Remote Professional Development: Using a System Modeling Tool for 3D Teaching and Learning

Posted on April 26, 2021 By Kimesha Reid-Grant, Cynthia McIntyre, Tom Farmer and Yadana Nath Desmond

Modeling is key to how scientists help explain complex phenomena—from the coronavirus pandemic to climate change—and explore scientific and engineering problems. The *Next Generation Science Standards* (NGSS) recognize the importance of Systems and Systems Models as one of the crosscutting concepts, and Developing and Using Models and Using Computational Thinking as two of the science and engineering practices. These capabilities are important in order to understand responses to the pandemic and to solve other pressing problems like water pollution and freshwater scarcity.

As an educator at an International Baccalaureate (IB) school committed to inquiry-based learning as one of its core values, I know the importance of content-rich extended opportunities for project-based learning to engage students in authentic learning experiences designed to tackle real-world problems. When the school closed due to COVID-19, I was faced with the task of engaging my students in a meaningful way without the benefits of experimentation and other hands-on methods to reinforce learning. I had attended two online professional learning workshops offered in April 2020 by **STEMteachersNYC**, a nonprofit organization dedicated to supporting a hour Introduction to SageModeler workshops were led by two scientists and researchers from the Concord Consortium and two NYC teachers. SageModeler is an online systems modeling tool, and I was hoping to learn how I could use it in an environmental science unit I was co-developing with another eighth grade teacher. We wanted our students to explore the Earth's spheres and to model the anthropogenic effects on the hydrosphere.

Like other teachers across the globe, becoming an online instructor practically overnight was a bit of a shock, and I had to learn fast and on my feet—and with the help of other teachers. The STEMteachersNYC model of teachers training other teachers and fostering collaboration among active practitioners was especially appealing, and the **SageModeler systems modeling tool** seemed like it could help my students see connections among Earth's spheres and within them.

My own journey to becoming a teacher was not unlike the "trial by fire" experience in the spring of 2020 when I was thrust into online teaching. Years ago, I had transitioned from working in a dolphinarium to becoming a high school teacher in a brand new high school near my hometown in Jamaica. I held an undergraduate degree in marine biology, but had no formal training in teaching. I taught by day, took classes as part of a small cohort of other first-year teachers in the evenings, and received my diploma after an intensive eighteen-month program. I went on to earn a master's degree at Florida International University, but my path to becoming a middle grades teacher at the International School of Brooklyn was circuitous by way of informal teaching, first at an environmental center then at a zoo, both in New York City. These experiences reinforced the importance of helping students to explore their world—from the local parks to lakes and forest areas—and to become engaged and informed community members, hallmarks of the IB approach.

Developing a remote curriculum with a systems modeling tool

Without our physical lab to engage students in exploration of phenomena, our goal was to design a unit to help students learn science through the integration of the three dimensions (3D) of scientific knowledge, as outlined in the NGSS: disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs). We planned to engage students using Systems and System Models (CCC) to make sense of the hydrosphere and to Develop a Model (SEP) of the factors impacting the health of the sphere (DCI).

hydrosphere. That's where SageModeler came in. Students were tasked with creating a predictive model for eutrophication based on what they had learned about the factors affecting the hydrosphere. I wanted students to get a holistic view, rather than simply learn concepts in isolation. Using static equilibrium modeling in SageModeler, they could see how a model's inputs determine an equilibrium state of the model, for instance, if nutrient fertilizers increased, water quality decreased (Figure 1).

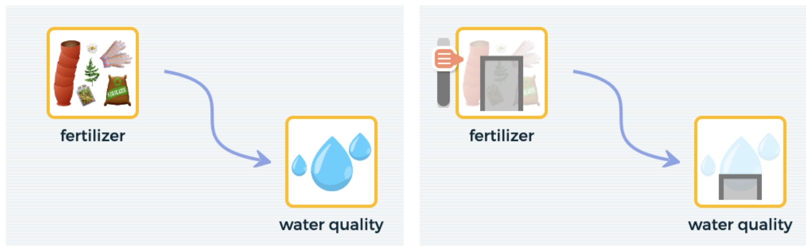

Figure 1. With SageModeler students select images from an embedded open-source, safe image database, make connections by dragging arrows between factors (left), then test their model to see if it runs as expected (right).

For background information, we researched case studies and learned about nutrient loading in the Mississippi River system, watched a TED talk about dead zones in the Gulf of Mexico, and created a video titled "Eutrophication for Dummies." As a culminating activity for the unit, students created a slideshow that incorporated their model to connect and explain factors affecting eutrophication, including factors that negatively affect water bodies and the things people can do to mitigate those effects. By looking at student models, I could peek into their heads to see how they represented their own mental models and what connections they made between all the factors we had explored as a class (Figure 2).

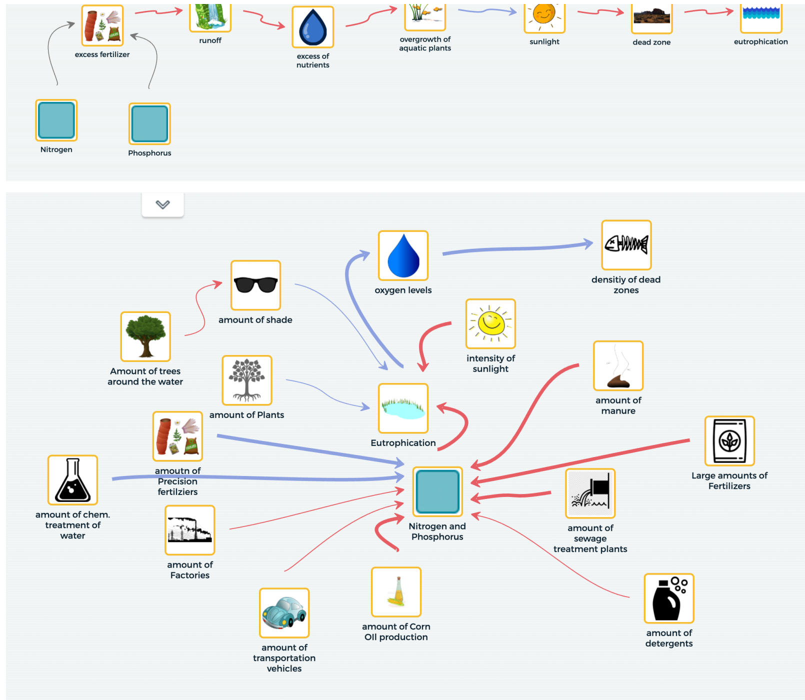

Figure 2. Sample 8th grade student models of factors affecting eutrophication. Each student developed their own static equilibrium model, selecting factors based on research to model an interconnected system using SageModeler.

Some student models included only two or three factors (e.g., amount of fertilization and amount of sewage) affecting eutrophication, but others were much more complex. And while I didn't want the students to create the same model, I thought about the disparity in their models and realized I had more to learn about scaffolding the model building process. Although most teachers don't have the time to observe other teachers in action, I wanted to see what other teachers were doing and hear their ideas, which would give me more confidence for the next time I used SageModeler.

Extended remote professional learning and a collaborative PLC

I reached out to the SageModeler group to inquire if they were planning to offer any summer training sessions. I was fortunate to participate in a 12-hour remote workshop in August 2020. The training was offered as part of a **research project** funded through a special National Science Foundation program designed to study various effects of COVID-19, including the educational impacts for both teachers and students who were teaching in a remote setting. Researchers from the Concord Consortium and **Michigan State University** were studying how to support teachers in developing effective pedagogical strategies to engage students in making sense of phenomena through building, testing, and revising models in a remote learning context. The project's goal was to determine what works for engaging teachers in the complexities of teaching remotely with thinking, and computational thinking using a principled approach for remote professional learning.

Before the workshop started, there were a number of assignments to complete, including a short **SageModeler tutorial**, like the one I had assigned my own students, and building a model to answer a driving question like "How can I improve the water quality of my local pond?" or "How is CO_2 affecting our oceans and the creatures that live there?" Participating teachers also joined a private Professional Learning Community (PLC) group on Schoology, where we could share resources and ideas.

Professional learning design principles

- Collaborative activities among researchers and teachers
- Individualized supports
- Focus on NGSS three-dimensional learning: integrating disciplinary core idea (DCIs), computational thinking (SEP), and system modeling (CCC)
- Use of relevant, discipline-specific phenomena
- Active construction of tangible products (models, instructional materials)
- Scaffolding with learning technologies (e.g., SageModeler)
- Explicit modeling of pedagogical strategies
- Sustained professional learning over time

The summer professional learning workshop was held over Zoom with two days of four-hour sessions, broken into two-hour chunks with an hour lunch break, and one day between to work on assignments. Project staff included researchers, curriculum and technology developers, and experts in system modeling. Teachers shared our early experiences with SageModeler and considered how we would integrate SageModeler into our own curriculum units. The group was set up to be collaborative from the start with full-group sessions for community building, small breakout sessions, and one-on-one sessions between individual teachers and project liaisons. This dedicated attention was possible because of the nature of the NSF-funded project, which included several researchers and postdoctoral students on staff from both the Concord Consortium and Michigan State University. Email support and individual Zoom chats were also available.

The PLC continued through fall 2020 and spring 2021 with one-hour afterschool Zoom sessions every three to four weeks when participating classroom challenges, and project staff demonstrated additional features of SageModeler as well as the pedagogy of teaching with modeling. Because of the many sample models and content areas explored by the staff and other teachers, I now see opportunities for systems thinking in many more of my science units—from the study of Darwin's finches to a new project-based unit I am currently designing on a local park ecosystem. I love that systems modeling allows students to take a bigger view, ask questions, and work to figure out solutions. For instance, if they see a lake covered in green algae, students can ask, "What's happening? What can be done to change this?"

One of the most valuable aspects of the PLC was the sharing of ideas about what works in the classroom to support students' model building, and doing so with teachers from around the country who teach all grade levels from elementary through high school. It's easy to get tunnel vision about a particular technology or tool, but seeing other teachers using it differently was eye-opening. Each monthly Zoom session started with a teacher sharing a model built by a student or a classroom tip. For example, to get students to collaborate on model building, one teacher included sentence starters ("I notice, It reminds me of, I wonder, Could it be…") to help students give feedback on other students' models. I offered my experience having students reflect on their own models in a meta-modeling exercise, asking them to describe changes they might make to their model and how they would do so. Engaging in reflective conversations and sharing resources with other teachers have been critical parts of my professional learning.

Conclusion

Through a National Science Foundation-funded project researchers, curriculum and technology developers, and teachers worked together to share ideas we brought back to our classrooms. It was exciting to participate in educational research designed specifically to study how to support teachers in continuing to offer NGSS-aligned 3D science teaching during remote schooling.

While teaching and learning through the pandemic, it became clear that teachers and students alike can benefit from innovative technologies to enhance learning. Through the PLC and one-on-one assistance from a curriculum developer, plus support from STEMteachersNYC, I am currently designing a new project-based environmental science unit focused on a local park. My students will use SageModeler to develop models around the driving question "What factors affect water quality in city parks?" and I will use my experiences from the PLC to ensure that I scaffold students' model building over time as they learn new factors about the park ecosystem.

thinking and modeling in my classroom, ensuring that my students are equipped to engage with real-world phenomena, become problem solvers, and contemplate important questions as examples of systems where their actions can have an effect on their world.

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