Science Teaching 589

Project GUTS/Supercomputing Challenge (Summer Teacher Institute)

Three Credit Hours

No Prerequisites

Instructor: Dr. Mike Topliff

E-mail: mtopliff@nmt.edu

Office phone: (505) 835-5735

Course Designation: This is an optional course. The Summer Teacher Institute (STI) is a two-week institute for teachers sponsored in conjunction with LANL/NNSA, Project GUTS (Growing Up Thinking Scientifically)/Santa Fe Institute, Supercomputing Challenge, New Mexico State University and New Mexico Tech. Acquiring skills to support computational science for mid and high school students is the overarching goal of STI. Topics will include problem solving, science, mathematical and agent based modeling, technology, programming, research, working with mentors, project management, time management, team management, presentations, gender equity, computer ethics, measurement and analysis and technical writing.

Course Description: High school teachers will learn how to sponsor a Supercomputing Challenge team and how to help students complete an appropriate computational science project in keeping with the Challenge mission statement. The computational project incorporates four components: Project Management, Structured Programming and Design, Mathematical and Agent Based Modeling, and Internet Research and Resources

Mid school teachers will learn how to be a GUTS club sponsor and how to help students work on the afterschool and summer science, technology, math and engineering (STEM) program. Project GUTS was designed for students from all different backgrounds to engage in scientific inquiry by investigating topics of interest to their local communities.

Materials, Readings, and Resources:

Guiding Student Research: Making Research Happen in Your School: The National Consortium for Specialized Secondary Schools of Mathematics, Science and Technology

Project Guts website: http://projectguts.org

Supercomputing Challenge website: http://challenge.nm.org

Programming Tutorials:
StarLogo TNG http://www.projectguts.org/?q=node/472
NetLogo http://ccl.northwestern.edu/netlogo/

Course Content: STI will address the way students learn and do science, research, and technical writing by immersing their teachers in an in-depth exploration of a compelling modern problem within the field of Epidemiology. GUTS leaders and Challenge sponsors will work together modeling disease dissemination, epidemic tracking and optimal treatment approaches using computational models. STI will focus on blog entries as a part of GUTS club reflection practice and technical writing for SC Interim and Final Projects.

An ongoing survey of students and teachers commissioned by the Challenge in March 2009 indicate that sponsor support, mentoring, and student interest are key factors in students and teams completing projects. These issues will be addressed in focus groups.

1. Introduction to StarLogo TNG

The StarLogo TNG language was designed to enable people to build their own models of complex, dynamic systems. Unlike many other modeling tools, StarLogo TNG supports a tangible process of building, analyzing, and describing models that do not require advanced mathematical or programming skills. Using StarLogo TNG, one can build and explore models and in the process one can develop a deeper understanding of patterns and processes in the world. In StarLogo TNG, one writes simple rules for individual behaviors. For instance, one might create rules for a bird, which describe how fast it should fly and when it should fly towards another bird. When one watches many birds simultaneously following those rules, she can observe how patterns in the system, like flocking, arise out of the individual behaviors. Building up models from the individual, or "bird," level develops a better understanding of the system, or "flock," level behaviors.

2. Introduction to NetLogo
NetLogo is a cross-platform multi-agent programmable modeling environment. NetLogo was authored by Uri Wilensky in 1999 and is under continuous development at the Center for Connected Learning and Computer-Based Modeling. NetLogo is a programmable modeling environment for simulating natural and social phenomena. NetLogo is particularly well suited for modeling complex systems developing over time. Modelers can give instructions to hundreds or thousands of "agents" all operating independently. This makes it possible to explore the connection between the micro-level behavior of individuals and the macro-level patterns that emerge from the interaction of many individuals.

3. Building Models and Presenting Data with Spreadsheets
The study of spreadsheets will be implementations of a priori models and presentation of data via graphs. Optional sessions in week two will follow up on models and graphs and an exploration of the statistical analysis features of Excel-compatible spreadsheets.

4. Math Modeling

Mathematical modeling is the process of creating a mathematical representation of some phenomenon in order to gain a better understanding of it; mathematical modeling is an integral component of the computational science project. During the process of building a mathematical model, the modeler must decide what factors are relevant to the problem and what factors can be de-emphasized. Once a model has been developed and used to answer questions, it should be critically examined and often modified to obtain a more accurate reflection of the phenomenon. In this way, mathematical modeling is an evolving process; as new insight is gained, the process begins again as additional factors are considered. Generally the success of a model depends on how easily it can be used and how accurately it predicts. The mathematical modeling/computational science module will include an overview of the role of mathematical modeling in the computational science project, modeling sites and resources, some examples of models (compartmental models, population models, epidemic models, one- and two-dimensional heat flow models, etc.), and an introduction to some pitfalls in numerical computation.

Course goals: High school teachers will

- participate in creating a team supercomputing computational project.
- present the project to a team of judges.
- learn about the Challenge timetable, milestones and expectations.
- learn programming skills: NetLogo, Star Logo TNG and Excel programming
- learn math and agent based modeling, computational techniques, project management tips, and research aides.

Mid school teachers will

- participate in modeling projects in epidemiology
- participate in a GUTS roundtable
- learn about the GUTS timetable, milestones and expectations.
- learn programming skills: NetLogo, Star Logo TNG and Excel programming
- learn math and agent based modeling, computational techniques, project management tips, and research aides.

Schedule: Students will attend classes from 8:00AM to 6:00PM for two full weeks of classes, 90 hours, covering core components of computational science: project development, programming, math modeling, and Internet resources.

Attendance: Attendance is required.

Grading: High school teachers will be graded on creating a teamed computational science project, and classroom participation. Mid school teachers will be graded on classroom participation in modeling disease dissemination, epidemic tracking and optimal treatment.

Assessment: A pre-test and post-test will be used for assessment.

The following table is from New Mexico Tech (NMT). Our Summer Teacher Institute supports those competencies within the right hand column.

COMPETENCIES FOR ENTRY-LEVEL SCIENCE TEACHERS:	**Addresses competency**
A. **Instruction and Assessment**: Preparation to teach science shall involve:	
(1) Inquiry, Including the Scientific Method	X
(a) Select and use a variety of instructional strategies and materials for teaching science meeting the needs of all students.	X
(b) Implement active inquiry based learning activities conducive to the development of scientific processes, critical thinking skills, and problem solving skills.	X
(c) Implement design technology/scientific method: identify a problem; propose a solution; implement proposed solutions; evaluate product or design; communicate a problem, design, and solution.	X
(d) Implement technology, including computers, interactive video, telecommunication, scientific instrumentation, and others.	
(2) Content Integration	
(a) Develop student understanding of the interconnectedness of the sciences and relate the major concepts of chemistry, earth and space science, physics, and biology to the teaching of science.	
(b) Develop meaningful application of all content areas, including math, technology, language arts, social studies, and arts, in the delivery of science instruction.	X
(3) Designing and Managing Learning Environment	X
(a) Fulfill the professional and legal obligations of teaching.	
(b) Incorporate the proper use of science tools, materials, media, and technological resources.	X
(c) Establish and maintain safety in all areas related to science instruction.	X
(d) Use and care for living organisms in an ethical and appropriate manner.	X
(4) Effective and Ongoing Assessment to Improve Student Learning	

(a) Use assessment techniques such as performance testing, interviews, portfolios, and observations, for assessing student outcomes which are aligned with instruction and consistent with contemporary assessment.	X
(b) Use assessment tasks which may be appropriately modified to accommodate the needs of students with physical disabilities, learning disabilities, limited English proficiency, and cultural diversity.	
B. History and Nature of Science: Preparation to teach science shall include:	
(1) Diversity and Human Endeavor	
(a) Describe science careers and reasons why people choose science as a career, including the impact of culture, gender, and other, factors.	X
(b) Describe the science contributions of people from a variety of social and ethnic backgrounds who have diverse interests, talents, qualities, and motivations.	X guest speakers
(c) Develop student understanding of the relationships among science, technology, and cultural values.	
(d) Recognize and respond to student diversity and encourage all students to participate fully in science learning.	
(2) Empirical Observation	
(a) Explain that science distinguishes itself from other bodies of knowledge through the use of empirical standards, logical argument, and skepticism.	X
(b) Explain that scientific ideas depend on experimental and observational confirmation.	X
(3) Historical Perspectives	Epidemics and history
(a) Understand that the body of scientific knowledge is continually being expanded and refined.	
(b) Explain how theories and ideas throughout the history of science are refined or discarded as new evidence becomes available.	
(c) Explain how Western, non-European, and New Mexican cultures have developed scientific ideas and contributed to scientific knowledge.	

C. Content Categories: The following areas are designed to allow potential science teachers to construct their pre-service educationwith an emphasis in one content area, while insuring they receive science education in any area which they might be required to teach. Preparation to teach science shall enable the teacher to understand and be able to teach within at least one of these emphases:	
(1) Life Science Emphasis: All science teachers, grades K-12 will be able to identify and understand the relationship among major concepts and principles of biology, including anatomy, physiology, ecology, behavior of organisms, evolution, genetics, cell biology, microbiology, classification, and human biology.	
(a) Teachers know and understand the characteristics that are the basis for classifying organisms.	
(i) Teachers for grades K-4 will demonstrate an awareness of living things including basic cellular functions and processes, structures, the roles of organisms in systems comprised of living and non-living components and describe life cycles of plants and animals.	
(ii) Teachers for grades 5-8 will use information about functions and cell structures to explain replication, reproduction, heredity, and disease, and categorize organisms based on methods of reproduction and offspring development.	
(iii) Teachers for grades 9-12 will apply information about cell structures and functions to the world in which they live including understanding of DNA, RNA, natural selection processes, and diversity in plants and animals and use biological classifications to understand how organisms are related.	
(b) Teachers will know and understand the synergy among organisms and the environments of organisms.	
(i) Teachers for grades K-4 will explain how an organism's behavior is related to its physical environment; describe the roles of plants and animals in the flow of energy; describe how environmental pressures may accelerate changes in organisms; describe populations, communities, and systems; describe the impact humans have on the environment; understand natural resources (renewable versus non-renewable) and how each relates to humans’ basic needs, and describe elements essential to good health.	
(ii) Teachers for grades 5-8 will understand organisms' physical and	

behavioral adaptations and how changes occur over time;describe how organisms meet their needs, grow, and reproduce while sustaining stable local surroundings within an ever-changing larger environment; predict organisms' behaviors that may result from external stimuli; use information about variation and diversity to explain population changes over time; categorize organisms based on their roles within the ecosystem in which they live; examine the impact humans have on the living and non-living world including issues related to overpopulation; illustrate the relationships among renewable and non-renewable resources and population, and model responsible health practices including issues relating to nutrition and exercise.
(a) Teachers will be able to know and understand the properties of matter.
(i) Teachers for grades K-4 will describe the observable properties of common items and substances and explain that elements are the basic units of all matter. (ii) Teachers for grades 5-8 will identify the properties of elements and compounds such as density, boiling point, and solubility and that these characteristics are independent of amountof the sample and articulate that chemical reactions occur in a predictable fashion and that the formation of compounds adheres to imperatives as conservation of matter.
(iii) Teachers for grades 9-12 will compare and contrast elements and compounds based upon the knowledge of the atomic/subatomic structure of matter and predict how atoms interact based upon sharing or transference of outer electrons.
(b) Teachers will know and understand the properties of fields, forces, and motion.
(i) Teachers for grades K-4 will describe how an object may be described with regard to its relative position to other objects; explain that an object's motion may be described by indicating change over time and describe how the earth's gravity pulls objects toward it
(ii) Teachers for grades 5-8 will illustrate how Newton's Laws describe objects in motion; describe quantitatively how an object's position, speed and motion explain motion and compare and contrast forces affecting the physical world.
(iii) Teachers for grades 9-12 will apply knowledge of the constancy of energy in the universe and the forms that energy take in daily life; predict the motion of an object based on the net applied force applied to the object and explain and graphically describe that a specific mass exerts a force on

others masses (velocity and acceleration).	
(c) Teachers will know and understand the concepts of energy and energy transformation.	
(i) Teachers in grades K-4 will describe the basic characteristics of light, heat, sound, and electromagnetism, and explain that energy exists in many forms and can be transformed and describe the process of chemical reactions and how time is a factor in chemical reactions.	
(ii) Teachers in grades 5-8 will apply knowledge of energy and energy transformation to science problems; explain how chemical reactions can take place over periods of time and explain how concentration, pressure, temperature, and catalysts may affect chemical reactions.	
(iii) Teachers in grades 9-12 will demonstrate their understanding of energy by identifying examples of transformation within and outside the school environment and devise scientific investigations demonstrating the impact of temperature and other variables on chemical reactions.	
(3) Earth and Space Science Emphasis: All science teachers, grades K-12, will know and understand properties of earth and space science.	
(a) Teachers in grades K-4 will describe the physical and chemical properties of earth's materials and the states of matter; describe the uses of earth's materials as resources and the sun as the major source of energy; describe changes in the earth's surface; describe changes in weather; recognize that fossils provide a record of animals and plants that lived long ago; represent the school and local community using symbols and maps; describe basic components of and movements within the solar system; identify the types of instruments and vehicles used for space exploration and describe human's movement toward space from early observations to recent explorations.	
(b) Teachers in grades 5-8 will explain how earth's materials can be transformed from one state to another; experiment with earth's materials using them as resources; model natural resources that shape the earth's surface; observe, measure, and record weather changes; explain how fossils are formed and how fossils provide evidence of complexity and diversity over time; use rectilinear coordinate systems such as latitude and longitude to locate points on the earth's surface; describe the interactions among the earth's lithosphere, hydrosphere, atmosphere, and biosphere; explain simple data derived from recent remote and direct observations in the solar system and space beyond; model the predictable patterns of the	

sun and planets in the solar system and cite benefits from continued exploration of space.	
(c) Teachers in grades 9-12 will evaluate information about earth's materials, energy, and geochemical cycles, model the interaction between the earth's internal and external energy sources; use tectonic theory to predict changes in the earth's surface; model weather patterns and other natural cycles related to the movement of matter driven by the earth's internal and external sources of energy; use fossil and other evidence to investigate how the earth changes; extend mapping techniques to learning in science and other content areas; explain the evolution of earth in terms of the interactions among the geosphere, hydrosphere, atmosphere, and biosphere; model interactions between components of the earth based on the understanding of the earth as a system containing a fixed amount of each stable chemical or element; trace the development of space exploration and discuss how recent missions impact understanding of the earth; evaluate the hierarchy of structures in the universe from atoms to galaxies and identify the pros and cons	
(4) Environmental Science Emphasis: All science teachers, grades K-12, will be able to identify and apply major concepts of environmental science, such as ecosystems, energy flow, population, ecology, natural resources, meteorology, geology, oceanography, and conservation.	
D. Environmental, Personal and Social Implications: Preparation to teach science shall enable teachers to understand	
(1) Personal, community, New Mexico and global environmental issues;	
(2) The approaches to evaluate the ethical implications of new developments in science;	
(3) Personal and community health issues;	X
(4) Decision-making and value-analysis skills for investigating science-related societal problems;	X
(5) Ethical use and care of living organisms.	
E. Professionalism: Teacher education programs shall develop reflective practitioners who:	
(1) Foster in their students scientific interest and curiosity.	X
(2) Participate in professional scientific organizations.	X
(3) Serve as representatives of the scientific community.	

(4) Engage students in coherent, focused, student centered science curriculum, consistent with state and national standards.	X
(5) Identify and use a variety of community resources, including local expertise, industry, local environmental settings and families.	X
(6) Take advantage of collaborative planning among colleagues, scientists, and science teacher educators, so that science, science methods, and other program components are mutually reinforcing.	X
(7) Explore and evaluate the process of curriculum and instructional implementation.	X