New Mexico EPSCoR

RESEARCH INFRASTRUCTURE IMPROVEMENT (RII 4)
PROPOSAL DEVELOPMENT PROCESS

EDUCATION & OUTREACH WHITE PAPER

FOR DISCUSSION
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TITLE: COMPUTATIONAL MODELING OF COMPLEX SYSTEMS

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Computational Modeling of Complex Systems

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Target Audience: students in K-12 and their teachers.

Description of Activity:
We will engage middle and high school students in computational modeling of complex systems leveraging the programs of two well-established educational organizations (the Supercomputing Challenge and Santa Fe Institute's Project GUTS). Students will be introduced to computational modeling and complex systems through agent-based computational modeling. Using this technique, students as young as upper elementary students are able to develop models of complex systems by describing the interactions between agents and the environment and the between agents and other agents who populate the environment in a block based computer language. Subsequently, students use the models they develop as experimental test beds to understand the behavior of the system they created. Emergent phenomena such as nonlinearities and feedback loops in systems can be observed and analyzed leading to greater understanding of complexity arising in systems comprised of many interacting interconnected elements or subsystems.

New EPSCoR curricular units will be designed and developed to align with EPSCoR research on the nexus of water, energy, and environment. These units will be implemented through Project GUTS afterschool clubs and Supercomputing Challenge teams at New Mexico middle and high schools. Teachers who act as Project GUTS club leaders and/or Supercomputing Challenge team sponsors will attend professional development workshops thrice yearly to prepare for the implementation of the units with students. Within each unit we will incorporate a field trip where students can participate in experiential learning activities (field-work) and collect real-world data to analyze and compare with computer generated outcomes. The culminating activity in each unit will be students' presentations of their research projects, models and findings at student roundtables and at the end of the year Supercomputing Challenge EXPO.

The goals for student learning are:

a) Students will gain an understanding of complex systems as systems in which there are unpredictable outcomes as a result of interactions between elements whether they are agents or subsystems;
b) Students will learn basic computer programming constructs that prepare them to join the computationally enabled STEM workforce;
c) Students will learn how to run experiments using computational models as experimental test beds; and

d) Students will be able to transfer the application of computational modeling as a scientific tool from one issue to another (i.e. when posed with a new scientific problem and asked for suggestions on how to investigate and gain and understanding of the issue, students will cite computational modeling as a tool that be used in the scientific investigation of the issue.)

Student learning will be evaluated through analysis of data collected through administration of pre- and post- surveys, interviews and focus groups.

Relevance to Energy-Water-Environment Nexus

The proposed activities have relevance to the Energy Water Environment Nexus in multiple ways. First of all, many issues at the nexus of energy-water-environment are complex systems problems that encompasses human and natural systems. There is an urgent need to understand these large complex systems to address the problems of the 21st century that affect us all such as climate change, energy consumption, loss of biodiversity, and virulent disease. (Emmott et al., 2006) We address this need by engaging students in thinking about systems as early as middle school. Secondly, computational methods and tools are an important part of all sciences in the 21st Century because they are used to study and understand (and possibly mitigate) complex systems problems. There is an increasing need for a workforce capable of understanding and applying computational concepts, methods, tools and technology. We address this need by actively engaging students in creating and using computational models as tools for scientific inquiry.

Thirdly, the NM EPSCoR activities will be customized to specifically align with Energy-Water-Environment nexus research projects. For example, EPSCoR scientists Chermak and Fernald [citation] use agent-based computer models to understand and address sustainability issues. In the EPSCoR white paper entitled "Sufficiency from Scarcity: Pragmatic Holism for Sustainability of the Water, Energy, Environment, Information Nexus", they outline using computational models and tools to develop a comprehensive understanding of the intricacies and trade-offs between human choices and the viability of the natural and environmental systems. Similarly we could use a simplified version of an acequia model as a basis for a curricular unit that emphasizes the sharing of a variable water resource, human choices and climate change impacts on water availability. Additionally, introductory materials that accompany each unit can incorporate EPSCoR research, data, and findings. And, finally, the activities outlined prepare youth to become computationally enabled STEM professionals that can carry out this research in future years.

Potential for matching funds:

Templeton funding (through SFI) for developing online complexity resources.
Google RISE – Summer workshops for students
Google CS4HS – teacher professional development
Private foundation support GUTS clubs and SC teams. (Lockheed Martin, Santa Fe Community, and others)