# STEP: A Case Study on Building a Bridge between HPC Technologies and the Secondary Classroom

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**Abstract:**

This paper discusses a case study that was conducted on a three year National Science Foundation in-service program called the Supercomputer Teacher Enhancement Program (STEP). STEP began in 1993 and continues today past the formal time of NSF support. The goal of this report is to document aspects of the STEP model that have enabled the program to build an enduring bridge between the technologies, researchers and staff of the San Diego Supercomputer Center (SDSC) and over forty secondary science and mathematics teachers and the learning environment of their classrooms in twenty-one schools from eight school districts in San Diego County. Two timely events added texture to this in-service program: 1) it was known at grant design time that SC95 would be held in San Diego and 2) the program began one year before NCSA Mosaic began the dramatic change in the way the public interacts with the Internet. NCSA Mosaic, and the other browsers that evolved, provided unexpected technologies that have had a profound impact on the classroom practice for the STEP teachers, as evidenced in this research. This paper documents how STEP adapted in the 1994 summer workshop to introduce this technology to teachers who had become comfortable with text-based tools for Internet access presented in the first July 1993 workshop. The personal interactions and lessons learned from STEP and its workshops in 1993 through 1996 and beyond are classified and quantified. This greatly influenced the design of a faculty outreach program to support undergraduate curriculum development for the Education Center on Computational Science and Engineering (EC/CSE), a partnership activity of the National Partnership for Advanced Computing Infrastructures (NPACI). This, in turn, led to NPACI educators' collaboration with educators from the National Computational Science Alliance (NCSA) to form the National Education, Outreach and Training program.

Keywords:

Computational_Science In-service_Preparation Internet WWW

# 1. Introduction

## 1.1 An Overview of STEP

From the 1993 Summer Workshop handouts [1], the goals of the Supercomputer Teacher Enhancement Program (STEP) were to:

- use computational resources to enhance the teaching of high school science;
- connect the high school classroom with the computational world outside;
- allow the high school teacher to develop an understanding of how science is currently done and
- introduce teachers to the tools of computational science and High Performance Computing and Communications (HPCC).

STEP was initially written and designed by a team from the University of California, San Diego (UCSD), the San Diego Supercomputer Center (SDSC) and San Diego State University (SDSU). The grant provided three years of funding, from January 1993 through June 1996. The field of computational science was fairly new in January 1993, so materials were designed and written for the first workshop in July 1993. As a historical view of the Internet and computational science, these materials are still available, now via the Wide World Web. An overview of how to access these materials is contained in the Appendix of this paper [app]. Linked access for year 1 [2], year 2 [3], and year 3 [4] of initial NSF funding are contained in the references of this paper. Year 3 also inicluded a special presentation by Don Anderson, "Using HTML for lessons on stand-along computers", [5]. Using remaining funds from the NSF grant, a year 4 [5] summer program was offerred, by Anderson on advanced Web topics.

The program involved intensive summer workshops at SDSC, from three to four weeks in length, reinforced by six Saturday meetings during the academic year. When funded in January 1993, the program was widely advertised. Applicants applied to the three-year program as teams from the same school in accordance with the program goal of establishing a core group of evolving expertise at the distributed school sites. A fan out effect was designed through the grant providing further remuneration for the STEP teachers to prepare and present staff development workshops on the summer materials to reach other educators at their school site and beyond. This extended the outreach that STEP and SDSC were able to accomplish.

The following table summarizes the Timeline for the STEP program:

| Time Frame | Participants | Objectives/Activities | Lessons Learned |
|---|---|---|---|
| 1993<br><br>Spring Semester | 6 Lead Teachers | Plan activities for upcoming sessions | + Lead teachers were essential for helping Stewart orient curriculum that would be helpful to high school teachers |
| 1993<br><br>July<br><br>Session I<br><br>1 week C Programming<br><br>3 weeks of STEP | 40 participant teachers (mostly science teachers, some math teachers) + 6 lead teachers | What is computational science?<br><br>What is the Internet?<br><br>Text-based e-mail using Macs or PCs connected to Unix Machine (Software email package: Elm)<br><br>Internet-based freeware<br><br>FTP (anonymous) | + Sessions take time, speakers need to stay for an extended period of time, cannot come in to give 1 hour guest lectures<br><br>- Sessions were very in-depth. The variety of software packages may have been somewhat overwhelming for those who were unfamiliar with general computer applications (e.g., |

| | | | |
|---|---|---|---|
| 8 AM-4 PM | | Programming in MATLAB | using MATLAB, spreadsheets, and C programming)<br><br>- Instructional Sessions were long, and little time was left for open lab<br><br>- Programming content not applicable for all high school teachers |
| 1993/94<br><br>Academic Year<br><br>6 Saturday meetings | 40 participants and administrators<br><br>1 Session for Administrators' briefing | Administrators were invited to see what participants had learned (held at SDSC)<br><br>Supercomputing '93 Education participation<br><br>Mosaic arrives; Stewart integrates this program into her Spring semester courses | + Administrators were very impressed with progress and technology. These information sessions had a greater impact than just immediate interest in that it motivated many administrators to begin thinking about getting involved in the Internet.<br><br>+ Maintenance of community through telecommunications |
| 1994<br><br>July<br><br>Session II<br><br>3 weeks of instruction<br><br>9 AM - 1 PM<br><br>afternoon lab time | 33 original participants;<br><br>7 new participants<br>5 Lead Teachers<br><br>(attrition due to personal commitments, etc.) | Review and update previous year to help integrate new participants.<br><br>Mosaic - provided GUI interface<br><br><u>Guest Speakers:</u><br>1) Dave Thomas - Montana State University- Brought in public domain software (Internet Tools, Viz Tools on diskette, collected from Internet)<br>2) Brian Lindow - Lawrence Livermore National Laboratory- provided software for Mac and PCs to connect to NESP Cray at LLNL. Data package queries could be made at local computer, then sent to NESP Cray at LLNL for crunching, then returned to local machine. Examples: Climate change, chaos, molecular models<br>3) Tony Freeman - Jet Propulsion Laboratory- brought remote sensing software and NIH Image to read SIR-C CD-ROM containing NASA data (e.g., to study deforestation in Rain Forest)<br><br><u>Collaborations</u><br>1) SIAM - Stewart sponsored 5 participant math teachers to attend annual meeting held in San Dieg<br>2) Randy Souviney - teacher educator from UCSD taught science teachers - introduced NSF Grant "Community of | + GUI interface was much more appealing<br><br>+ Mosaic enabled teachers to begin developing hypertext Web pages for classroom use<br><br>+ Connectivity limited in schools; therefore lessons concentrated on stand-alone applications (based on HTML) |

| | | | |
|---|---|---|---|
| | | Explorers"<br>- also brought in PPP which improved connectivity, provided GUI | |
| 1994/95<br><br>Academic Year<br><br>6 Saturday Meetings | Participants and Lead Teachers<br><br>1 Session for Administrators' briefing | Planning of curriculum; review of prior activities. | + Involvement of administrators in annual debriefing<br><br>- Many participants were not yet sponsoring their own in-service programs; although some were availing themselves of the SDSC facility to run seminars and classes |
| 1995<br><br>July<br><br>Session III | 40 participants<br><br>and lead teachers | Stand-alone web development on machines with or without fast Internet connectivity prepared and presented by Don Anderson<br><br>NIH software became a helper application in browser tool<br><br>Guest Speakers:<br>Dave Thomas<br>Brian Lindow<br>Randy Souviney<br>Bill Barowy of BBN | + SC'95 proved a motivating factor for supporting participants efforts to create for a larger community who came to San Diego to learn<br><br>+ Advanced HTML features were helpful for teachers' lesson planning |
| 1995/96 Academic Year | 6 academic year meetings<br><br>Administrators were invited to attend SC95 | Supercomputing '95:<br><br>STEP teachers provide several workshops at the international conference on the tools they had learned to use and to share examples of the curriculum enhancements they made incorporating these technologies | + Presentation using WWW to national audience served as strong motivator |
| 1996<br><br>July<br><br>(Extended session) | 33 Participants and Lead Teachers | Don Anderson developed and presented sessions regarding more advanced web development including use of tables, frames, Javascript, client-side techiques, server-side techniques and more | + Participants were sponsoring workshops, others were writing grants, and arranging collaborative grants with outside community |

Table 1. STEP Timeline

## 1.2 Significant aspects of STEP program model:

1) Participants received stipend (including summer workshop attendance, academic year meetings, planning and implementing for in-service programs).

2) Participants received continuing education units for attendance at each workshop.

3) Division of labor between grant administrators and STEP instructors supported efficiency and productivity of entire program.

4) Inclusion of school administrators proved essential for encouraging integration of Internet in school buildings and districts.

5) 2+ teachers from each school served to establish local support group at each site.

6) National recognition at 1996 Smithsonian/Computerworld Innovators ceremony, Washington, D.C., June 1996 [6].

# 2. Analysis of Case Study Data

In the following section, we attempt to document the variety of ways in which the respondents described their experiences with STEP. The data corpus consists of 33 letters [7] written in answer to the following purposely open-ended request:

Describe, in your own words, the impact of STEP on you.

The data analysis involved identifying common themes found in the 33 respondents' comments. Table 2 indicates the percentage of comments falling into 10 different theme categories. The first column of the table indicates the percentage of respondents mentioning a comment falling into that theme (out of a total of 33 respondents). The second column indicates the percentage of comments of that theme in relation to the total number of comments (223 total comments, which indicates an average of approximately 6-7 comments per response).

| THEME | Percentage of Respondents | Percentage of Total Comments |
|---|---|---|
| Professional Growth/Improvement in Teaching | 100% | 18.80% |
| Inservice Programs | 100% | 14.70% |
| Ongoing HTML Projects | 98% | 14.30% |
| Curriculum Development | 94% | 13.90% |
| Expertise of Instructors and Guest Speakers | 88% | 13.0% |
| Personal Growth/Improvement of Self | 52% | 7.60% |
| Contributions to the school | 49% | 7.20% |
| Applications for/Procurement of Grants | 30% | 4.40% |
| Community Outreach | 21% | 3.30% |
| >Larger Education Community Work> | 18% | 2.0% |

Table 2. Distribution of Comments Regarding STEP Program

## 2.1 Professional Growth/Improvement in Teaching

As Table 2 indicates, the largest category of responses included comments regarding professional growth. Many of the participants noted that the STEP program enabled them to rethink and consequently change their views of

teaching. For example one comment stated, "This has been the best thing that has happened to me since I began teaching!" Others noted that the experience supported their belief that technology is an essential tool for teaching in the age of the Internet.

Other respondents in this category listed some of the professional recognition that they have received. All of those respondents indicated that they believed the awards were due, at least in large part, to their participation in STEP. These awards include: 2 recipients of the Tandy Educator of the Year, the 1996 San Diego Science Alliance Teacher of the year, the Global Internet Lead Teacher, the Mentor Teacher Award, and the California Science Project Mentor coach for Martin Luther King Middle School. As one recipient explained

> Since the STEP program expected and allowed for staff development training at our site, it put me in a position of expertise in the eyes of my peers and has opened many opportunities for influencing change within our site and cluster. Because of my involvement, my principal nominated me for a Tandy Scholars Award which I received.

Several respondents also noted that their participation in STEP lead to a variety of different collaborations including working with other STEP participants, other science educators who have responded to web pages that have been posted, other community organizations, other faculty at the same school, and other faculty at other schools (such as a local school of medicine), and faculty associated with the San Diego Urban Systemic Initiative program.

## 2.2 Inservice Work/Programs

One of the goals of the STEP charter was to support the dissemination of information through inservice programs. To this end, STEP participants were encouraged (and financially rewarded) to plan and implement programs for faculty at their schools, and at conferences. According to conservative estimates from the 33 respondents, a total of 5,941 teachers in the San Diego county have been affected by the STEP program through various inservice training sessions. The range of these programs runs from short 2 hour sessions to week-long sessions.

The topics covered included introduction to the Internet as a resource, HTML lessons for the development of personal web pages, Imaging workshops, computer applications for science workshops, and other workshops designed to specifically introduce various web pages developed by the participants. As one participant described her curriculum

> I have conducted several workshops, not only for the staff of Mira Mesa High, but for one of our feeder schools and for science teachers across the state at the San Diego Science Educators Association Conference in March. My message has been two-fold--to show the unlimited opportunities offered by Internet research and to excite teachers about the possibilities that they and/or their students can also create their own web pages. What a motivation when students know that their end product could end up published on the Web for the whole world to see!

## 2.3 Ongoing HTML Projects

Given that the thrust of years 2 through 4 of the STEP program focused on the production of HTML programs, it is not surprising to read about the accomplishment of personal goals. However, reading the participants' enthusiastic descriptions of their ongoing projects is overwhelming. Examples include: Mathematics education web site with K-12 resources and links to other sites; several "how to" HTML pages such as directions for using frames, directions for programming graphics with Pascal, and many others described below in the "community outreach" and "contribution to schools" sections of this report.

## 2.4 Expertise of Instructors and Guest speakers

28 of the respondents began or ended their letters with statements describing the expertise of the STEP faculty and guest speakers. These statements included "outstanding", "knowledgeable", "helpful", and "supportive". As one respondent noted

> Some of the important highlights of the program include learning a variety of computer techniques taught by highly regarded experts in various fields, the excellent facility and equipment of the San Diego Supercomputer Center where most of the training sessions took place, and the collaborations and interactions among some of the finest teachers in San Diego County who participated in the program.

In addition, several comments indicated the important fact that the STEP instructors set up an atmosphere in which the teachers felt comfortable with technology rather than being intimated by it. In this way, the teachers felt that the program had dissolved the walls erected between classrooms and the wider education community. None of the respondents indicated any negative comments about the workshops, the activities, or the instructors.

## 2.5 Personal Growth/Improvement in Self

As noted above, STEP did achieve its initial goal of supporting professional development. However, 52% of the respondents also noted that they also derived personal growth and satisfaction from the experience of learning. In particular, 24% of the respondents noted that they "Went from little/no knowledge of the Internet to being viewed as an expert by peers". Others noted that they felt an increase in their self confidence which enabled them to organize large-scale programs and serve on committees dealing with technological innovation with increased confidence and expertise. For example, one wrote

> Over the past four years I have gone from near zero knowledge and capability to a place where I understand and can, have, and will continue to apply my skills directly into the classroom. I feel superbly competent to undertake any educational challenge that technology may place in front of me. I feel absolutely prepared for the beginning of the next millennium.

In summary, the respondents indicated a great deal of satisfaction with their own progress and their abilities to continue teaching "on the cutting edge" of technology.

## 2.6 Curriculum Development

It is interesting to note the variety of ways in which the teachers have integrated technology into their curricula. The list includes adding activities that involve 3-D modeling, Spreadsheets, MATLAB, Simulations, Using HTML and web publishing to motivate students, Computer application, Internet Research for supporting content in Student projects (such as photosynthesis and animation), Internet-based course in which students design their own pages, Java programming, Remote scientific visualization course, 3-D applications course, GIS data analysis web site, and a school information site describing environmental information.

One example of an innovative curricular project was described as follows:

> Our WWW access has led to linking my science classes and GATE program with Dr Randy Souviney, Associate Coordinator of Teacher Education at UCSD, and Sally Ride, UCSD Physics Professor and former NASA astronaut. They are principal investigators into how middle school students interpret geo-referenced data using recent developments in scientific visualization tools and space borne images within an "Earth Tectonics Unit" to help students better understand the integration of geography and science.

Another respondent noted:

> One of the areas I feel technology will provide a positive influence is assessment. I am currently working on an interactive astronomy test that uses web-page technology to "link" the student to information and test questions. The student records the answers as the test is taken and the computer grades the test instantly.

## 2.7 Contributions to School

A second goal of the STEP program was to empower the participants to bring technology into their own schools. To this end, the participants were asked to bring their administrators to an informational meeting during the fall after each summer session. The goal of these meetings was to acquaint the administrators with the work and to elicit their administrators' support for integrating technology into their own schools. Five of the respondents (15%) indicated that their participation in the STEP program was an influential factor in procuring funds to have the schools wired for the Internet.

Other ways in which the respondents contributed to their schools include: serving as members of long-term technology planning committee (10%); designing web pages for the school or department and posting assignments to keep parents involved (10%), and setting up and serving as network director of a WAN or LAN (5%). As one respondent noted, "I have become an agent of change" at my school by holding weekly HTML courses. Another noted

> The Carlsbad School District has benefited from the participation of Paul Zeigler, Jay Klopfenstein, and I. Together we have offered inspiration and an impetus for change. Valley Jr. High School now has a very nice computer lab that is connected to the Internet and Carlsbad High School has recently been wired and will be on the network very soon. When the school and district want to boast about the advancement of technology in the classroom, we, the STEP participants, are almost always mentioned.

## 2.8 Procurement of Grants

Ten of the respondents (30%) noted that they had been directly or indirectly responsible for writing and receiving grants to purchase equipment for their schools. Examples of these grants include State Grants for staff development and equipment purchase, Perkins Grant, Magnet grants for school, Grant for Faculty development with purchase of Laptops, Title 7 Grant for purchase of equipment, GTE Equipment grant, and a Marine Science Grant to support the development and maintenance of a web site for integrating technology into the science curriculum.

## 2.9 Community Outreach

As noted earlier, all respondents described ongoing projects in which they have been involved. Many of these projects have received national acclaim within the field of education. Examples include the TRITON project that aims to integrate Internet resources and research, the Global On-line Learning site, the WESST assessment tool, the Mathematics education site, and the Astronomy Site. All of these sites are designed to support other teachers' efforts to locate resources on the WWW. One respondent described his efforts to contribute resources by stating

> The experience I gained from the STEP program has opened up some significant opportunities for me. I am currently spending some of my "spare time" working with Global On-Line Learning, a non-profit organization that provides on-line instruction for the educational community. Our goal is to give schools access to quality educational materials with sound instructional foundations, at no cost to the users. The lessons are interactive, giving students practice, feedback, and evaluation. We are also developing an application called WESST, a Web-based Evaluation System and Support Tool, in conjunction with the SDSU Department of Educational Technology. WESST is a tool for the easy creation, delivery, and recording of multiple choice tests over the Internet. Other test types such as short answer and matching are in the works. Our web site is located at: http: / /www.goleam.org.

Some examples that extend beyond the immediate educational community include a collaboration with the San Diego Water Authority, Action-oriented environmental projects, HUB Coordinator for SCOPE project in California, Portfolio projects, and the KidSat NASA project which involves having students use the path of Space Shuttle to request pictures of desired locations, the Frontiers for Science program, and the organization of several adult education classes.

One example of the highly innovative and influential projects was described by its author who stated

> Roger Wynn and I displayed and presented an "Educational Poster Exhibit" titled "Welcome to the Watersite Workshop". This on-line project was recognized as one of the innovative educational websites by the Smithsonian Institution. The website emphasizes water resources, careers in the water industry and the on-line sharing of water quality testing by staff and students from their local watersites. This website project branched into working with Ivan Golakoff, the Educational Director for the San Diego county Water Authority. We presented our website to the regional water authority board and gained board support for assisting in the implementation of a K-12 science webserver and website at the water authority. This agency support has been outstanding in providing water quality testing kits for teachers, along with a training program that ranks as one of the best in the country. This program is offered three times a year for more than a hundred science teachers. They work with both students and teachers to support "school to career" experiences in the classroom and with outdoor computational field studies. See at http://iip.ucsd.edu/personal/klopfenstein.

# 3. Impact of STEP on the Designers

## 3.1 Education Center on Computational Science and Engineering (EC/CSE)

The Education Center on Computational Science and Engineering (EC/CSE) has been established as a partnership activity of the National Partnership on Advanced Computing Infrastructure (NPACI). It acts on behalf of the California State Universities (CSU) System, the largest undergraduate system in the United States with an undergraduate enrollment over 225,000 (FTE, Fall 1996). The CSU serves a large, geographically distributed, racially diverse student population. The EC/CSE received strong support from the CSU Chancellor's Office to ensure dissemination over the entire state. The EC/CSE is located at San Diego State University (SDSU), the largest campus of the system with an undergraduate enrollment over 30,000 (Fall 1996), chosen due to efforts already completed in Computer Science, Physics, Chemistry, Geology and Geography to incorporate computational science into the undergraduate curricula. The EC/CSE, its staff and equipment are located in the University Library, a natural complement to the Data Intensive Computing thrust of the NPACI.

The EC/CSE develops and conducts seminars and focussed workshops covering topics from the NPACI Technology and Applications Thrust areas applicable to educators from the campus, the CSU, the NPACI and the National Education Outreach and Training (EOT) program formed jointly with the educators from NPACI and educators from the National Computational Science Alliance (NCSA). The EC/CSE uses SDSU as a model for outreach to faculty to become familiar and investigate the use and effectiveness of new technologies in their undergraduate curriculum. One current example from STEP involves STEP participant, Steve Wavra, and SDSC/NPACI researcher, Phil Bourne, using the Molecular Interactive Collaborative Environment (MICE) [8]. This involves collaboration between the classroom at Southwest High School, near the Tijuana Border, and Visualization Laboratory at SDSC, many miles away.

Stewart speaks to the Education Technology course on Instructional Design of Dr. Allisson Rossett, SDSU College of Education, Fall 1997. The text used in the course, Integrating Educational Technology into Teaching [9], provides a concise introduction to using some of the standard computer tools in instructrional design, and defines and describes the Learning Theories, Strategies for using Tools, and Techniques for Assessment used in this field.

## 3.2 ACM SIGCSE Research in Computer Science Education

Participation this year by Stewart [10] with the Association for Computing Machinery (ACM) Special Interest Group on Computer Science Education (SIGCSE) has made clear the close parallel between the strategic directions in computer science education [11] and research in computational science education. Computational science was called out as one of the key fields in the ACM Workshop on Strategic Directions in Computing Research [12,13]. The use of evaluation was summarized at an ACM Working Group meeting in Barcelona 1996

[14] and has immediate application to computational science education research. The SIGCSE97 Keynote Address was given by Professor Andrew S. Tanenbaum [15]. This was a particularly entertaining, and pertinent, presentation that the authors would recommend the Computational Science Education community use as a starting point for dialog on the impact of a technically evolving field on the learning environment which faculty can construct.

# Conclusions

The obstacles preventing full integration of supercomputing resources in the secondary schools are extensive, but the design of the STEP program can serve as one viable model for empowering teachers, their peers and their students. The history of the project and the evolution of training materials are available to assist others who wish to extend the outreach of High Performance Computing. We plan to conduct further research on the EC/CSE program to document the ways in which this model can be adapted to the undergraduate education experience to build another bridge between High Performance Computing and the undergraduaate classroom.

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# Appendix

### FTP Contents on rohan.sdsu.edu (anonymous ftp) /pub/stepinfo

This page is also at URL: http://www.stewart.cs.sdsu.edu/SC97/step/ftp.html

This provides a Web Based access to a subset of the files available from the anonymous ftp site rohan.sdsu.edu

```
ftp rohan.sdsu.edu
login as anonymous
password is your email address
cd pub
cd stepinfo
ls
```

Sample script for accessing Anoymous ftp site
    Commands and responses from an ftp access
Contents of entire FTP site
    FTP to stepinfo annodated contents
README file from FTP sites
    README overview statement
FTP access to the archive so you can easily connect yourself.
    FTP to the archive