Games and Simulations in the Classroom

How interactive media can demonstrate scientific phenomena and enhance the educational experience

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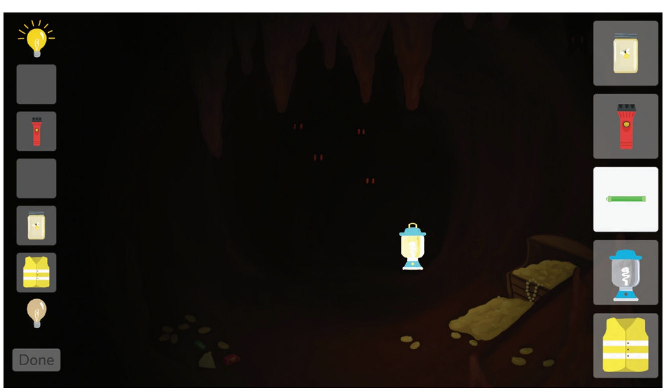
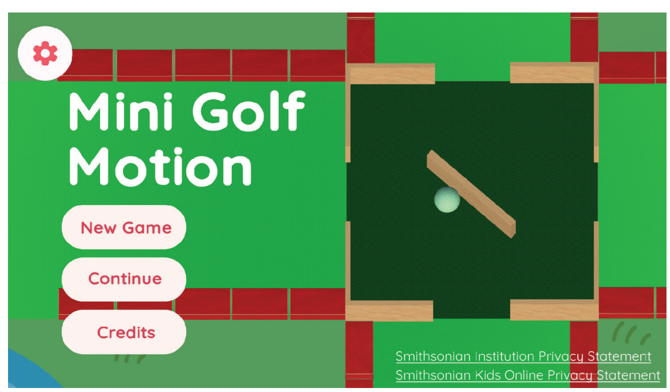
During the COVID-19 pandemic, educators relied more heavily on digital games and simulations as teaching tools as many classrooms shifted to remote learning (Favis 2020). However, games and simulations don't just help with remote learning. Extensive research, much of which is summarized in S. de Freitas's literature review (2018), has been done on the efficacy of digital games and simulations in a diverse range of educational settings, leading to the conclusion that game-based learning—that is, the exploration of educational concepts through interaction with digital media—is a valuable supplement to more traditional styles of pedagogical instruction. Specifically, there is evidence that games and simulations have marked benefits on development of critical thinking, problem-solving, systems thinking, and creativity skills—all of which are crucial to science education (US Department of Education Office of Educational Technology 2017).

The Difference between Digital Games and Simulations

Though games and simulations for learning are similar, there are some differences between these two types of digital media.

Credit: Smithsonian Science Education Center





Light Up the Cave (left) is an example of a simulation, while *Mini Golf Motion* (right) is an example of a game.

- Simulations allow students to engage with one or more phenomena that are present in the real world but don't necessarily have a defined gameplay outcome (such as a win condition), though simulations may have very real and defined learning outcomes!
- Digital games frequently also simulate real-life phenomena but often incorporate more elements of fantasy and/or story and usually have a definite end goal for the player (such as acquiring a certain number of points to get to the next level).

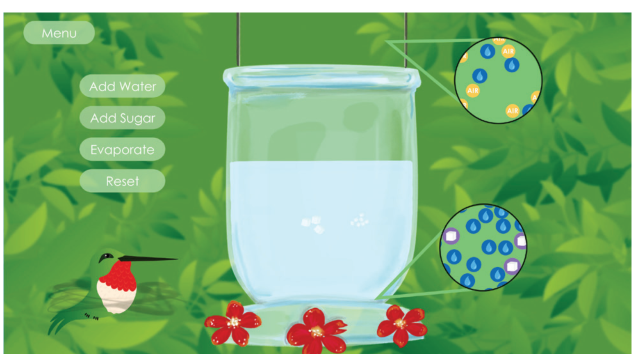
Both games and simulations offer opportunities for guided exploration and interaction and have outstanding potential for educational use.

Introducing and Explaining Phenomena and Problems

With Next Generation Science Standards* (NGSS), phenomena and problems often drive student inquiry. A phenomenon highlights something that is happening in the world that requires scientific reasoning to explain. An NGSS lesson often introduces a phenomenon at the starting point of a module or series of lessons. This gives students self-guided opportunities to learn about and test theories in the designed digital world in a process known as sensemaking.

Digital simulations and games can be used to present a variety of phenomena to students. For example, the Smithsonian Science Education Center's *Light Up the Cave* simulation is featured at the beginning of the first grade Smithsonian Science for the Classroom "How Can We Light Our Way in the Dark?" module to give students an opportunity to investigate the phenomenon of light sources in a dark environment. Students use their experience with the simulation to prepare for concepts like reflectivity, beams of light, and shadows, which are introduced later in the module.

Some phenomena and problems are particularly well-suited to be explored through digital games and simulations. Scientific phenomena that are too big, too small, too far away, or too difficult or dangerous for observation within a classroom are natural fits for the safe space of a virtual world. For example, in *Sugar Simulation*, fifth grade students model what happens on a particle level when sugar is dissolved in water, something that is difficult for students to observe firsthand.



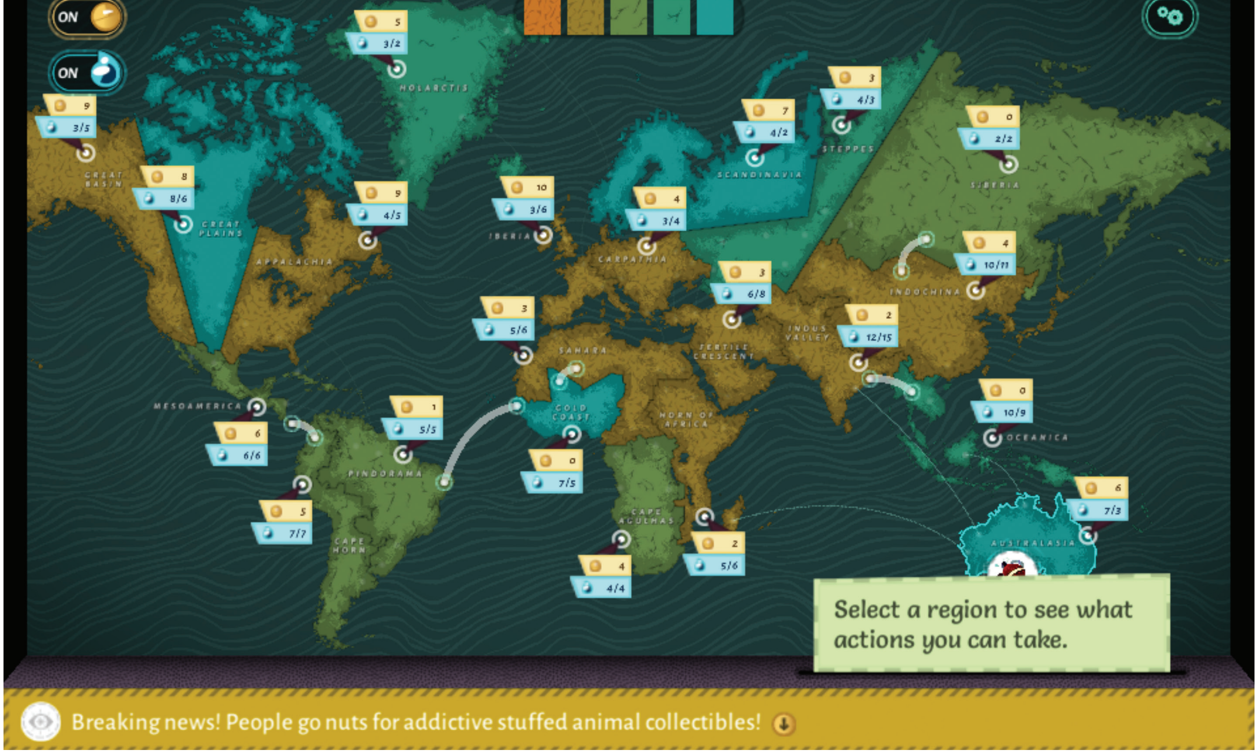
Credit: Smithsonian Science Education Center

Sugar Simulation models sugar, water, and air particles and their interactions.

Developing Science and Engineering Skills

Science and engineering practices, one of NGSS's three dimensions to learning science, further promote use of simulations within the science classroom. One practice, **developing and using models**, encourages opportunities for students to use and construct models that can take the form of simulations. Simulated models can represent science-based events, which can be used by students to construct diagrams, make predictions, and form arguments. For example, in the simulation *Sunlight on the National Mall*, first grade students observe five images of the Sun as it is perceived to move through the sky over a single day. They diagram the perceived location of the Sun and formulate predictions on how the Sun appears to move throughout the course of the day in an arc shape. The simulation and model-based activities based around this lesson help students overcome misconceptions to a complex natural event (Glassman et al. 2020).

Digital games and simulations also provide students with a potential for modeling activities that develop their engineering and problem-solving skills. As they reflect on real-world problems represented in a digital environment, students can try to apply multiple solutions to assess which strategies work best while learning more about a scientific phenomenon. Students interact with simulations to design solutions by assessing which approaches best solve a problem through iterative design. In the Smithsonian's physical science digital game *Mini Golf Motion*, students learn about how collisions can change the directions of moving objects



Credit: Smithsonian Science Education Center

Aquation: The Freshwater Access Game addresses issues of personal, agricultural, and commercial freshwater use on a global scale.

through designing angled walls in a miniature golf course. As students learn more about the physical systems of the game, they can then construct better models that demonstrate more efficient solutions. Using the problem-solving skills from the simulation, students can apply similar strategies to a nondigital context.

Mathematics and computational thinking is another science and engineering practice that highlights simulations as a useful way to represent variables and apply quantitative relationships. Representative variables of complex data types can be utilized in ways that highlight and reveal the larger systems with which students need to interact. Like developing and using models, students can use this data to better understand science phenomena and to solve problems.

Variables of a simulation can also demonstrate larger trends or patterns in data that students can analyze and apply to real-world contexts. *Aquation: The Freshwater Access Game* deals with issues of personal, agricultural, and commercial freshwater use on a global scale—a problem that is too big to observe in person but perfect to analyze with data sets and variables. This game represents a region's access to fresh water through variables. Using numeric relationships to their advantage, students can choose between and implement in-game solutions that improve the freshwater availability to citizens around the world. Students find patterns and relationships between geographical locations and wealth to the region's ability to access fresh water. Simulated variables like these allow students to start explaining the crisis of freshwater availability by looking at the relationships and patterns of data.

Supporting Diversity, Equity, Accessibility, and Inclusion

While it is difficult to reach every student and educator in a heterogeneous learning environment with a single digital game or simulation, there are practices that help broaden the audience and enable a diverse group to access and learn from the content. These accessibility features—which serve to ensure that "all digital learning tools . . . are perceivable, operable, understandable, and robust" (Smithsonian Science Education Center 2020, 18)—not only allow more students from a wider range of backgrounds and in a greater variety of educational settings to use and learn from the content being provided but will also make the experience better, easier, and more fluid for all users (Gorney 2018).

Within the game or simulation itself, students can employ a number of accessibility strategies or features. One simple, yet often overlooked, step is to test for various forms of colorblindness, which affect over 4% of the world's population (Colour Blind Awareness n.d.). This also ensures that colors used in the game have sufficient contrast, which helps all users perceive important game elements. Similarly, adding voiceover to all written text not only makes the game more accessible to students with low vision and those who are learning to read but also supports all users in having a more fun and seamless experience.

When considering where and how to release a simulation or game, accessibility is again a strong driver of the decision-making process. Since data shows that students frequently use laptops (including Chromebooks), tablets, and smartphones in educational settings (Bernstein 2019), it is important to support all these platforms, either through native apps or web apps, to ensure technological equity. Additionally, a growing portion of consumers of learning games and simulations in the United States is Spanish speaking, so both English and Spanish versions of the game should be released to allow for greater access.

Perhaps the most traditionally underexplored portion of the accessibility support for a digital game or simulation comes in the materials created to surround the game experience. A text alternative short story supports students for which a visual game requiring eye-hand coordination may not be appropriate, including students with low vision. Offline activities, including an NGSS-aligned lesson plan booklet, enable students with limited access to high-speed internet or internet-capable devices to enjoy and learn from the digital product. And helpful teacher tips allow educators to get the game running on a variety of devices and assist in enabling all their students to succeed.

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Digital Games and Simulations with Smithsonian Science for the Classroom

The Smithsonian Science Education Center (SSEC) has published many digital games and simulations for their NGSS-aligned grades K–5 Smithsonian Science for the Classroom curriculum series. These freely available resources can help students expand their understanding of complex phenomena while developing their science and engineering skills. The utilization of these digital tools fits well with Next Generation Science Standards. The SSEC's focus on development of inclusive products supports the accessibility needs of many students, helping to increase the pool of future scientists, engineers, and problem-solvers.

Learn more about Smithsonian Science for the Classroom.
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