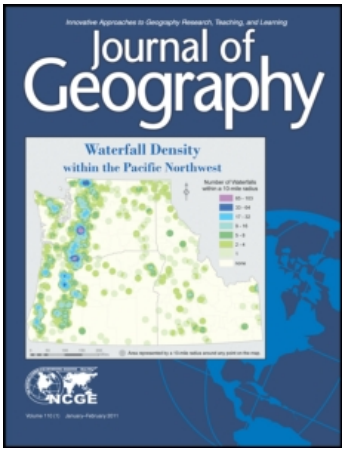

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Google Earth as a (Not Just) Geography Education Tool

Todd C. Patterson

Abstract

The implementation of Geographic Information Science (GIScience) applications and discussion of GIScience-related themes are useful for teaching fundamental geographic and technological concepts. As one of the newest geographic information tools available on the World Wide Web, Google Earth has considerable potential to enhance methods for teaching geography and helping students develop other capabilities. Google Earth's utility as a teaching tool in precollegiate environments is illustrated through development of a South Carolina-based lesson plan focused for seventh grade students that increases students' geographic awareness while also building critical thinking, analysis, and inquiry skills in support of various educational standards.

Key Words: *Google Earth, education, teaching methods standards*

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Introduction

The role of computers in instructional technology has been of interest particularly since the advent of personal computers. With prices for computing technologies continually decreasing, the presence of computers in educational and home settings has increased dramatically over the last fifteen years. Many schools have advanced beyond the first level of adopting technology (acquisition and implementation of hardware and network wiring), but technology-rich curricular activities have yet to be widely introduced (Cates *et al.* 2003, 155). Implementation of geographic information systems (GIS) in elementary and secondary education has not been very widespread over the same time period, underscoring a lack of technology-rich curricular activities (Bowman *et al.* 2005; Baker 2005; Donaldson 2000; Kerski 2000). The advent of Google Earth, however, is a formidable technological tool to help strengthen these weaknesses in geography curriculum. The purpose of this article is to discuss the utility of Google Earth as a tool for geography education, with a broad-based South Carolina-oriented lesson plan for seventh graders as an example.

Background

Lack of time is a significant barrier to implementing GIS in curricula because of the need for educators to learn the software and understand the underlying data. Educators also need to prepare materials to support lessons, as well as provide sufficient time for students to learn the software and incorporate the tool in the learning experience (Meyer *et al.* 1999). Educators' focus on GIS tools has been particularly problematic due to the amount of time required to learn and apply the tools. The time associated with learning GIS applications has been a considerable factor in GIS and related technologies having only limited implementation in K–12 classrooms (Bednarz and Bednarz 2004, 24). For example, a 2002 Kansas review identified that a high proportion of GIS teacher-training workshops were focused on the development of GIS skills (KanGIS 2002); experiences from a comparable Texas institute reiterated that finding (Bowman *et al.* 2005).

Access to appropriate hardware has traditionally served as a critical barrier to implementing GIS applications (Meyer *et al.* 1999). Aside from commitment of time, Baker (Baker 2005, 44) cited several additional impediments to implementing GIS in K–12 classroom settings, including: insufficient resources, incompatible computing and network systems, school district demands for security that require leveraging the most current operating system, and separation of subject disciplines to correspond to a school day's schedule.

Despite barriers to implementation and utilization, states have been increasing pressures to utilize GIS without sufficient support, resources, or lessons. The gulf between demand and ability to implement technology continues to widen in the wake of various standards for which educators are being held accountable, such as state departments of education and academic discipline standards (wherein spatial considerations are becoming increasingly important, including epidemiology and political science) and the recent *No Child Left Behind* initiative (U.S. Department of Education 2002).

Given the advent of computers and the evolution of digital technologies from video games to television, contemporary students have a different manner of learning and applying tools at their disposal. Growing up in the information age, video and images are a primary means of information gathering for students. Focus on computing equipment has largely evolved to be a primary, daily tool rather than a career path. In order to be productive in the coming years students

need to acquire technologically-based skills early-on and apply them in broad and diverse ways.

Geography, as a unifying discipline, brings much strength to educational approaches. GIS, with its emphasis on digital information processing and analysis, can contribute greatly to unify various disciplines that focus on spatial trends and elements. Yet for reasons previously cited, GIS continues to be underutilized as an instructional technology. Google Earth, albeit having limited spatial analytical tools in comparison to a true GIS, can be implemented in classroom settings to help make spatial information more relevant to students and teachers at all levels. Google Earth can also be utilized to enable students to meet challenges of various standards-based curricula by helping them understand information in spatial or geographic context.

The use of Google Earth not only supports spatial thinking but also helps develop critical analytical skills and prepare students to use more advanced features found in a true GIS. That is true because spatial thinking is "an amalgam of three concepts: concepts of space, tools of representation, and processes of reasoning" (Committee on the Support for the Thinking Spatially 2006, xiii).

Why Use Google Earth to Support Education

Studies have demonstrated that the use of online resources has helped to improve student comprehension of major concepts and skills while also helping students gain confidence in their knowledge of geographic issues (Solem and Gersmehl 2005). Psychological studies have also demonstrated that the recallability of information is greater with visual images than text (Wager 2005).

Google Earth can help to foster spatial thinking and develop critical technology and thinking skills. Lesson plans can be developed to help students consider the construct, context, and quality of spatial data. Students can also work independently on an interactive basis while also collaborating with others with comparable interests. Various Internet-based resources can be incorporated into the learning environment to allow students to gain greater knowledge of areas of particular interest to them. As Leamnson (1999) noted, in many situations learning happens outside the classroom; by using technology students may expand their knowledge and enhance their thinking and analytical skills and can apply external learning to situations presented within the classroom.

The use of Google Earth keenly supports the "four E's" of the learning life cycle model (Cates *et al.* 2003, 155), allowing students to *engage* in the lesson, *explore* the earth, *explain* what they identify, and *evaluate* the implications of what they are learning. The very nature of Google Earth allows students to explore the earth in a dynamic and interactive manner, helping them understand the spatial context of their locale and engage in spatially-oriented learning in an entertaining and meaningful manner.

Disadvantages of Using Google Earth

Although a freeware tool, Google Earth does require Internet access on a reasonably fast connection. The tool is not client-side intensive but insufficient bandwidth would limit the utility of Google Earth in the classroom by disengaging students' interests if the tool is not responsive to the user's requests. Use of the tool has three primary substantive requirements comparable to utilizing other technologies in the classroom: opportunity (time), motive (desire), and resources (skills and capabilities). The point-and-click interface makes the latter point less intrusive and consuming than other GIS technologies.

Although Google Earth and its related sites have a breadth of data available, the student would need to understand how to create his or her own account to search for data not included in the Google Earth interface and then how to open the dataset once a desirable dataset is identified. In some cases the true accuracy and authenticity of data may not be readily available, which could pose risks to the educational value of the lesson.

Google Earth is also not a true GIS (Table 1). The introductory concepts can open the door to expanded use in more sophisticated tools, but Google Earth has limited capabilities and tools to support true spatial analytical operations. The tool does not have a query capability or the functionality to perform complex spatial operations—even in the nonfreeware versions.

Advantages to Using Google Earth

Despite some disadvantages, Google Earth has a number of advantages to support its utilization in precollegiate educational environments. Technology by itself is worthless, but as a tool technology offers enormous potential to extend our capabilities. Google Earth supports a student's learning because it also can serve as an entertainment venue. The incorporation of affective components, or visual and emotional images to communicate and motivate, help make Google Earth a powerful classroom tool.

Unlike many client-side applications, students are not required to be at school in order to use the application. The free version of Google Earth can be installed by any user, thus allowing students to utilize the application outside the educational atmosphere and not be subject to licensing requirements many commercial off-the-shelf GIS applications impose.

The Google Earth Community and Google's Keyhole mapping service, Bulletin Board Service (BBS; available at http://bbs.keyhole.com), feature a variety of data layers that include supplementary readings and supporting photos and videos. There are also increasingly more services available to Google Earth with streaming media (for near-real-time information, such as satellite locations and weather updates). Keyhole BBS not only provides data but it also serves as a collaborative discussion forum for users to discuss data implications and evolution, as well as peripheral ideas. Another supplemental source of data

Table 1. Google Earth as a geographic information system. (Source: Based on *Learning to Think Spatially* 2006, 75; adapted by author.)

Function of a GIS	Functional Description	Google Earth's Capability	
Query	Question asked of a support system (can be based on spatial location and/or tabular attribute).	No	No query (spatial or attribute) query function is currently available.
Buffer	Area around an object of a specified distance to constraint or contain details.	No	No tool is available to calculate buffers.
Overlay	Use of multiple spatial data layers registered to all other data layers utilized.	Yes	Data provided by Google Earth or in compatible format can be displayed with other layers.
Proximity	Proximity of features to an object or area of interest.	Marginal	Proximity can be determined visually but no tools are provided to calculate proximity or distances.
Connectivity	Inter-relatedness of locations (such as network characteristics).	Marginal	Connectivity can be determined visually but no tools are provided to calculate connectivity.
Modeling	Analysis of processes, results, trends, or projecting possible results of decisions.	Marginal	Analysis can be performed visually but no tools are provided to conduct complex or nonvisual analytical operations.

and discussion is the Google "Maps Mania" blog (available at *http://googlemapsmania.blogspot.com*). The blog features various datasets for Google Maps and Google Earth and protracted discussions about the utilization of Google's spatial tools.

Hardcopy materials can help to build spatial thinking, but there are certain limitations to their utility. According to Thomas *et al.* 1998 (202), "Atlases have long provided people with a visual representation of their world and have encompassed a wide variety of topics." Atlases can be invaluable resources for classroom activities, although their value to support dynamic, interactive curriculum is more limited. Rystedt (1995) concluded that digital atlases provide interaction opportunities not found in print materials; Google Earth supports this notion by extending interactive components in seemingly endless dimensions. Google Earth challenges how digital atlases are produced, disseminated, and utilized because of its collaborative forum through the Keyhole BBS. If a single map is not effective at illustrating a process, mapping can be made more dynamic by providing the user with information related to a place and increasing the level of interactivity and enhancing the user's experience as a novice explorer. For example, the user does not have to just see the Grand Canyon from space, they could see it from various angles and appreciate its depth in a virtual fly-through. The same is true for urban landscapes in various select cities across the globe.

Since Google Earth is not a true GIS, users do not need to learn the interfaces or particular nuances of desktop GIS applications that may require special skills. Google Earth's interface is simpler because of a limited range of functions. The application is geared toward more point-and-click operations without complex menus and tools; nonfreeware versions provide a relatively powerful capability to develop and enhance functionality.

With a simpler interface, Google Earth also has less complex functionality and cartographic capabilities than true GIS applications, which should require significantly less time for teacher training. Teacher's preparation time can also be shortened because many datasets are readily available through the Keyhole BBS, along with support discussion forums that can help frame the context for students to consider the data's accuracy and applicability. Thus educators can be more focused on the lessons and not the mechanics of the application itself.

Geography Unifies Diverse Disciplines

Geography is widely considered a unifying discipline; as such, geography brings many strengths to educational approaches. Since geographers concern themselves with spatial information, or information about the locations and patterns of things in space (Gersmehl 2005, 98), the five basic themes of geography—location, place, relationships with place, movement, and regions (Natoli *et al.* 1984)—establish the foundation for sound geospatial education. The interrelatedness of these themes is the cornerstone for establishing geographic lessons, with organized treatment of skills around five major topics (Gersmehl 2005, 97):

Table 2. Categories of skills that geographers use to help analyze spatial relationships. (Source: Based on Gersmehl 2005, 100-111; adapted by author)

Category	Fundamental Question	Examples
Expressing location	Where Is It?	• Relative location (left, right, up, down, north, south) • Finding places on a map using mathematical coordinates • Surveying and navigation
Describing conditions at a location	What Is There?	• Features and conditions identified at a place
Tracing connections with other locations	How Is It Linked?	• Reasons for movements and structures • Examination of barriers, chokepoints, channels • Flows along connections
Comparing locations	How Are Places Similar or Different?	• Verbal or graphic comparisons of two or more places • Analogies, averages, ratios • Trends and complex analysis
Determine the zone of influence around a location	How Far From a Feature Is Its Influence Significant?	• Basic economic influences of commercial activities • Role of laws and regulations that influence location • Non-symmetrical influences
Delimiting a region of similar places	What Nearby Places are Similar to This One?	• Basic regional delineation • Role of boundaries
Describing the area between places	What Is the Nature of the Transition Between Places?	• Taking notice of changes during travel • Measuring distance, elevation, slope, and interpolation activities • Understanding fields versus discrete areas
Finding an analog for a given place	What Distant Places Are Similar to This One?	• Consider urban analogs • Identify patterns across diverse, distant areas
Identifying a spatial pattern	Are There Biases, Clusters, Strings, Donuts, Waves, and Other Distinctive Patterns?	• Making distinctions between ''even'' and ''random'' • Identifying biases through income differences • Consider subjectivity of spatial-pattern analysis
Comparing spatial patterns	Are the Spatial Patterns Similar?	• Patterns of well-known combinations of features (e.g., malaria and mosquitoes) • Sampling and scattergrams
Determining the exceptions to a rule	Where Are the Places That Have More or Less of Something than Expected?	• Correlation between natural resources and prosperity, and related anomalies • Expectations versus observed crime rates, flooding, life expectancy
Analyzing changes in pattern through time	How Do Things Spread?	• Weather predictions • Historic spread of empires • Employ logic to examine spread of activities (e.g., disease, economic prosperity)
Devising spatial models	Are Places Linked by One or More Intermediate Processes?	• Inter-relatedness of places (e.g., El Niño's effects refugee migration)

(1) asking geographical questions;

(2) gathering geographical information;

(3) organizing geographical information;

(4) displaying geographical information; and

(5) answering geographical questions.

Geospatial information can be explored through various as means, as out-lined in Table 2. Google Earth can be utilized to further enhance cross-discipline unification by virtue of helping to support not only the National Geography Standards, but also various state and federal standards for education.

The *National Science Education Standards* (1995) promote a core of inquiry skills to expand scientific-related research and thinking. Google Earth in the classroom can support these standards as well as Olson and Loucks-Horsley's (2000) standards by having students answer questions through scientific investigations, using Google Earth to gather, analyze, and interpret data by thinking critically and logically.

Using Google Earth in the classroom helps fulfill the national standards' requirements by (1) being used in lessons that question how humans obtain and use earth materials as resources; (2) asking students to describe features of the earth; (3) inferring how human behavior changes the earth's surface; (4) measuring distances; and

(5) using other thinking and analytical capacities. Google Earth frequently posts data of recent significance on its main Web page, *http://earth.google.com/*, such as updated imagery during hurricanes Katrina and Rita in late 2005. Students can read about the current event, view photos and video in the context of the event, and write analyses of its implications, which provide students with an implicit understanding of spatial information while explicitly building skills in critical thinking, analysis, and writing.

The *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics 2000) includes requirements for measurement, data analysis, and probability, reasoning and proof, communication, connections, and representation skills among students. Although the true mathematical functions in Google Earth are not comparable to those present in a true GIS, lessons can be developed to introduce students to each of the concepts, again helping to build spatial skills while explicitly developing other capabilities. Such lesson incorporation is consistent with the International Society for Technology in Education's (2000) *Educational Technology Standards and Performance Indicators for All Teachers* that supports the planning and design of learning environments and experiences in the context of a broad curriculum, technology operations, and related concepts.

The ability to support thinking in spatial terms and help students to understand natural and cultural phenomena is certainly a strength of Google Earth. Lessons can be devised to help educators teach about place while providing students an interactive tool. Students can also learn some attributes associated with place, including basic relationships among features. Each of the eighteen National Geography Standards is supported (Table 3), and Google Earth and its associated resources provide the potential to incorporate multiple standards across the six sections. Table 3 provides general applications for utilizing Google Earth. Specific use of Google Earth for each of the geography standards could be considered in significantly more depth and as separate papers. The implications of Google Earth to support the National Geography Standards are considered in some depth in the lesson plan section of Table 3.

Google Earth is a particularly useful tool to help introduce students to the five themes of geography—location, place, relationships with place, movement, and regions (Natoli *et al.* 1984). Students can begin to understand the notion of scale by starting with a global perspective (which enforces the spherical nature of Earth) and zooming to different areas.

As a digitally-based resource, Google Earth also supports the technology standards (*National Educational Technology* 1998) because it provides productivity tools to collaborate and communicate, and locate, evaluate, and collect information from a variety of sources. Google Earth provides technology resources for solving problems and making informed decisions—important capabilities students need to be productive members of society. (Illustrations of these resources and applications are suggested in Tables 1, 2, and 3, and outlined in the included lesson plan.)

Advanced versions of Google Earth, while not free, also provide the ability to create spatial data and upload to the forums discussed above. While the professional version could be cost-prohibitive for many schools, the implications of developing local data sets to enhance learning by understanding a student's own environment are tremendous. It should also be noted that the Google Earth data format is a customized eXtensible Markup Language (XML) text-based format that individuals could create and edit with a simple text editor, such as the Windows Notepad. The XML-based Keyhole Markup Language (KML) specifications are publicly available should students wish to develop their own datasets and learn the particular technology.

Towards Implementation: A Seventh-Grade Lesson Plan

A South Carolina-oriented lesson plan targeted for the seventh grade was developed to help illustrate the utility of Google Earth as an educational tool. This involved incorporating several types of data into a single KML file. The seventh grade was chosen to apply Bloom's taxonomy of cognition to support the creation of learning objectives at an appropriate age level (Lever-Duffy *et al.* 2005, 44–45) in order to demonstrate the applicability of the various standards and the utility of Google Earth. Data in the KML file are meant to illustrate both the breadth and depth of Google Earth as a potential educational tool.

The lesson plan involved using data in the KML and base imagery data available directly through Google Earth. The lesson plan is designed to help students along several educational fronts, specifically:

- knowledge (memorizing, recognizing, recalling);
- comprehension (organizing, describing, interpreting);
- application (applying information, solving problems, finding new ways to use information);
- analysis (finding underlying structures, separate whole into components, identify motives and hidden meanings);
- synthesis (compiling, combining); and
- evaluation (making value decisions and judgments).

The South Carolina standards at the seventh grade level incorporate these areas broadly in the context of world history. The challenge for students in the lesson plan is to have them think contextually, relating geographic space and landscapes with historical processes. The questions to be answered in the lesson plan help students identify patterns, consider complex relationships, develop

Table 3. Utility of Google Earth to support the National Geography Standards. (Source: Based on *The Eighteen National Geography Standards* (The National Council for Geographic Education 2006); adapted by author.)

Section of The National Geography Standard	Google Earth's Utility to Support The National Geography Standard
The World In Spatial Terms	
1. How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information.	The interactive nature of Google Earth makes learning about the world more personal (such as finding where you live) and engaging to explore the world. Students can compare cartograms to Google Earth imagery to understand how geographic representations vary.
2. How to use mental maps to organize information about people, places, and environments.	Consider a student's perception of the world and their relative place, and challenge the student to clarify their perceptions versus the reality they identify when employing Google Earth.
3. How to analyze the spatial organization of people, places, and environments on Earth's surface.	Measure distances and capabilities of people to interact due to transportation networks or geographic limitations to connectivity.
Places and Regions	
4. The physical and human characteristics of places.	Utilize the terrain feature of Google Earth to appreciate the physical nature of place—such as undertaking a virtual fly-through of the Grand Canyon or NewYork City.
5. People create regions to interpret Earth's complexity.	Review political regions (such as state boundaries) and consider how functional regions (such as religious cultural regions) influence their permanence or contribute to their instability.
6. How culture and experience influence people's perception of places and regions.	Review urban growth for major cities and consider how such growth affects how people interact and perceive the world around them.
Physical Systems	
7. The physical processes that shape the patterns of Earth's surface.	Review Mount Saint Helens or Hawaii to consider the physiologic processes at work and the impact of volcanic events both locally and globally. Consider the location of fault zones and the potential socio-economic impact of potential earthquakes.
8. The characteristics and spatial distribution of ecosystems on Earth's surface.	Consider river and forest systems' locations and the implications of their spatial reduction.
Human Systems	
9. The characteristics, distribution, and migration of human populations on Earth's surface.	Consider what places provide the most clear evidence of urbanization and development. As urban locations expand consider how migration affects the environment and physical resources.
10. The characteristics, distributions, and com-plexity of Earth's cultural mosaics.	Utilize Web services to ingest maps of cultural regions and consider ethnic tensions resulting from competing or conflicting cultural groups. (Such activity also helps to enforce the utilization of diverse technologies in Google Earth.)
11. The patterns and networks of economic interdependence on Earth's surface.	Consider how Afghanistan's neighbors. (What does landlockedness mean, and what does relying on neighbors for access mean? How has air travel reduced reliance on physical neighbors for economic viability?)
12. The process, patterns, and functions of human settlement.	Apply a concept, such as Central Place Theory, and identify places where the concept is evident in Google Earth. Consider why the concept is evident—or not—in the identified location.
13. How forces of cooperation and conflict among people influence the division and control of Earth's surface.	Review the ongoing Middle East conflict. Consider Israel's location and its strategic importance. Utilize terrain in Google Earth to understand the strategic nature of the Golan Heights, and how conflict has evolved in the region.

Table 3. *(Continued)*

Section of The National Geography Standard	Google Earth's Utility to Support The National Geography Standard
Environment and Society	
14. How human actions modify the physical environment.	Review farmland distribution along the East Coast of the United States. Consider what impact conversion of forests to farmland and farmland to developed areas has on the physical environment.
15. How physical systems affect human systems.	Review coastal development in South Asia and consider the effects of the 2004 tsunami both immediately and over time.
16. The changes that occur in the meaning, use, distribution, and importance of resources.	Consider the discovery of gold in the western United States and how that influenced development of the country. Find examples of terracing in China and how rice influenced its development.
The Uses of Geography	
17. How to apply geography to interpret the past.	Identify Baghgad, Iraq and Cairo, Egypt, and consider the physical surroundings of those cities. How did natural resources both influence and limit development, and cause evolution of mankind to emanate from such cultural hearths.
18. To apply geography to interpret the present and plan for the future.	Find your house or neighborhood on Google Earth. Why do you live there? What might the area have looked like fifty years ago? Consider how the neighborhood has changed during those fifty years, and what amenities are close by. How might the area change over the next fifty years, and what is needed to support such development or rejuvenation?

technology-based skills, learn important skills in support of various math, science, and social studies standards, and effectively (but implicitly) understand the five themes of geography.

Specific objectives of the lesson plan include students' ability to:

- become familiar with Google Earth as a technological tool by exploring the earth through Google Earth's interface and turning data layers on and off;
- become familiar with interpreting aerial, remotely sensed image data by answering questions included in the lesson plan, including considering special trends and patterns;
- identify geographically significant features and consider their importance, as well as the impact of development on them as unique resources; and
- consider how the earth has changed over time and how external threats and forces have contributed to such change.

The use of Google Earth in the lesson plan achieves a more active learning approach because the tool helps to facilitate learning. It supports understanding of many of the geography standards by helping students consider history in the context of geography (such as why a dam was built along a South Carolina river), the evolution of technology and how it helped shaped culture (such as identifying changes in population over time and how improvements in transportation had an affect on urban development), and environmental consequences to ineffectively managed growth (such as the implications of encroaching agriculture and development on the unique landscape of the Carolina Bays). Students are challenged to consider the strategic location of landmarks such as Fort Sumter and why certain areas experience changes in population over time.

Conclusion

As with any implementation of technology, there is a danger of insufficient time and appropriate tools to meet the intended objectives. Google Earth falls within those dangers, although its intuitive interface and powerful yet simple tools help to mitigate those pitfalls. The ability of students to apply deductive logic to reach conclusions promotes development of analytical skills; by requiring written explanations of observations, use of the tool also helps develop literacy.

Google Earth empowers students by giving them the means to complete complex tasks and by providing them considerable latitude in the design of projects. Students are made aware of spatial trends and implications while not explicitly knowing they are learning geography; this can be both a potential strength and weakness. Although Google Earth does not have a multitude of tools and capabilities as does a true GIS, it enables students to learn about spatial patterns and think spatially. It also sets the stage

for students to engage in GIS as they begin to ask more complex and detailed questions after they reach the limit of Google Earth's utility.

This discussion is intended to scratch the surface of the utility of Google Earth as an educational tool. There continues to be a need for researchers and educators to engage in meaningful dialogue regarding the pros and cons of the technology. A further implication for future research includes developing scientifically-derived measurement criteria to critically evaluate the effectiveness of students' learning using Google Earth.

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