

Overcoming Assessment Problems in Google Earth-based Assignments

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ABSTRACT

Educational technologies such as Google Earth have the potential to increase student learning and participation in geoscience classrooms. However, little has been written about tying the use of such software with effective assessment. To maximize Google Earth's learning potential for students, educators need to craft appropriate, research-based objectives, utilize engaging student-centered learning techniques, and directly assess student learning. Several example activities are included to suggest how Google Earth-based geoscience lessons can be created and still maintain measurable learning outcomes. © 2011 National Association of Geoscience Teachers. [DOI: 10.5408/1.3604822]

INTRODUCTION

The use of educational technology, according to [Herrington and Kervin \(2007\)](#), can serve as a departure from traditional lecture-based instruction because it “not only [functions] as a means to engage students in meaningful and immersive learning environments, but also to enable[s] students to use and experience powerful cognitive tools.” Technology's continual integration into our schools reflects the truth of the statement: from kindergarten to graduate school, new learning tools are increasingly used everywhere from in-class activities to learning assessment (e.g., [Cauley et al., 2010](#); [Lamb and Johnson, 2010](#); [Salend, 2009](#)). In order to prepare students for the science, technology, engineering, and mathematics (STEM) fields, teachers in their corresponding educational disciplines have become leaders in adopting instructional technologies and encouraging scientific thought ([Marshall, 2010](#)).

Similar to other science teachers, earth science educators have in their content area a rich source of computer and web-based technologies that aid in geospatial explorations, including global positioning system (GPS), ArcGIS, and Google Earth (e.g., [Mannel et al., 2007](#); [Sherman-Morris et al., 2009](#)). Of these innovations, Google Earth may be the most popular due to its free cost, relative ease of use, and adaptability. It is certainly one of the more discussed geospatial technologies in geoscience education (e.g., [Lamb et al., 2008](#); [Sherman-Morris et al., 2009](#)). For example, the Science Education Resource Center (SERC) lists seven broad categories on its website (serc.carleton.edu) in which Google Earth can be utilized in classrooms:

1. to support hands-on inquiry by students in computer classrooms,
2. as a basis for homework assignments,
3. for dynamic presentations during class lectures,
4. for inquiry during class presentations,

5. to create imagery and maps for PowerPoint, Word, and other presentation tools,
6. as a data discovery, organization, and distribution tool for research projects, and
7. to enrich discussion of an issue that arises spontaneously during an informal classroom discussion.

Of these seven categories, four (3, 4, 5, and 7) are rooted in teacher-centered direct instruction (e.g., lecture), while the remaining three (1, 2, and 6) have the most potential for student-centered inquiry-based learning when using Google Earth. Rather than having the teacher as the sole disseminator of information, inquiry-based teaching practices allow students to actively participate in a variety of exercises that challenge them to analyze, synthesize, and evaluate information ([Chun, 2010](#)).

Student-centered learning offers a variety of benefits over traditional teacher-directed instruction. Perhaps most important, this approach to instruction keeps students engaged. Putting students in the driver's seat of their learning by encouraging such tasks as creating or analyzing rather than listening “enables students to think of themselves as learners” ([Bryk, 2010](#)). Placing the focus on learners also means student-centered strategies are easily tailored to suit individual students' learning needs. This personalized instruction can radically affect students' involvement in their own learning by making content more comprehensible as well as meaningful ([Hannafin et al., 2009](#)). A comparison of teacher-centered and student-centered introductory geology courses by [McConnell \(2009\)](#) found that students participating in the inquiry-based classes felt that “the group arrangement took away the impersonal feeling of a large class, provided an opportunity to participate, gave students a peer to explain the material, and let them hear the opinions of others.” Those students also performed better on exams, were more satisfied with their experience, and were less likely to drop out than those in lecture-based classes. The inclusion of classroom technology gives educators a fantastic opportunity to break away from traditional teaching styles and involve their learners in inquiry-based learning practices ([Herrington et al., 2007](#)).

Science education's emphasis on analysis and synthesis of information, along with Google Earth's interactivity, provides teachers with an excellent opportunity to utilize active learning strategies. Still, many educators at the K–12

Received 16 September 2010; accepted 29 October 2010; published online 1 August 2011.

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and collegiate levels seem to limit their student-centered Google Earth activities to worksheets (Table I). Out of five Google Earth-based lesson plans found through different online sources, three were limited to worksheet-based activities and assessment. With activities such as worksheets with fixed answers, a teacher may easily assess how students have met whatever objectives the teacher has set for the lesson, activity, or project. In doing so, they may have also limited students' interest and participation by not providing students with an engaging learning environment.

Like other instructional strategies, technology use has the unfortunate potential of being ineffective if not paired with clear objectives and appropriate assessments. This may even occur without the teacher's knowledge. Dittmer (2010) has warned that although technology "engages students in their own learning, and within a technological context in which students are generally quite comfortable," it may still end up taking "on the worst elements of older models of correspondence courses" if used incorrectly. Even with the best of intentions, assignments rooted in classroom technology may still end up reflecting the "wooden, top-down...teaching model" which Dittmer (2010) described. This is just as true for the Google Earth software as for any other classroom technology. To fully utilize Google Earth, educators must be able to couple student-centered instructional strategies with clearly defined learning objectives and motivating engaging assessments. This article discusses those issues in further depth.

RELATIONSHIP BETWEEN OBJECTIVES, INSTRUCTIONAL METHOD, AND ASSESSMENT

Creating effective objectives, and following them up with quality assessments, requires an understanding of

what has become one of the most influential objective-writing tools for K–12 (and to an extent, collegiate) educators (Booker, 2007). In his first *Taxonomy of Educational Objectives* handbook, Benjamin Bloom (1956) outlined different ways of thinking about information and how learners can use those different ways of thinking to their advantage. As education researchers have extensively written about Bloom's Taxonomy (e.g., Booker, 2007; McConnell et al., 2003; Wineburg and Schneider, 2009), we only outline the taxonomy due to its relevance in creating educational objectives and assessments.

Bloom's taxonomy consists of six separate levels of thinking (also known as "cognitive domains") which range from the least to most cognitively challenging (McConnell et al., 2003). The domains are Knowledge (the least cognitively demanding), Comprehension, Application, Analysis, Synthesis, and Evaluation (the most cognitively demanding) (3 Bloom, 1956). Each cognitive domain is also associated with a variety of activities designed to utilize domain-respective skills. For example, the act of remembering specific information falls into the Knowledge domain and any activity that requires a person to recall something such as a name, date, or location would fall into that domain as well. Activities that fall into the most cognitively demanding domains of the taxonomy (Application, Analysis, and Synthesis) are considered more challenging for learners but they allow students to move beyond the simple recall of information and to actively forming learning (McConnell et al., 2003). The more challenging levels of the taxonomy are appealing for geoscience educators because the skills the domains require form the bedrock of scientific thinking. Analysis requires learners to break down material into component parts or compare and contrast content to a student's personal experiences. The Synthesis domain focuses on putting parts together through the organization of

TABLE I. A sample of different Google Earth lesson plans available online, most of which fail to take educational objectives or measurable assessments into account.

Source	Lesson	Objectives	Assessments
Axelson, D., Plate tectonics: http://sitescontent.google.com/google-earth-for-educators/Home/google-earth-lesson-plans (July 2010).	Students investigate different geographic features of plate tectonics.	Yes, but could be more specific (ex., "Classify volcanoes by the three types.")	Presentation graded by generic rubric, knowledge-based vocabulary quiz
De Paor, D. et al, Glaciers and glacial geology lab: http://www.lions.odu.edu/~ddepaor/ccli/labs/Glacial.html (July 2010)	Students cover glacial geology.	None written	Worksheet
Juicy Geography, Modelling sea level change on the Gold Coast: http://www.juicygeography.co.uk/sealevel.htm#credits (July 2010).	Learners model the effect of rising sea levels on the coast of Australia.	None written	Presentation or report; no rubric provided
Scholastic, Climate Change: http://teacher.scholastic.com/lessonplans/exploreyourearth/lesson1.htm (July 2010).	Students tour different areas of the United States affected by climate change.	None written	Worksheet
Discovery Education, Earth's surface: http://school.discoveryeducation.com/lessonplans/programs/earthssurface/ (July 2010).	Using Google Earth or Maps, students find geographic locations shown in a video.	Yes, but none are measurable (ex. "Discuss the use of satellites")	Worksheet

thoughts, ideas, and information from the content. Finally, in Evaluation, students judge the value of material for a given purpose. Google Earth can be a means to help students develop in these cognitive domains. Increased cognitive involvement translates into increased student interest, participation, and most importantly, learning (McConnell *et al.*, 2003). Each cognitive domain in Bloom's Taxonomy has a list of verbs associated with it that are used in objective writing (Overbaugh and Schultz, n.d.; lists of these verbs can be found easily online). These verbs are combined with other simple yet critical parts that produce measurable objectives for teachers to set for their lessons. The type of cognitive domain the instructor targets in writing a Google Earth-based lesson will affect the objectives, activities, and assessments he or she chooses for the lesson.

Although Bloom's taxonomy can be a helpful tool in designing learning objectives, objectives can be taken a step further to indicate the instructional method and the level of proficiency at which the learner will be assessed. A popular format for student-centered objective writing is known as the "ABCD structure", which breaks a written objective into four parts: audience, behavior, condition, and degree (Heinrich *et al.*, 1996; O'Bannon, 2001). Combining all of these things—not necessarily in ABCD order—ensures that educators have produced objectives that are clear and measurable. Learning objectives written in ABCD format would be done in a fashion similar to this:

Students (A) will find the approximate (D) geographic coordinates of the world's three tallest mountains (B) using Google Earth (C).

After using Google Earth (C), learners (A) will be able to accurately (D) explain the location of the volcanoes in the Pacific Ring of Fire (B).

Students (A) will be able to create a five stop (D) tour of the Grand Canyon (B) using Google Earth (C).

Putting the objectives into more direct terms for students may prevent confusion; the critical purpose of informing learners is to let them know "what they will learn, why they will learn it, and how they will be assessed" (Larson and Keiper, 2007).

CREATING QUALITY ASSESSMENTS

Booker (2007) explained that: "Assessment... involves objectives. The objectives need to tie into measurable outcomes. Those outcomes need to be... about student behavior. Those behaviors need to reflect Bloom's Taxonomy." The purpose of assessment is not solely grades, but rather, to reveal lots of information about a group of students: how effectively the teacher is teaching them, whether a certain topic or skill must be re-taught, and how involved students are in the class (Larson and Keiper, 2007). Assessments are derived from the learning objectives; objectives, in turn, should be influenced by the results of assessment (Chun, 2010). Educators who tie their assessment to objectives based on Bloom's Taxonomy have the advantage of knowing which cognitive domain they will be challenging in their students and are deliberately crafting assignments that will help their students master the targeted cognitive domain.

Teachers at the K–12 and collegiate levels should keep in mind while writing objectives that although higher-order thinking is important, it is something which needs to be gradually introduced to students to be effective (Booker, 2007; Wineburg and Schneider, 2009). A teacher should not start out with intensive Evaluation-level assignments until they are sure that their students have the background knowledge required to do so. This also applies not only to school years or semester-long classes, but also to students' educational experiences in the long term. The cognitive ability as well as background skills and knowledge of the learners should be taken into consideration when designing objectives and assessments (Booker, 2007). This is no different when designing Google Earth-based assignments.

TYING OBJECTIVES AND ASSESSMENT WITH GOOGLE EARTH

Knowing the basics of effective objective and assessment creation, teachers can make the most out of Google Earth activities. In this section, an example activity or project will be given for each level of Bloom's Taxonomy. The assignments shown are designed to facilitate student-centered inquiry-based learning and as such relate to three (numbers 1, 2, and 6) of the SERC's seven possible uses of Google Earth listed in the Introduction. The examples have been designed to teach plate tectonics in an introductory geology course. Of course, "subduction zones" (and plate tectonics, in general) as a topic could easily be changed to fit any other subject matter. Each assignment builds (or "scaffolds") off of the previous activity, allowing students to continue to utilize the information and skills they are learning (Holton and Clarke 2006; Streitwieser *et al.*, 2010).

We should note that ideas for several of the activities have come directly from or have been modified from a wide variety of sources (mostly online) and others have been created based off of Bloom's Taxonomy. For educators of all levels, there are a wide variety of websites geared toward Google Earth activities—the Science Education Resource Center's site (serc.carleton.edu/sp/library/google_earth/how.html) is one great starting point and provides an excellent portal to a wide variety of online sources such as *Google Earth Lessons* (<http://gelesson.com>) and the website of the Digital Library for Earth System Education (DLESE) (dlese.org/educators). Example objectives (in ABCD format) have also been included and will preface the explanation of the assessment. For an in-depth introduction, explanation of Google Earth features, and tutorials, the "Support" page on the Google Earth website (<http://earth.google.com/support/>) is an excellent resource.

Knowledge—Using Google Earth, students will record the location of three subduction zones. This assignment concept could be completed after watching a class video, reading text/listening to lecture, or even watching a teacher-created Google Earth tour of subduction zones. Rather than using a worksheet or an oral review to assess what students have learned from the lesson, students can use Google Earth itself as a tool to demonstrate their knowledge to teachers by placing differently labeled/colored "Placemarks" in the general area of the appropriate subduction zones. The Placemarks can be stored in a folder that the student can label and, with the right click of a mouse, email to the teacher to

check for accuracy Fig. 1). As an alternative, teachers could simply have students write the geographical coordinates of their Placemarks. For more information on creating Placemarks, *Juicy Geography* provides an excellent Flash-based tutorial on their resource list (<http://www.juicygeography.co.uk/resourceslist.htm>).

Comprehension—After using Google Earth to view the location of four Placemarks in the Pacific Ocean, students will be able to recognize the morphologic differences between subduction zones and mid-ocean ridge spreading centers. This assignment utilizes one of Google Earth's newer features—the "Ocean" layer—to give students an opportunity to delve into the depths of the Atlantic on a three-dimensional basis. Teachers can assign a variety of activities to assess what the students have learned from their experiences. Some activities may include taking a student poll using a classroom response system (also known as "clickers") and having the students discuss why they chose their answers, or even having students explain as a group to the class why they picked what they did. As long as the student response mirrors what the teacher has decided the appropriate answer to be, the teacher can be sure that the student has grasped the important concept of the assignment.

Application—From the previous information collected, students will write a set of characteristics that one can use to locate subduction zones and mid-ocean ridges elsewhere on Earth. This activity challenges learners to utilize knowledge they have about certain geological principles (in this case, plate tectonics) and apply it on their own. Placemarks could be useful in this activity as well—by having students drop them on features such as mountains or ocean trenches. Google Earth

add-ons like "Real-time Earthquakes" by the U.S. Geological Service (available on the Google Earth site) allow students to gain an even clearer picture by showing plate boundaries and recent seismic activity (Fig. 2). The teacher could also pull up a subduction zone on Google Earth and have students read out their written characteristics of subduction zones. The class could then collectively compare their descriptions to the shown subduction zone.

Analysis—Using Google Earth and the volcano layer, learners will be able to infer that a majority of volcanoes lie near subduction zones. Google Earth's "Volcano" feature reveals the locations of all of the planet's major volcanoes. Groups of students can analyze the geographical features around large clusters of volcanoes and compare them to other clusters, reaching the conclusion that most have a great deal of similarity. Using the Plate Boundaries layer in the *Real-time Earthquakes* add-on, in addition to the Volcano layer, makes the answer obvious: most volcanoes lay near plate boundaries. Students would then have to investigate what would cause volcanoes to appear in such locations. Having student groups create a poster about what they have learned about a volcano chain's location along a plate boundary could be used to assess learning. Teachers could use a simple rubric—distributed to the students beforehand—to grade the poster. For educators with a limited amount of time on their hands, Rubistar (rubistar.4teachers.org) is a free tool that can expedite rubric creation.

Synthesis—Using Google Earth and the Volcano layer, students will formulate a hypothesis to explain why volcanoes occur along subduction zones and present the information in a five-stop Google Earth tour. This activity would give students

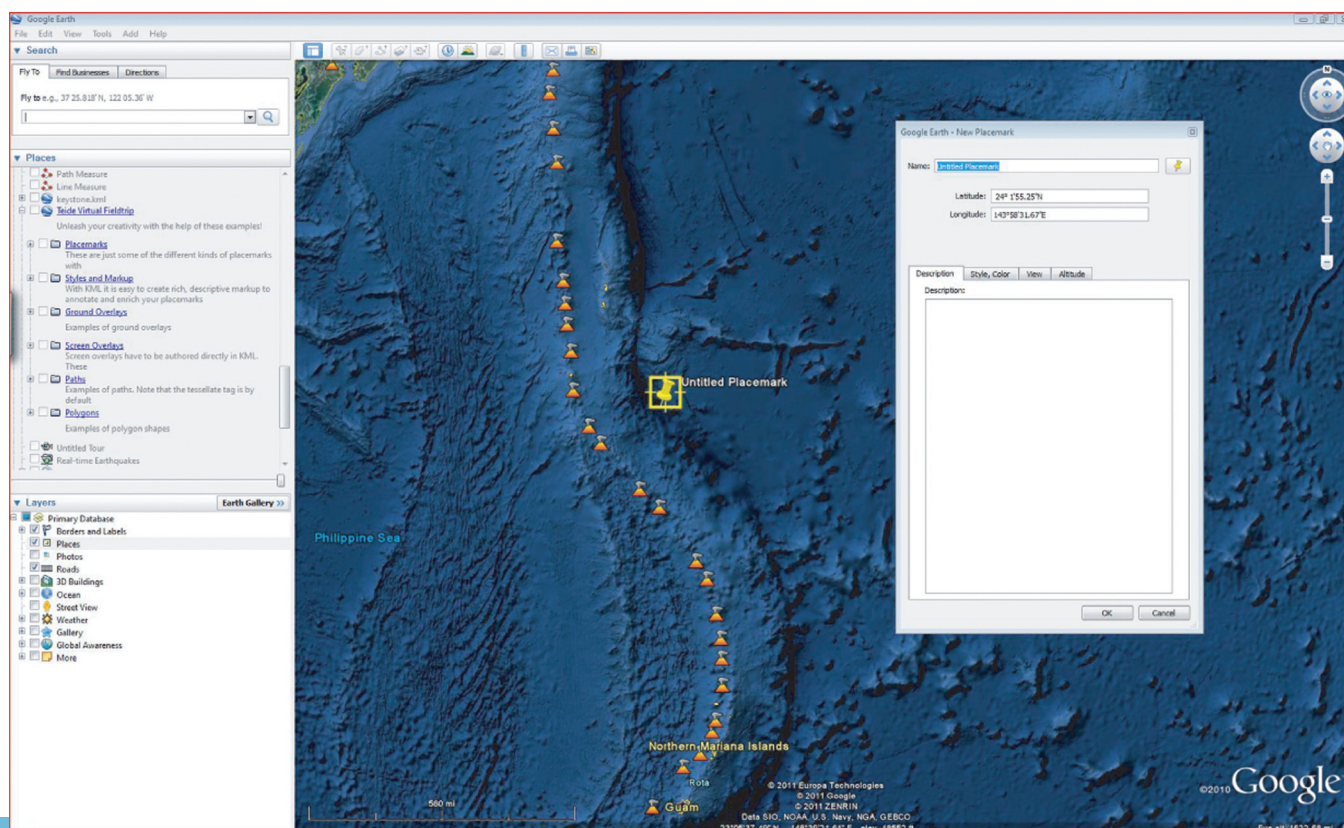


FIGURE 1: Placing and editing a Placemark in Google Earth. A Placemark resembles a pushpin and be easily placed anywhere on the Google Earth globe. The location of the Placemark button is indicated by the arrow (top left).

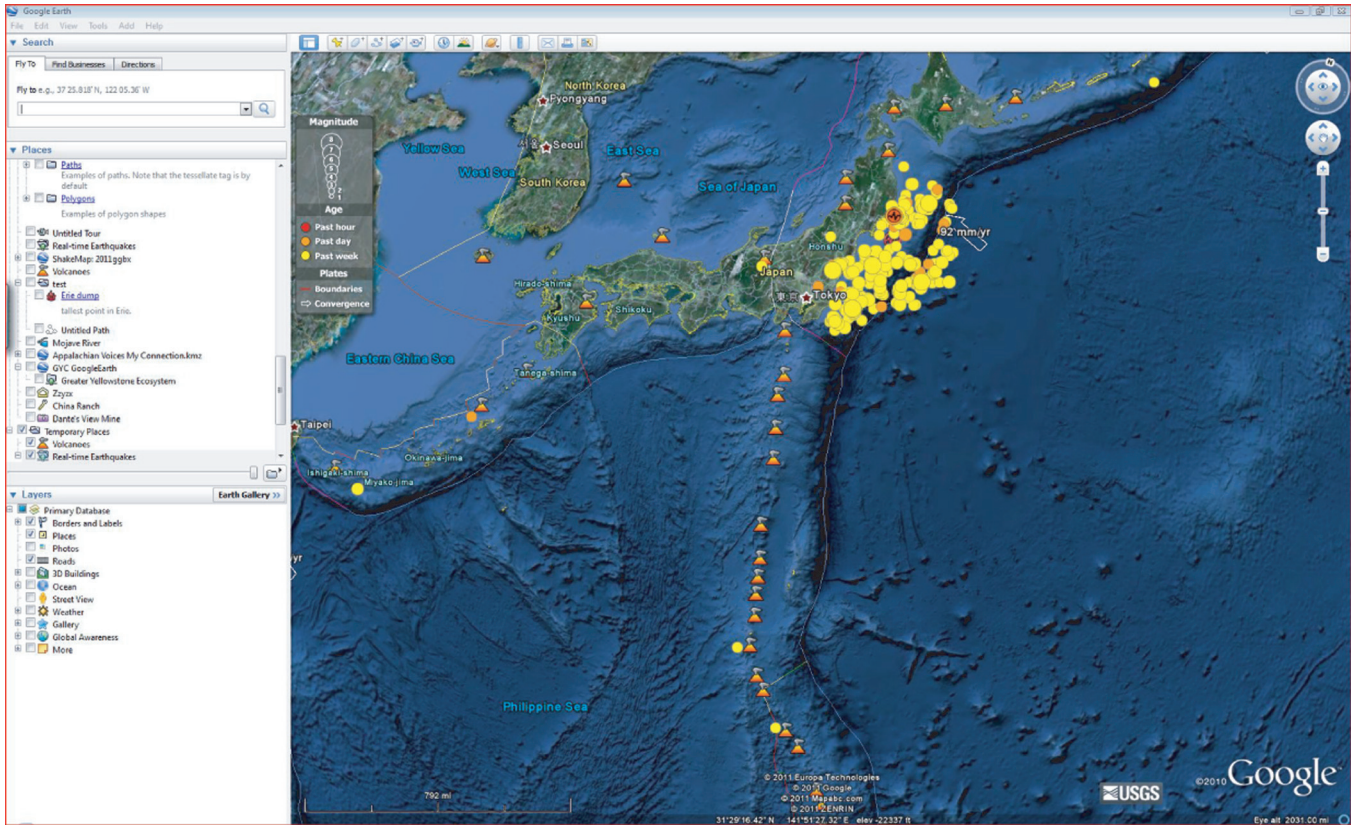


FIGURE 2: Looking at Japan’s coastline through the United States Geological Survey’s “Real-time earthquakes” add-on for Google Earth. The hollow arrow represents tectonic plate movements while the white dots (near the white arrow) signify areas of recent seismic activity. The line underneath the hollow arrow is a tectonic plate boundary.

an opportunity to create a product that displayed their knowledge of a given topic—in this case, reasons why volcanoes appear alongside subduction zones. Learners could create a tour of subduction zone features to present evidence for their hypothesis. Again, the *Real-time Earthquakes* add-on’s Plate Boundaries layer could be useful here. Just as with Placemarks, tours can be easily emailed to a teacher for evaluation. For an assessment that gives students so much creative license, a rubric would again provide valuable guidelines. Rather than the rubric a teacher would create for the Analysis example, however, a rubric created for this activity would be more beneficial if it were highly detailed.

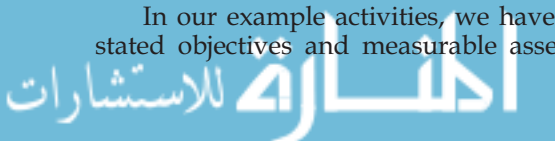
Evaluation—Using Google Earth, the volcano layer, and the USGS Earthquake add-on, students will evaluate the accuracy of their hypothesis. To evaluate the hypothesis that was formed in the Synthesis activity, students could compare their Google Earth subduction zone tours with those of other students. This might be done by having students create a table listing evidence that does and does not support their hypothesis that was obtained from the tours, which they and other students have constructed. The teacher could then guide a discussion based on students’ tables, making sure that students come to an accurate conclusion and any incorrect perceptions are cleared up.

with student-centered inquiry based learning, gives teachers the tools to improve the effectiveness of their Google Earth-based lessons. Unlike many available assignments written for Google Earth (Table I), this instructional approach of tying objectives and assessments together can measure students’ progress toward the learning goals set by the educator. The feedback gained from assessment allows the instructor to adjust future learning objectives to meet the learning needs of the students. The use of classroom technology—Google Earth—also helps keep students entertained and engaged and allows them to view geology on a much larger and more interactive scale than they would have had access to otherwise.

In our examples, we have taken the concept further by combining and scaffolding the lessons to teach about the concept of plate tectonics. Our series of activities was designed to ensure that each one would branch off of information or skills derived from a previous activity. [Streitwieser et al., \(2010\)](#) have noted that scaffolding is beneficial in student-centered science classrooms because of the tiered way in which content is introduced to students: educators first teach students “about the cognitive tasks, social interactions, tools, and artifacts that constitute scientific practices.” Once those have been mastered, the teacher “identif[ies] aspects of those practices where learners are most likely to encounter obstacles and provid[es] support to overcome them.” Applying activity in the examples to cognitive domains of Bloom’s taxonomy fits perfectly into the scaffolding concept: students are introduced to Knowledge-level information and are gradually applying higher-

DISCUSSION

In our example activities, we have shown that clearly stated objectives and measurable assessments, combined



order thinking skills in a scientific manner. Since lessons are student-centered, the teacher acts as a facilitator of knowledge and assists students who are having difficulty.

These teaching strategies are not restricted to our example activities and can be altered in a variety of ways to fit any teaching activity. For instance, the scaffolding technique used in the example activities could easily fit into a single day's lesson or be stretched out over an entire semester while remaining just as effective (e.g., Vacca, 2008; Streitwieser *et al.*, 2010).

The same strategies used in our examples could be applied to any of the geoscience Google Earth activities found in Table I to maximize their potential for student learning. Adding more specific educational objectives in ABCD style would give both the teacher and students clear expectations of what students should be able to learn through the lesson or activity and how they will be assessed. For instance, in the website Juicy Geography's lesson about sea level changes (where the description of the lesson's goals is to "create a series of Google Earth polygons to illustrate the impact of sea level change"), a more specific objective may be useful: *Using Google Earth, students will model the effects of sea level change on the Australian Gold Coast and create a five-stop tour to highlight the worst hit areas.* The assessment ("modeling sea level change and creating a five-stop tour") also becomes more specific and clearer for students, as well as keeping them engaged while creating the tour. The lesson would not end there, however. Depending on the quality of students' tours, the teacher would then reteach the content to students who did poorly or build upon the lesson's content and move forward. Applying the same appropriate research-based objectives, utilizing engaging student-centered learning techniques, and directly assessing student learning has the potential to make any Google Earth-based lesson more effective.

Suggestions for Further Study

Google Earth is still a relatively new program and, as such, there is still much work that needs to be done to integrate it into the classroom instruction. Here, we have argued that employing a student-centered inquiry-based approach can maximize student learning potential when using Google Earth in geoscience classes. However, additional work should also address student skill and retention levels from Google Earth use (e.g., McConnell *et al.*, 2003) as well as the ability of students to transfer the knowledge they have learned from this virtual setting to real-world situations. By better understanding these attributes of this learning environment, educators can make more informed decisions about the use and integration of Google Earth into their classrooms.

CONCLUSION

Google Earth has the potential to bring the best of educational technology into teachers' classrooms. It allows students to go beyond simple maps and worksheets to provide them with a unique, interactive, and engaging look at our planet. Given its variety of add-ons and layers, it is capable of being used in a wide variety of content areas. Even better, Google Earth is a tool that can transport learners across the entire globe in seconds, giving them an

opportunity to interact with areas of our planet that they will most likely never travel to. Its ease of use, free price, and adaptability make Google Earth a must for any teacher's classroom.

Possibly no other content area can benefit more from using Google Earth than that of geoscience education. Rather than various maps or diagrams of geological data, it is now condensed into a virtual, interactive, three-dimensional model. Fortunately, geoscience educators at all levels understand that potential and have diligently worked to place Google Earth into their classrooms. The question then—as with any educational technology—is how to maximize its potential in a learning environment. For many teachers with educational training in their background, ideas such as learning objectives and assessment may be second nature. Others may have never had the opportunity to be exposed to them. This purpose of this article, then, is not to criticize those who may be unfamiliar with objective writing or tying assessments to those objectives—it is to provide guidance on how they can be created and tied to the Google Earth software. Detailed objectives, when measured by student-centered inquiry-based assessments and combined with excellent programs like Google Earth, will help geoscience educators facilitate their students' learning in a way teachers could only dream about ten years ago and will hopefully instill in students a sense of respect and understanding for those who study our planet.

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