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The Shodor Education Foundation: Supporting Appropriate Uses for Technology in the Classroom

Bethany Hudnutt

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Abstract:

The Shodor Education Foundation is dedicated to helping educators and students at all levels understand and use technology appropriately in math and science education. This non-profit organization focuses on content, teacher, and student as the three elements essential in computational education. There are many higher level concepts now open to study at a younger age because of the computational power of computers. Shodor's projects extend educational resources and opportunities as far as possible. An emphasis is placed on science and mathematics explorations, developing numerical models and simulations integrated with the curriculum, professional development, and access to a network that supports their use in a learner-centered environment.

Introduction

The current mantra in education is "technology, technology, technology." But teachers remain frustrated with technology because they do not understand when it is an appropriate tool to use. To teach a particular concept, sometimes the best tool to use is pen and paper, sometimes manipulatives, and sometimes a computer.

Many educational software developers do not understand appropriate uses of technology either. Much software is a drill and kill style: databases of practice problems with graphics and sound to make the experience more interesting to students. School administrators often do not understand how technology can be used, so they purchase these types of software and become frustrated because teachers are not using them.

In large part, teachers do not use technology because they can teach the same concepts in their classrooms without using a computer. There are many hassles in working with computers: technical difficulties, technical support if something

goes wrong, security issues, etc. Large portions of class time are sometimes spent just getting students logged onto the machines. These issues coupled with software that only replicates what teachers already can accomplish in the classroom keep teachers from using computer technology.

But computers do have excellent applications in the classroom and can be time saving devices to teach concepts. Computers are designed to perform repetitious computation quickly. There are many concepts in science and math that involve a great deal of tedious computation. Teachers now have the power to teach those concepts without bogging down students in the details of those computations and can focus the lessons on the concepts instead.

Computers should not replace a student's understanding of arithmetic and algebra. Rather, when the arithmetic or algebra hinder the teaching of a concept because of the computation involved, the use of computers is appropriate and pedagogically invaluable. The study of probability at the middle school level offers an excellent example.

Students are taught how to compute theoretical probability and also told the more times an experiment is conducted, the closer the experimental probability will be to the theoretical probability. If a coin is flipped one hundred times, theory predicts the coin will land on heads fifty times. As a teacher with lots of material to cover taking the class time to have students flip a coin one-hundred times is not a feasible option and only a few flips of the coin will not suffice. Even if a student flipped a coin one-hundred times, they will not get exactly fifty-fifty because one-hundred is a small number of independent, random events. It may take thousands of such events to convince the doubting students a coin is fair or luck has nothing to do with the results. A computer can simulate flipping a coin thousands of times in a fraction of a second.

There are many higher level concepts now open to study at a younger age because of the computational power of computers. Modern science and mathematics are more concerned with pattern recognition and characterization than with mere symbol manipulation. The Shodor Education Foundation's mission is to help educators understand how to incorporate technology in math and science classes so students can study patterns difficult, if not impossible, to study without computers.

There are three elements essential to education and all three must be present and effective or education process collapses: content, teacher, and student. Shodor uses the framework of a tetrahedron as its symbol as a representation of these interdependent elements. The tetrahedron is the simplest and most stable of all regular three-dimensional solids. If any edge of the tetrahedron is removed, the solid collapses. Shodor's various projects each address all three essential elements and range from courseware development, online course development, conducting workshops for K-16 educators nationwide, and K-16 student development.



In support of Shodor's vision to permeate math and science education with computational science methods, Shodor always attempts to disseminate its resources as far as possible. The name Shodor recalls the role of the hammer in the shodoring process of making and applying gold leaf. Gold leaf is gold hammered thin so it can cover an object. Similarly, Shodor works to extend valuable educational resources and opportunities as far as possible. A special emphasis is placed on enabling authentic science and mathematics explorations at all educational levels, developing numerical models and simulations integrated with the curriculum, professional development, and network access to support their use in learner-centered environments.

Below are brief descriptions of Shodor's K-12 projects, computational modeling tools and resources to support these projects, online course offerings, as well as undergraduate projects. Projects that support middle school math and science curriculum are noted in the descriptions. Links to the online materials and further information on the projects are also provided.



K-12 PROJECTS

Modeling and Visualization Workshops for K-12 teachers

Email: workshops@shodor.org

One of Shodor's expanding initiatives is offering workshops to introduce teachers at all grade levels to modeling and visualization technologies, techniques, and tools. The software used in the workshops concentrates on inexpensive programs commonly used in most schools or specialized software freely available on the web. Instruction stresses inquiry based learning. These workshops, taught by national leaders in the use of computing tools in science and mathematics, provide teachers with instruction and ideas on how to integrate these technologies, techniques, and tools in their own classrooms.

Workshop content is not predefined. Shodor will work with institutions in advance to develop an agenda appropriate to the needs of the participants. The workshops therefore simultaneously meet Shodor's intent of putting modeling and visualization tools in the hands of teachers while meeting the institution's goals and teacher needs.

The workshops may include the introduction of modeling software such as Project Interactivate, STELLA, Mathematica, Excel, and Geometer's Sketchpad. Workshops also involve teaching critical thinking skills when using numerical computation to know if solutions are correct.

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Project SUCCEED (Stimulating Understanding of Computational science through Collaboration Exploration Experiment and Discovery)

<http://www.shodor.org/succeed>

SUCCEED is a year-round program in which North Carolina students, from sixth graders to undergraduates, participate in authentic research and collaborate with practicing scientists in computational science fields. The objective of the program, funded in large part by a grant from the Burroughs Wellcome Fund, is to prepare students to become leaders in 21st century science and education while the students create materials that will help others understand topics in science and mathematics. This program enables about four hundred students to become part of a learning cycle in which the process of scientific exploration serves to enable computer-enhanced science and mathematics explorations for students around the world.

SUCCEED accomplishes its goals through an integrated, three-phase program. First, students generally attend summer computational science workshops. Workshops target middle-school age ranges as well as high-school. Then, students showing an interest in furthering their knowledge are offered after-school and informal summer science internships. Students wishing to continue their science explorations are offered interdisciplinary research apprenticeships as their aptitudes and interests allow. Students in all three activities work side-by-side with Shodor's scientists with experienced students serving as teachers and mentors for younger participants.

SUCCEED permeates all of Shodor's projects as it is these very same interns who are responsible for most of the design, maintenance, and implementation of these projects. Shodor staff mentors interns in the programming of the

computational tools, designing and maintaining most of the Web sites described below, and even instructing some of the SUCCEED workshops.

SUCCEED-HI (Hearing Impaired)

<http://www.shodor.org/succeedhi>

Built upon the success of Project SUCCEED, SUCCEED-HI introduces middle and high school students with hearing impairments to computational science. The program developed after senior staff member Bob Gotwals attempted to give a workshop for deaf middle-school students as part of SUCCEED's first summer of workshops. Fluent in American Sign Language (ASL), Bob realized an immense language barrier existed, especially since the terms commonly used in computational science did not exist in American Sign Language. He organized and wrote a grant funded by the National Science Foundation (NSF) to develop terms for use in ASL. In addition the project would fund internships for hearing-impaired students interested in undergraduate research in computational science. SUCCEED-HI is a result of that effort.

Curriculum development teams, consisting of staff from Barton College and the Eastern North Carolina School for the Deaf, develop grade- and language-appropriate materials for the use of computational science in science, mathematics, and the social sciences. Interpreters, Inc. and the National Technical Institute for the Deaf have joined resources to form a technical signs team to develop signs for the computational science terms. Shodor's participation in the realm of computational science ensures widespread dissemination of products, approaches, methods, and "lessons learned" through the national computational science community.



Student Science Enrichment Program Web Site (SSEP)

<http://ssep.bwfund.org>

Shodor staff directs the work of interns in developing and hosting the Web site for the Student Science Enrichment Program. SSEP is an invaluable resource for middle and high school science educators and their students. Through SSEP, the Burroughs Wellcome Fund awards grants to other North Carolina non-profits that provide creative science enrichment activities for students in grades six through twelve. Through the enrichment program students have opportunities to experience authentic science through activities such as assisting with research in chemistry labs, studying water-quality side-by-side with scientists, or even hands-on course work using cadaver parts and computer software.

Individual program awardees are provided grants of up to \$60,000 per year for three years. SSEP awards a total of one million dollars to non-profits annually and is entirely supported by the Burroughs Wellcome Fund, a private foundation whose mission is to advance the medical sciences by supporting research and other scientific and educational activities.

As well as hosting the SSEP Web site, Shodor is also an SSEP awardee. Shodor's SSEP funds support Project SUCCEED. These funds, in turn, also support SSEP as it is the student interns from SUCCEED who are responsible for the design and maintenance of the SSEP site.

Durham Workforce Partnership

<http://www.dwp.org>

Shodor houses and maintains the server for the Durham Workforce Partnership, a job-network site dedicated to helping Durham students find jobs and perspective employers to find quality employees. Shodor assisted in developing a "Modeling Your Career" program available on the site, for helping students understand what kind of income they will need to support the lifestyle they want as well as what kind of education they will need in order to obtain their dream career.

Project RAMP (Realizing Achievement through Mathematics Performance)

<http://www.shodor.org/ramp>

RAMP is a Durham Public Schools initiative funded by National Science Foundation to provide resources to support the school's math curriculum and to foster communication with students, parents, and the community. The Web site was designed and is maintained by student interns at Shodor.

National Computational Science Leadership Program (NCSLP)

<http://www.ncsec.org/>

The National Computational Science Leadership Program, funded in part by a National Science Foundation grant, is intended to build a national reservoir of secondary education teachers-leaders who can utilize computational science effectively to enhance science and math education. In conjunction with East Carolina University, the National Center for Supercomputing Applications, the University of Alabama, and other educational and vendor partners, Shodor is working to develop a core group of teachers to reach out from within their school districts to share the knowledge acquired through the training with other teachers. Hence, NCSLP is more than just training, it is a leadership program. To extend the reach even beyond the participants' school systems, the models, curricula materials and instructional applications generated by participating teachers are made available on the Web site.

Each team of teachers is expected to produce one module during the course of the program. The interactive modules contain a numerical modeling program, suggested lesson plans, and supporting materials. Among the modules created by the NCSLP 2000 teams:

- a blood-alcohol content simulation
<http://www.ncsec.org/team1/mainpage.htm>
- a simulation to determine the oxygen content in water
<http://www.ncsec.org/team17/index.html>

- a simulation to study the physics of curves
<http://www.ncsec.org/team21/default.htm>

Other modules developed can be found at <http://www.ncsec.org/models.cfm>.

COMPUTATIONAL MODELING TOOLS AND SUPPLEMENTAL RESOURCES

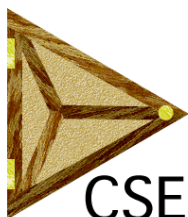


Project Interactivate

<http://www.shodor.org/interactivate>

Project Interactivate, Shodor's most widely used mathematical modeling and visualization courseware, is freely available on Shodor's Web site. Interactivate contains more than eighty classroom-tested interactive modeling and visualization math activities designed to help students learn concepts from arithmetic, algebra, geometry, probability, and data analysis. Interactivate can be easily adapted for use in single computer classrooms, several computer classrooms or laboratory settings. The project originated as middle-school mathematics courseware but also has applications at other levels.

Over seventy suggested lesson plans and equally as many discussions based on various concepts contained in the activities help teachers in supporting standards-based approaches to mathematics education. The courseware developed from collaborations with classroom teachers from the U.S. Department of Defense Schools and other school systems, content experts, curriculum designers, and education technologists.



CSERD

Computational Science Education Reference Desk (CSERD)

<http://www.shodor.org/cserd>

The Computational Science Education Reference Desk provides access for both educators and researchers to computational science resources and training tools. CSERD is more than just tools, it also contains a plethora of information to help researchers and educators implement appropriate computational science solutions in classrooms and laboratories. The content is organized by the field of application, topic, and level of experience for which the content is designed. CSERD also provides an environment for dialog in an on-line community for the use of computational science in both classroom and laboratory.

Although CSERD is primarily a tool for advanced high school science or undergraduates, it is notable that one of the Shodor interns who maintains the site and writes code for the exploration tools is an eighth grade student.

Modeling and Simulation Tools for Education Reform (MASTER)

<http://www.shodor.org/master/>

The MASTER tools are the result of ongoing collaborations with the National Center for Supercomputing Applications (NCSA), George Mason University, and other organizations. They are designed to be interactive tools and simulation environments that encourage exploration and discovery through observation, conjecture, and modeling activities. Of the MASTER tool set, the ones most appropriate for use at the middle school level are GalaxSee, Fractal Modeling, and SimSurface and several of the environmental models.

The repertoire of interdisciplinary tools include:



GalaxSee Available for download, GalaxSee uses Newton's laws of motion to build model galaxies, solar systems, and planet-moon systems.



Fractal Modeling Tools The Fractal Modeling Tools enable users to explore many different and fascinating aspects of these bizarre mathematical objects.



SimSurface Available for download, SimSurface is designed for use in scientific investigation of optimization problems with many variables, like minimizing potential energy.



Environmental Models Users work with various air and water quality models to study effects of pollutants in the air and water.



GnuPlot Users graph two and three-dimensional mathematical functions with the ability to animate three-dimensional graphs.



BioMedical Models These models are a collection of computational tools to study epidemiology, pharmacokinetics, and physiology.



The Pit and the Pendulum An interdisciplinary application of computation, The Pit and the Pendulum uses the laws of physics in order to analyze this famous Edgar Allan Poe story.

InteGreat! InteGreat computes the integral of a function using several numerical methods so the user can see how solutions vary depending upon the method.



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ONLINE COURSE OFFERINGS



Braille through Remote Learning (BRL)

<http://www.brl.org>

Braille through Remote Learning is an on-line educational offering designed to provide braille training to educators, braillists, parents, students, and others who wish to become Braille literate. Although the courses are not directly related to computational science, the courses still fit into the foundation's "shodoring" mission to extend valuable educational resources and opportunities as far as possible. By combining electronic technologies and quality materials, BRL provides a complete Braille instructional program for anyone who has an interest in Braille. The program was developed with funding from the U.S. Department of Education's Braille Literacy Program.

The program consists of three integrated courses:

- *Introduction to Braille*: a 12-session basic course in Braille literacy, designed for beginning students of Braille or for those who need a Braille refresher.
- *Braille Transcribers*: a course focused on the production of Braille materials, with an emphasis on the brailleing of textbooks (using the new "Formats" Braille code).
- *Specialized Codes*: a basic introduction to specialized codes, such as mathematics Braille, music Braille, computer Braille, and chemistry Braille

There are, unfortunately, no instructors available at this time for the courses. Limited technical or other support is available via email. Civic-minded corporations that might be interested in sponsoring this course should contact a

staff member at the Shodor Foundation.

Portland State University recently contracted Shodor to use the Braille materials to create an online textbook. The PSU Braille course will combine all three courses into a single yearlong course.

Computational Atmospheric Sciences

<http://www.shodor.org/os411>

This series of six sequential courses was funded for development by the Air Pollution Training Institute (APTI), an organization run by North Carolina State University under contract to the Environmental Protection Agency. APTI contracted Shodor to develop this comprehensive curriculum to prepare professionals to work in the field of air quality modeling. In the typical "Shodorific" manner, these courses were designed in such a way so they could be used and understood by many others outside of the specialized field of air quality modeling. Many of the models in these courses are also available as part of the MASTER tool set.

Parts of these six courses are now also being used as material for air quality modeling workshops for middle- and high school teachers. Two pilot workshops were given at East Carolina University and UNC-Asheville; based upon the success of those workshops a new \$25,000 proposal has been submitted to the EPA to run the workshop six times across the state of North Carolina. Materials for this workshop can be viewed at <http://www.shodor.org/talks/aqm/>.

Computational Chemistry for Chemistry Educators

<http://www.shodor.org/compchem>

This fifteen-session course on the technologies, techniques, and tools of computational chemistry gives educators the opportunity to study chemistry in a manner different from traditional teaching and education in chemistry. Most computational chemistry studies are concerned with the area of quantum chemistry: describing the chemical properties and behaviors of atoms and molecules. This course is designed for enrichment for students and teachers of students in advanced high-school chemistry, community college chemistry courses, and undergraduate study at small colleges.

Chemistry Fundamentals

<http://www.shodor.org/unchem/>

Funded by the chemistry department at UNC-Chapel Hill, this course offers a review of high school level chemistry. The original goal of the program was to provide an introduction or a review to freshman chemistry students on the basic mathematical skills required to be successful in freshman chemistry. In addition, the materials worked to introduce or review basic skills in the use of a calculator.

Evaluations suggested that, while the mathematics and calculator sections were

useful, one of the most appreciated benefits of the materials was the review of basic high school chemistry. While maintaining the reviews of mathematics and calculator fundamentals, the course was significantly expanded to review basic chemistry. In addition, a number of advanced sections on the use of numerical methods in chemistry were added.

UNDERGRADUATE PROGRAMS

National Computational Science Institute (NCSI)

<http://www.shodor.org/scsi>

Although NCSI is the newest project pending at Shodor, it is the oldest in terms of the concept it supports. Initially, Shodor was founded to train teachers and faculty in computational modeling methods so they could in turn teach their students these methods (think tetrahedron). NCSI is the planned expansion of a smaller program, the Shodor Computational Science Institute, SCSI, into a nationwide pedagogical effort.

The SCSI Project supports teams of faculty at small-to-medium sized colleges and universities to work together to enhance their professional standing through the wider use of mathematical modeling and the tools of computational science in their classrooms. This focus on modeling enables faculty to learn computational science and how to teach it in engaging and enriching interactive environments, incorporating the same tools, techniques and technologies that characterize the modern practice of science and engineering. Continuous support and follow-up, materials development, access to high performance computing and visualization resources, and evaluation will be coordinated and enabled by using collaborative tools and electronic networks.

The NCSI Project is similar to SCSI but larger in scope. Pending finalization of funding from the National Science Foundation, NCSI will provide multiple workshops nationwide, promote computational science and dozens of national discipline and society meetings, and extend the number of online training opportunities in computational science.

FOR FURTHER INFORMATION

If you are intrigued about numerical modeling in science and mathematics education or have further questions regarding Shodor, please contact the Foundation at (919) 286-1911. Shodor staff members are always responsive to inquisitive people and proud to show off the Foundation. Most importantly, Shodor is concerned with quality education and welcomes the sharing of new ideas to involve modeling and visualization methods in education. Please feel free to contact us or make an appointment to stop in and visit.

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