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Who are interested in online science simulations? Tracking a trend of digital divide in Internet use

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ABSTRACT

Although the Internet has become a major source for disseminating educational resources for science, technology, engineering, and mathematics (STEM), little is known about the extent to which these resources are being used, their relationship to academic performance, and the type of users accessing these resources online. This study used two innovative tools, Google Trends and Web analytics, to explore interest in and usage of the PhET website, one of the most well-known online science simulation resources. This study found that search interest in the PhET science simulations has been growing continuously since 2005. However, search interest in PhET was positively correlated with academic performance and income, and negatively correlated with the achievement gap between high- and low-performing students. Moreover, Internet users in states with more White students were more interested in the PhET science simulations. Yet Internet users in states with more Black students were less interested in these science simulations. These findings suggest that the way online STEM resources are being used is likely to widen, rather than narrow, the achievement gap. This is the first study to utilize Internet search trend data and Web analytics tools for monitoring Internet use for educational purposes.

1. Introduction

Science simulations are computer-based interactive representations of real or hypothesized scientific phenomena (National Research Council, 2011). Science simulations help students visualize abstract concepts and observe phenomena invisible to the naked eye, such as molecular motion (Olympiou, Zacharias, & deJong, 2013). Science simulations also allow students to conduct virtual experiments, manipulate variables, and immediately observe results that would naturally require long periods of time, such as the effects of varying amounts of greenhouse gases (Scalise et al., 2011). In addition, scientists routinely create and use simulations to model and understand natural phenomena. Science simulations can help students access and construct the mental models of scientists for understanding and explaining scientific phenomena (Wieman, Adams, & Perkins, 2008).

A growing body of research has explored the potential of science simulations to improve content understanding and student engagement in science education (Jimoyiannis & Komis, 2001; National Research Council, 2011; Olympiou et al., 2013; Scalise et al., 2011). In a recent review of 79 studies on science simulations for Grades 6–12 (Scalise et al., 2011), 96% of the studies reported at least some learning gains, suggesting that well-designed science simulations are a powerful learning tool. These studies frequently reported positive outcomes for science simulations with respect to supporting students in engaging in active and extended scientific inquiry, understanding dynamic processes of scientific phenomena with animated representations, and supporting student collaboration, individualized learning, and continuous assessment (Scalise et al., 2011).

Motivated by the promising potential for science learning and student engagement, science educators and researchers have developed many interactive science simulations and made them freely accessible on the Internet. One of the most well-known online science simulation resources is that created by the Physics Education Technology (PhET) project (http://phet.colorado.edu/) at the University of Colorado at Boulder (National Research Council, 2011).

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2. PhET online science simulations

The PhET website contains a large collection of simulations for topics in physics, chemistry, biology, earth science, and mathematics from elementary school to college levels. All simulations are free to the public. The PhET project was founded in 2002 by Carl Wieman, a Physics Nobel Laureate, with the goal of using interactive simulations to improve science education (Xue, 2012). The development of PhET simulations has been supported by dozens of federal, corporate, and private sponsors, including the National Science Foundation, the William and Flora Hewlett Foundation, and the O'Donnell Foundation.[1]

PhET simulations were conceptualized and built based on sound design principles (McKagan et al., 2008; Perkins et al., 2006; Wieman et al., 2008). The simulations emphasize real-world connections and use familiar objects to bridge science concepts and real-life experience (e.g., balloons, faucets). The simulations incorporate visual representations to make the invisible visible and provide multiple representations to promote deeper understanding. In addition, the simulations invite students to explore, to change variables, and to measure and analyze data using embedded tools. The simulations were carefully designed to simplify the complexity of reality and present challenges to students that are neither too easy nor too difficult. Common misconceptions were anticipated and guidance and feedback was built into the simulations to scaffold student learning (Wieman et al., 2008). PhET simulations can be used in both formal and informal learning environments, such as inquiry-based lessons, laboratory activities, homework, and student-directed self-exploration (Wieman, Adams, Loeblein, & Perkins, 2010).

Rigorous research has been conducted to evaluate the effectiveness of PhET simulations (Adams et al., 2008a, 2008b; Finkelstein et al., 2005; McKagan, Handley, Perkins, & Wieman, 2009).[2] For example, a study that compared use of a simulation called "Circuit Construction Kit" with equivalent electric equipment found that students conducted more spontaneous experiments using the simulation and gained a better understanding of the concepts of current and voltage than those who used real circuit equipment (Finkelstein et al., 2005). In addition, the researchers conducted over 200 individual interviews with students when they used PhET simulations in a think-aloud format (Adams et al., 2008a, 2008b). These studies showed that the PhET simulations engaged students, who preferred using the simulations rather than actual equipment, and helped them learn science concepts.

There are currently a total of 128 simulations on the website,[3] including 94 in physics, 39 in chemistry, 38 in biology, 19 in earth science, and 31 in mathematics. Some simulations cover multiple subjects. These simulations serve students from elementary school to college, including 47 simulations for elementary school, 83 for middle school, 110 for high school, and 115 for university students.[4] Some simulations are listed cross grade levels. PhET simulations have been viewed over 110 million times.[5] Few online science simulations are as large in scale or as popular. With strong support from a variety of foundations, conceptualized and developed by researchers with high scientific credentials, and empirically tested by rigorous research, PhET simulations are widely recognized as exemplars of science simulations (MERLOT, 2006; National Research Council, 2011). PhET simulations received the Tech Award in 2011, a prestigious award that honors organizations for using technology to make the world a better place (McCracken, 2011).

Although a great deal of research has been conducted on PhET simulations in various educational settings, little is known about how these simulations are being used on the Internet and many questions remain unanswered: To what extent are Internet users interested in and using these online science simulations? What type of users may be more interested in the simulations? How is interest in the simulations related to academic performance? This study aimed to address these questions using Internet search trend data and Web analytics, two innovative tools that have rarely been used in educational research.

Over the last decade, the Internet has become a major source for disseminating educational resources for science, technology, engineering, and mathematics (STEM) (Lee et al., 2011; Porcello & Hsi, 2013). Yet little is known about the extent to which these resources are being used, what type of students use them, and their impact on student learning. The paucity of research in this area is partially due to the lack of an effective method for tracking real-time Internet usage. This study described how to monitor the Web for education through a case study on PhET, one of the most well-known STEM resources on the Internet. The tools and methods used in this study can be applied to analyze other Internet-based STEM resources. Understanding how online STEM resources are being used is important, because prior research has suggested that, given equal access to the Internet, Internet use can enlarge, rather than narrow, the digital divide (Hargittai & Hinnant, 2008; Wainer et al., 2008).

3. Internet use and digital divide

Attewell (2001) differentiated two levels of digital divide. The first digital divide refers to unequal access to computers and the Internet, which creates a gap between the "haves" and "have-nots." Poor, less educated, and minority families were less likely to have access to computers and the Internet. Great progress has been made in the last two decades with regard to closing the first digital divide in school and at home (National Center for Education Statistics, 2010; Tsikalas, Lee, & Newkirk, 2007). However, not all computer use is beneficial, which leads to the second digital divide—sociodemographic inequalities in the use of computers and the Internet (Attewell, 2001).

Depending on the type of online activities that one engages in, Internet use can reinforce the privileges of the advantaged and enlarge social inequalities. For example, Hargittai and Hinnant (2008) found that young adults with a college degree were more likely to engage in capital-enhancing use of the Web as compared to less educated peers. Such use refers to online activities that can advance career, improve education, increase civic engagement, and inform financial and health choices. Similarly, van Deursen and van Dijk (2014) found that highly educated adults were more likely to use the Internet for personal development, while adults with lower education levels were more likely to go online for gaming and social interaction. In addition, a recent study published by *Nature* found that the vast majority of students who took

[1] Information was retrieved from http://phet.colorado.edu/en/about/sponsors.
[2] A more complete list of research on PhET simulations is available at http://phet.colorado.edu/en/research.
[3] Information was retrieved from https://phet.colorado.edu/en/simulations/index.
[4] Information was retrieved from https://phet.colorado.edu/en/simulations/category/by-level.
[5] Information was retrieved from http://phet.colorado.edu/.