Project GUTS

Using, modifying, and creating computer models for simulating phenomena

BY RAJA RIDGWAY

Computer science (CS) education is on the rise. In the last several months, many states have taken concrete steps to increase access to K–12 CS education, from developing standards to setting aside funding for teacher development (*Code.org* 2018b) Additionally, a new framework for teaching CS has been developed, which explicitly describes the overlap between CS education and science education (K–12 Computer Science 2018). From defining problems and asking questions to analyzing and communicating data, there are many ways to integrate computers and computational science into our middle school science classrooms.

Modeling

One specific way to integrate CS thinking and skills into the science classroom is through modeling with computers (see "Essential Definitions" sidebar). Computer simulations have played a major role in advancing science (Denning 2017) and allow us to model phenomena that are beyond the reach of our labs or budgets. Because computer models can be automated, we are able to choose which variables and factors to manipulate before we play the simulation forward in time. Essentially, we have the capacity to work with "virtual testbeds" to run simulated experiments!

It is important, however, to question whether our students are fully engaging in the practice of modeling with simulations when they use computers. In Appendix F of the *Next Generation Science Standards* (NGSS Lead States 2013), the practice of modeling goes beyond simple usage to also include development and revision of computer models themselves. Although students can and should be using computer simulations to run experiments and gain insights into phenomena, they should also be adapting and creating their own computer models. Luckily, we don't all need to get computer science degrees to make this a reality in our classrooms.

Project GUTS

Project GUTS (Growing Up Thinking Scientifically) was started in 2007 with the goal of supporting students in learning how to use, modify, and create their own computer models to understand a variety of phenomena. Although originally developed as an afterschool program, a collaboration with *Code.org* in 2014 supported Project GUTS in developing a curriculum and training for teachers

Essential definitions

- Modeling: the act of abstracting features (elements and their behaviors) of the real world to form a computer model
- Simulation: the act of running a model to visualize how the modeled system changes over time

*Definitions provided by Irene Lee, Project GUTS founder and program director.

looking to infuse computer science into their daily lessons. The program focuses on the sequence of use-modify-create to support students in meeting the vision of the *NGSS*.

Who is the ideal teacher?

Project GUTS has been developed to be appropriate for anyone who teaches science! Whether you teach a core science class, a STEM elective, or an afternoon science club, there are ways to make the curriculum work for you. Also, you do not need to have a computing background to be successful. All you need is a desire to integrate CS principles, thinking, and skills into your classroom!

What is the program?

Project GUTS's curriculum (see Resources) is focused on the sequence of using, modifying, and creating models, and then using those models to run simulated experiments (a free login is required to access the attachments and join discussions). Specifically, the curriculum uses StarLogo Nova (see Resources; a free login is required), a free program that can be used on any device, from laptops to Chromebooks to tablets—all you need is an internet connection (see Figure 1). StarLogo Nova uses block-coding (see Figure 2) to allow students to progress from being able to read and interpret the code to rearranging and adapting the sequences of blocks. As students continue to develop their proficiency and understanding of the algorithms, they eventually move to choosing and sequencing the blocks to form new algorithms themselves.

FIGURE 1: StarLogo Nova (Module 2: Water as a Shared Resource)

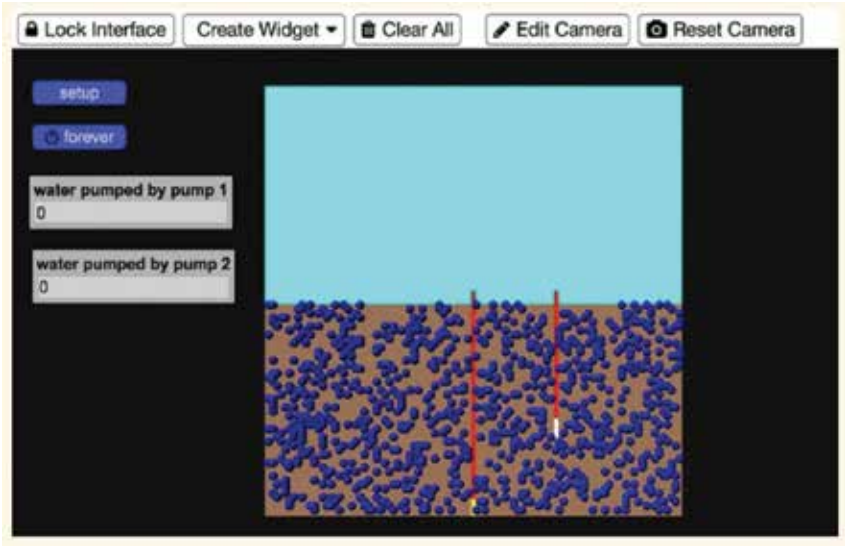
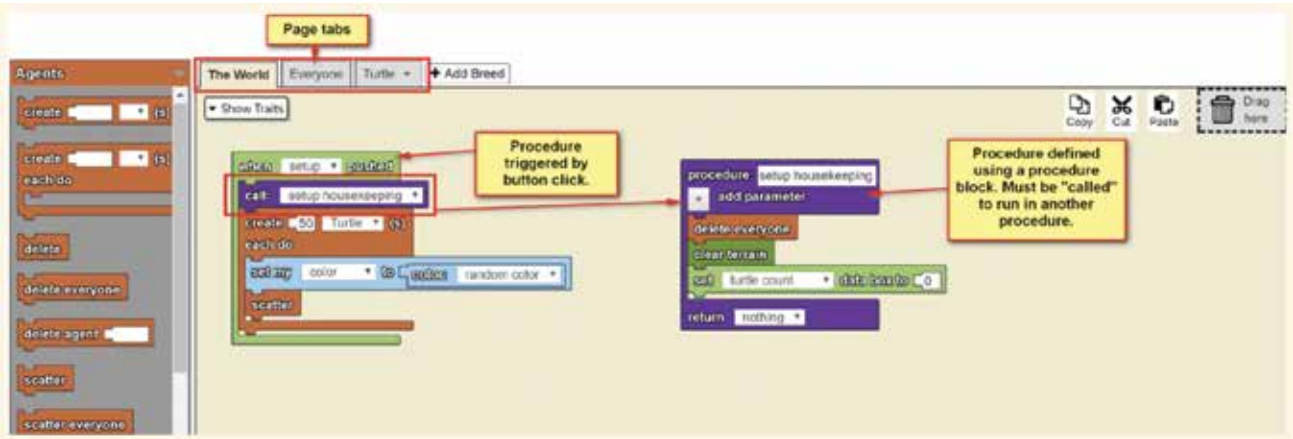


FIGURE 2: Block-coding in StarLogo Nova



The curriculum includes four modules, each of which spans five or six lessons, and focuses on various topics in middle school science. The topics, which include Earth science, life science, and physical science, can be clearly aligned to *NGSS* performance expectations (see Figure 3), and explicit notes are included for connections to science and engineering practices and crosscutting concepts. A newly updated version of the *Instructor Handbook: Computer Science in Science* has been released for 2018 and includes a variety of approaches to meet the needs of all students (see Resources; a free login is required). Scaffolds are provided to support students who might find the tools and processes challenging, along with extension tasks for students who already have experience with computing and are moving quickly. The *Instructor Handbook* provides directions for students to register and to save their projects, including a "Student Activity Guide" handout that takes students step-by-step through accessing the website to creating and saving projects (pp. 30–39). Depending on your students' experience with computers, you may want to consider creating logins for each of your students and providing this information to them on the first day. This will increase the efficiency of the login process and will allow you to have

FIGURE 3: Project GUTS and the *Next Generation Science Standards* (NGSS Lead States 2013)

Module	Length	*NGSS* performance expectations
Introduction to Modeling and Simulation	6 lessons	Focuses on science and engineering practices and crosscutting concepts to build student capacity with tools and thinking skills
Earth Science: Water as a Shared Resource	5 lessons	MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. MS-ESS3-4: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
Ecosystems as Complex Systems	5 lessons	MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
Introduction to Physical Science: Chemical Reactions	5 lessons	MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures. MS-PS1-2: Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

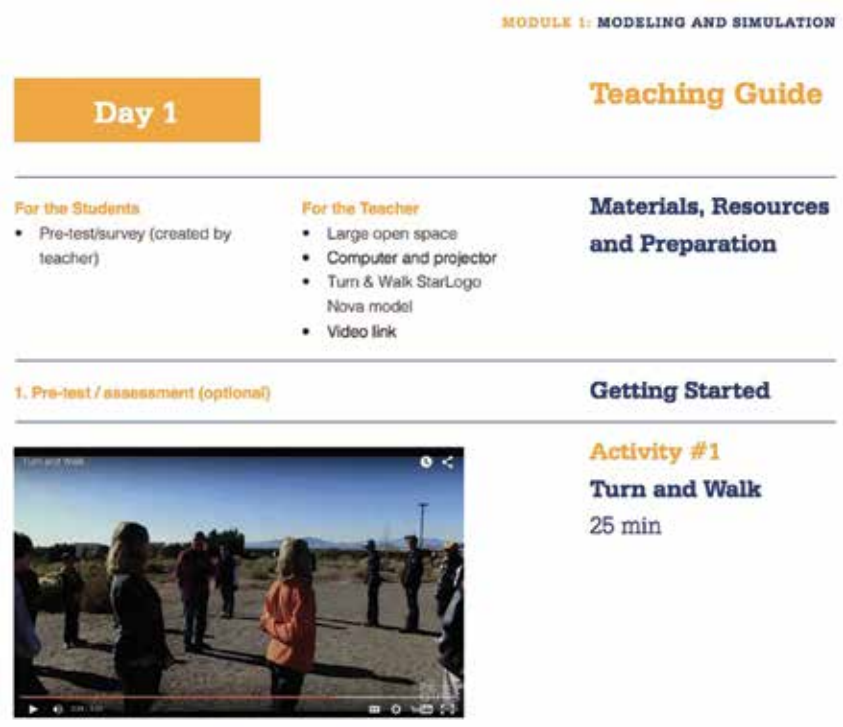
all students' login information. Additionally, consider having all students work within the "Public Gallery" so that you and the rest of the class can see their work.

How do I get started?

You can get started right now! To prepare yourself and your students for modeling with StarLogo Nova, start with Module 1. This introductory module is planned for six days and takes students from considering the purpose of a computer simulation on day 1 to modeling the spread of disease on days 5 and 6. Start by reviewing the teaching guide for each day (see Figure 4). A timed agenda is included along with student materials and links to relevant external resources. As you review the curricula resources and build your own simulations, consider visiting the Project GUTS YouTube channel (see Resources), which includes playlists for each of the modules.

If you prefer to get your learning started via professional development, consider signing up for an in-person workshop on the website or taking their online course (see Resources). While you are on the website, you should also check out the discussion forum, where you can introduce yourself, learn about other teachers doing similar work around the country, and share resources. Finally, if you have specific questions, reach out to founder and program director Irene Lee at *info@projectguts.org*.

FIGURE 4: Teaching Guide: Module 1, Day 1



Why should I do this?

In addition to diversifying your approach to science education, integrating CS principles and computational thinking is an opportunity to build real-world skills that students will need as productive 21st-century individuals. As noted on *Code.org*'s advocacy website (2018a), there are currently over half a million computing jobs available, with less than 50,000 CS graduates in 2017.

It is also important that all students have the chance to build their computational science skills in middle school. Given that girls and students of color are currently under-represented in rigorous high school CS classes (College Board 2017), integrating CS into your science classroom in middle school can help build confidence and interest before students reach high school. The Project GUTS curriculum and resources can help make this possible, specifically through their guidance for how to support specific groups of learners.

Conclusion

With Project GUTS, you now have the curricula resources to transition from simply using computer simulations to modifying and creating them. You've also got access to a community of like-minded educators who are

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- Past NGSS Workshop Participant, Minneapolis, MN

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National Science Teachers Association

integrating CS into their classrooms.

How else are you integrating CS into your middle school science classroom? Do you have a great resource or experience to share? Let me know via email! ●

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RESOURCES

Project GUTS curriculum—*https://bit.ly/2MByoOV*

Project GUTS instructor handout—*https://bit.ly/2MByoOV*

Project GUTS online professional development course 2017—*https://guts-2017.appspot.com*

Project GUTS YouTube channel—*http://bit.ly/2LXTivh*

StarLogo Nova—*www.slnova.org*

Teachers With GUTS professional development network—*www.teacherswithguts.org*

Raja Ridgway (*rridgway@relay.edu*) is the director of computer science education and an assistant professor practicing secondary science education at the Relay Graduate School of Education in Denver, Colorado. He is a former middle and high school science teacher who now supports teachers with integrating computer science into their classrooms.