The National Computational Science Institute
and The Shodor Education Foundation, Inc.
A Briefing Paper

This document will serve as background information for understanding the on-going and developing relationships between Shodor, MCNC, and the colleges and universities of North Carolina.

Introduction:

The Shodor Education Foundation is a North Carolina, non-profit research and education organization dedicated to the advancement of science and mathematics education, specifically through the use of computation and communication technologies. Since its inception in 1994, Shodor has consistently pursued a focused vision for changing science education at the undergraduate, secondary and middle school levels by allowing faculty and students to explore new learning and teaching modes based on interactive explorations enabled by mathematical modeling and computational science tools. In doing this, Shodor has established itself as a national leader in developing innovative modeling courseware in mathematics and many areas of science, including physics, chemistry, astrophysics, biomedicine and environmental science. Shodor-developed materials have been repeatedly recognized as being the "best of the web" in education, including awards from the National Council of Teachers of Mathematics (NCTM), the Eisenhower National Clearinghouse (ENC), Encyclopaedia Brittanica, and Forbes.com,

Shodor has demonstrated remarkable success in attracting significant numbers of women and minority students to their workshops, internships, and classes, providing unquestionable evidence that their methods have great potential for addressing important demographic needs as well as facilitating science education reform. The growing importance for the United States to achieve greater demographic diversity in the workplace was the focus of a recent study initiated by Congress. This study underscored the national imperative for expanding the workplace diversity, especially at the higher end, if the US is to maintain a competitive edge in science, engineering, and technology[1]. This seemingly inherent characteristic can be potentially beneficial in supporting systemic efforts by the university system to help address this growing national imperative.

NSF Will Fund Shodor to Establish the National Computational Science Institute

Shodor has received a national endorsement and major funding from NSF to lead a national center for computational science education. NSF's funding, anticipated to be some $2.75M over three years will enable Shodor to expand its programs nationally by providing workshops and instructional resources to stimulate and challenge the young learners in both our state and the nation. MCNC is preparing to host the public announcement of this prestigious award at the North Carolina Supercomputing Center on December 18, 2001 at 10 am.

The "Roots" of NCSI are very much in North Carolina "Soil"

From 1991-1994, the National Science Foundation funded MCNC/NCSC to organize and offer an undergraduate workshop series for small to medium sized institutions called the *Carolinas Summer Institute in Computational Science.* This project was funded under what was then known as Undergraduate Faculty Enhancement. Dr. Robert M. Panoff, then Manager of Education at NCSC, was the principal investigator on this grant; Dr. Holly P. Hirst (ASU), Dr. Dan Warner (Clemson) and

[1] *Report of the Congressional Commission on the Advancement of Women and Minorities in Science, Engineering, and Technology Development, July 2000 (www.nsf.gov/od/cawmset).

D.E. Stevenson (Clemson) were hired as workshop faculty. These four constituted the founding board of directors for Shodor in 1994.

Over several summers, teams of faculty from North and South Carolina came to MCNC for three rigorous weeks of training in high performance computing, visualization, and computational science. UNC faculty came from NC A&T, NCCU, Elizabeth City State, Appalachian State, UNC-Pembroke, UNC-Charlotte, and UNC-Wilmington. Faculty from UNC-Chapel Hill and NC State served on the advisory committee.

Shortly after the incorporation of Shodor, work started on designing a new workshop program to take into account the increased power of desktop machines and to be broken into one-week increments. The result was the Shodor Computational Science Institute that offered a series of workshops and other training activities. While schools in the southeastern US were the focus, SCSI workshops drew a national audience. UNC campuses taking advantage of this training included North Carolina Central University (which hosted the workshop in 1998), Appalachian State University (host from 1999-2001), Winston Salem State University, UNC-Pembroke, UNC-Charlotte, and East Carolina University.

In addition, Shodor has been engaged in several significant projects to explore on-line learning in science and computational science in partnership with either MCNC, UNC campuses, or both. Shodor and MCNC developed an on-line course called *Computational Science for Science Educators* (http://www.shodor.org/compchem) which was taken by scores of faculty across the state and across the country, learning how to do computational chemistry so that they could better teach computational chemistry. This course now will serve as the model for the work to be done on-line through NCSI. Shodor also worked with several UNC campuses (UNC, WSSU, ASU, ECU) to develop an on-line chemistry review course for entering freshmen (http://www.shodor.org/unchem) which has significantly improved chemistry performance and retention on those campuses which are using it.

UNC Faculty and Students Develop Materials and Help Teach Workshops

A hallmark of Shodor's programs is the use of faculty and students to help develop their materials for workshops with faculty and students. Shodor is consistently one of the leading providers for mentorships for students from the North Carolina School of Science and Mathematics; Many undergraduates at UNC, NCCU, and NC State have worked or are still working for Shodor in a variety of capacities. Our summer workshops for high school and middle school students are staffed with a high percentage of students from UNC campuses. The newly-hired program manager for NCSI was herself a graduate of NCSSM and UNC-CH and worked for two years at Shodor in an NSF-funded *Research Experiences for Undergraduates* internship.

NSF's Funding for Shodor's NCSI Signals a Strategic Change in Promoting Computational Science Education

NSF's long-standing strategy for promoting computational science education has been based upon the assumption that changing an individual teacher's behavior would result in introducing computational science and methods into the curriculum. For nearly two decades, NSF funded workshops and provided incentives to attract individual teachers to learn computational methods and mathematical modeling. Beyond the individualized incorporation of computational methods for enrichment of existing curricula, there is no measurable evidence to show that this paradigm has resulted in systemic migration of computational science and methods into the undergraduate curriculum.

NSF's funding of Shodor's NCSI signals a major shift in the paradigm that acknowledges that campus-wide institutional reforms to inorporate computational science must address systemic and not merely individualized processes for change. Since this degree of systemic change has never been undertaken at the undergraduate level, NCSI is proposing, as a first step, a partnership with a state-wide, multi-

campus university system in order to create a "process testbed" by which computational science can permeate throughout the undergraduate curriculum.

Shodor's Vision for Promoting Systemic Curriculum Reform

Shodor's vision for stimulating and promoting national, systemic curriculum reform will be to expand its successful regional programs to create **The National Computational Science Institute (NCSI**). NCSI will introduce the hands-on use of computational science, numerical models, and data visualization tools across the undergraduate curriculum. With the National Science Foundation grant, NCSI will offer an expanded set of in-person, video-conferenced, and web-accessible workshops, seminars, and support activities. The initial target audience for NCSI will be teams of faculty from predominantly undergraduate institutions (PUI's), minority serving institutions (MSI's), and community colleges whose students will be the next generation of scientists and engineers, the next generation of K-12 teachers, or both. With supplemental funding, NCSI will offer computational science workshops and sponsor educational activities for in-service teachers, business and government leaders, and the general public. NCSI participants will then assist others on their own campuses and at neighboring institutions to introduce computational science in their own classes. NCSI will proceed along three synergistic but distinct routes that can be modeled as **PULL, PUSH**, and **PERMEATE**.

NCSI's Strategic Vision is to PULL, PUSH, and PERMEATE

Regionally distributed workshops will PULL faculty within a reasonable travel distance for a week of intense interdisciplinary training, collaboration, and curriculum development in computational science. Participants will explore the use of modeling and visualization tools in existing courses, while stimulating the creation of new courses and promoting new modes of undergraduate research.

NCSI staff and participants will proactively PUSH computational science and computational science education onto the agendas of professional and discipline-specific societies, offer workshops, conduct tutorials, present papers and posters, and serve on program committees.

To sustain these efforts, NCSI will PERMEATE on-going and proposed undergraduate curriculum efforts by providing interdisciplinary and discipline specific web-accessible courses for faculty enhancement, and resources for interactive exploration including an interactive curriculum, problem-based modeling modules, tools, and tutorials, leveraging Shodor's award-winning Computational Science Education Reference Desk.

NCSI will work in partnership with the Education, Outreach and Training Partnership for Advanced Computational Infrastructure (EOT-PACI), the National Computational Science Education Consortium (NCSEC), the Burroughs Wellcome Fund, Sigma Xi, and more than two dozen academic institutions, high performance computing centers and vendors, including the North Carolina Supercomputing Center. MCNC/NCSC will provide supercomputing time, staff consulting, and use of training and video facilities in support of the state and national NCSI efforts.