to use these resources in education.

Methods of incorporating inquiry through Web mapping

Because the Earth is monitored as never before, satellite images and aerial photographs are often collected before, during, and after natural disasters or other Earth-changing events. For example, using the USGS Coastal resources at http://coastal.er.usgs.gov/hurricanes/katrina/ enables discussions about impact, land use, preparedness, and policy, in this case, about Hurricane Katrina (Figure 3).

Educators can compare historical to current satellite images over a 40-year time span using the Esri Change Matters Viewer (http://changematters.esri.com/compare). Sensors taking these images use infrared wavelengths, prompting discussion about the electromagnetic spectrum. At any scale and location, students can investigate changes, the reason for those changes, and analyze whether the changes were from natural forces or human-caused forces. Students can compare historical street view imagery in Google Maps and discuss changes in seasons, time of day, natural features, and the human-built environment.

As an example, the intersection of issues of irrigation, politics, climate, and internal drainage can be investigated through the past 40 years of change in the Aral Sea in Central Asia (Figure 4).

Using ArcGIS Online (www.arcgis.com), a web-based mapping platform containing analytical tools, maps, and data, students can investigate 150 years of hurricane patterns in the USA (Figure 5). The data can be re-classified and symbolized, and additional variables can be overlaid, such as population density or current storms. This is done not to make the "perfect map" but to deepen understanding of the variables under study.

Students can use GPS receivers, tablets, probes, smartphones, or even pencil and paper to record attributes for input into a live web map. Students can collect data in citizen science "crowdsourced" mode (Goodchild 2007), as well as make their maps true multimedia experiences (Kerski 2014) (Figure 6).

Students mapping data collected in the field gain experiences and skills, but the importance extends further into immersion in natural places (Louv 2006), cultivating connections to the

Fig. 3. Oblique aerial image of Biloxi, Mississippi waterfront in 1998, and in 2005, after Hurricane Katrina. *Access this map here*: www.arcgis.com/home/webmap/viewer.html?webmap=efc693e235dc4d95dc4d959495875dd775e33d

local environment (Sobel, 1999 and 2005), even if fieldwork is limited to their own campus (Broda 2007).

Maps have received attention due to the advent of storytelling capabilities coupled with dynamic cloud-based mapping services. Esri Storymaps (http://storymaps.arcgis.com) allow students and educators to weave text, audio, video, photographs, and live webmaps together to tell stories about historical to current events, field experiences, exploring the major characters in fiction or nonfictional works, and much more (Figure 7).

Synthesis

Students active in geography education develop key critical thinking skills, including understanding how to carefully evaluate and use data. Students who are well grounded in the spatial perspective through geography may be better able to use data at a variety of scales, in a variety of contexts, think systematically and holistically, and use quantitative and qualitative approaches to solve problems, becoming better decision-makers (Milson and Kerski, 2012). Students engaged in web mapping tools make heavy use of the geographic inquiry process. Key to this process is that geography is taught as an applied science and it leads to action. It also leads to

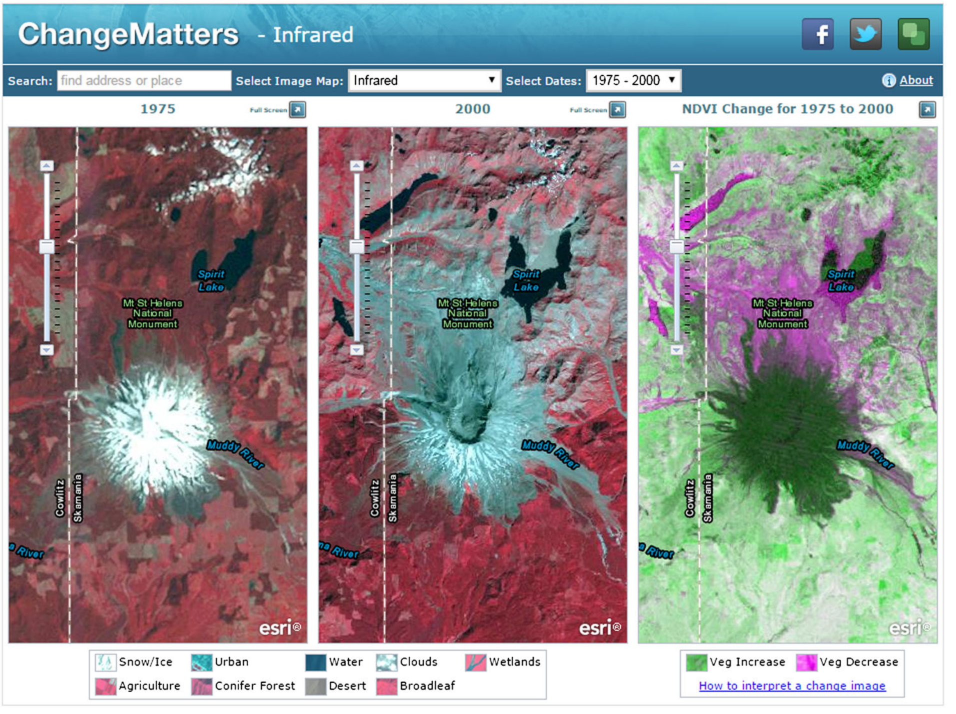

Fig. 4. Aral Sea as seen from the Landsat satellite in 1975 (left) and 2000 (center) with changes between those two time periods (right), using the Change Matters viewer.

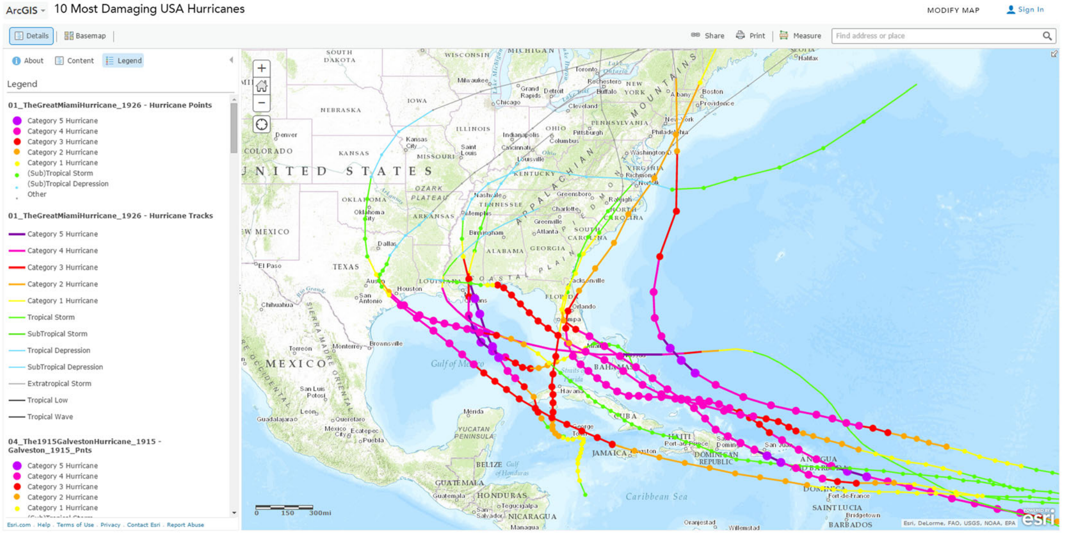

Fig. 5. Examining the 10 most damaging hurricanes in the USA over the past 150 years, using ArcGIS Online.

expanding careers. Web mapping, a green technology, is used on a daily basis to benefit the environment, from protecting habitat to planning urban greenways, and thousands of other ways.

These tools may hasten the ability of educators to meet spatial learning challenges (National Research Council 2006), and can support standards-based, inquiry-driven methods of teaching

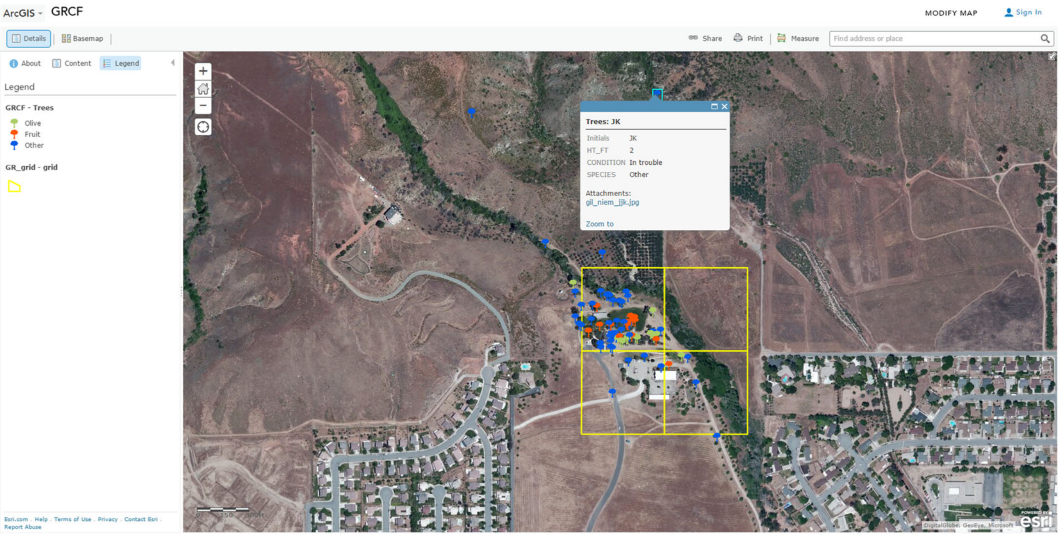

Fig. 6. Collaborative citizen science tree mapping from smartphones, mapped in ArcGIS Online.

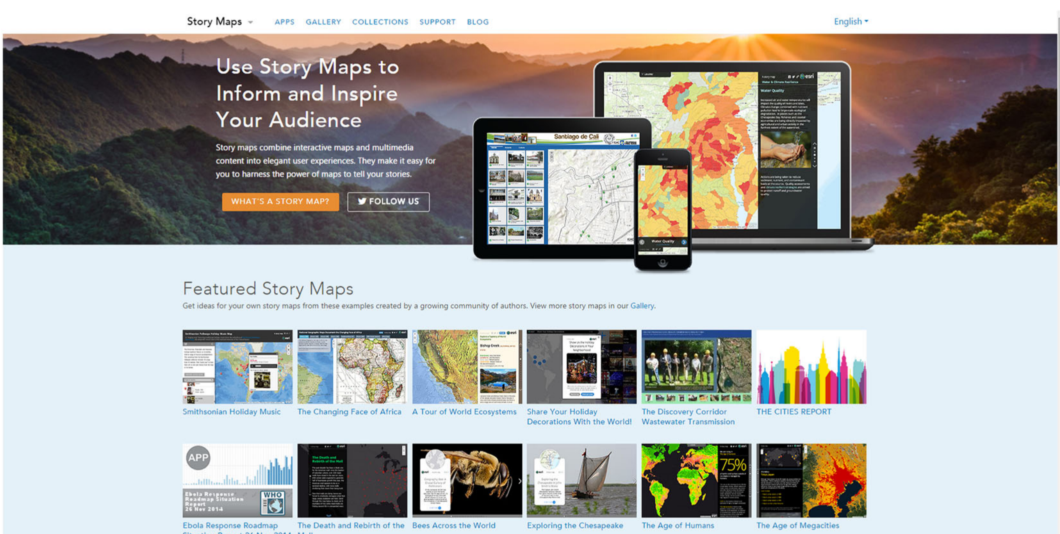

Fig. 7. A sample gallery of storymaps on a wide variety of subjects and scales, on http://storymaps.arcgis.com.

and learning, while providing basic analysis tools for exploring geographic or scientific data (Milson, Demirci, and Kerski 2012). They can be key in addressing skills identified by the Partnerships for 21st Century Skills initiative (LeVasseur 2005) and in recommendations on the value of thinking spatially (Bednarz 2004; Gersmehl and Gersmehl 2006). As noted above, the geo-enablement of societies is in some places leading to greater access in some areas and greater inequalities in others (Graham, 2011).

Students can use these resources to understand that the Earth is changing and think geographically, scientifically, and analytically about *why* it is changing. After using these web maps, students need to ask and grapple with value-based questions. *Should* the Earth be changing in these ways? Is there anything that I should be doing about it? This captures not only the heart of spatial thinking, inquiry, and problem-based learning, but of education for activism – to make a difference in this changing world of ours.

Given the five trends identified in this article, geography seems poised to occupy a more important role in education and society. Will geographers seize the opportunity afforded to the discipline to catapult it to the "world stage"?

Getting Started

ArcGIS Online: *www.arcgis.com/home* – Maps, apps, tools, and data, which allow for investigation of local to global issues, in the field or in the classroom on tablets, laptops, or smartphones.

WorldMapper: *www.worldmapper.org* – Create cartograms on over 700 health, technology, cultural, economic, physical geography, and other variables.

Google Maps: *maps.google.com* – Examine satellite imagery and maps; examine historical and current street views of streets, but also trails and points of interest.

GapMinder: *www.gapminder.org* – Examine trends in demography, health, and economics by country and over time with dynamic graphs and data.

Urban Observatory: *www.urbanobservatory.org* – Compare population density, land use, and other variables for dozens of urban areas around the world.

Milson, Andrew, Demirci, Ali, and Kerski, Joseph J. 2012. *International Perspectives on Teaching and Learning with GIS in Secondary Schools*. Springer, 353 pp. Discover how schools in 33 countries around the world are using geotechnologies.

Esri Education Community blog: *http://blogs.esri.com/esri/gisedcom/*. Connect to the global community in GIS in education and discover data, tools, best practices, and professional development.

YouTube Geography Channel: *www.youtube.com/geographyuberalles* Learn about space, place, geotechnologies, fieldwork, geography, and STEM education with the over 2500 videos here.

Short Biography

Joseph Kerski is a geographer who believes that spatial analysis through digital mapping can transform education and society through better decision-making using the geographic perspective. He holds three degrees in Geography. He has served as geographer and cartographer at NOAA, the US Census Bureau, and the US Geological Survey. He teaches online and face-to-face courses at primary and secondary schools, through MOOCs, and universities such as Sinte Gleska University and the University of Denver. He serves as Education Manager for Esri and focused on thought leadership in geospatial technology education. This includes curriculum development, research in the effectiveness of GIS in education, professional development for educators, and fostering partnerships to support GIS in education at all levels, internationally. He has authored books such as *Spatial Mathematics*, *The Essentials of the Environment*, and *The GIS Guide to Public Domain Data*.

Note

* Correspondence address: Joseph Kerski, Esri Education 1 International, Esri, Broomfield, Colorado, 80021 USA. Email: jkerski@esri.com

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