6 Outreach and Educational Activities

Wayne State University, located in Detroit, is one of Michigan's three national Carnegie Research I universities with over 14,000 post-baccalaureate students. The student population is diverse in age, educational and ethnic backgrounds. Thirty percent of our students are from minority ethnic groups. There are three *specific objectives* that my Education Career Plan will accomplish:

- to produce graduates from the bachelors, masters, and doctoral programs with the skills necessary to succeed in both industry and academia,
- to increase representation of members of minorities in the physical sciences, and
- to incorporate undergraduate and high school students in research projects.

6.1 Bringing High School Students to Science: HiSchool DiSCo

Interest in science should be developed early, before one decides to enter college. There are several ways to get high school students interested in science. Yet, I firmly believe that the most effective one is to use your own example and energy to excite the students about a career in science. This is one of the most exciting aspects of the profession of educator, that involves not only teaching but also sharing one's personal and professional experiences.

My own experience, as well as numerous exchanges with the high school teachers participating in our RET program led me to conclude that one of the important factors to ignite a student's interest is to make him or her an integral part of a real scientific research project. I could clearly recognize it while acting as a judge for the Junior Science and Humanities Symposium (annual competition of research projects among Michigan high school students, which takes place at WSU): students, involved in research with active university groups are more excited about the results of their investigations and generally fare better in this competition. The research program proposed here has a natural potential for doing precisely that. A general feature of the computational tasks proposed in section 5 is that the input and output files containing the integrals to be evaluated and final results are usually quite small, but the intermediate expressions could be rather large. This makes it possible to distribute the tasks and collect the results over the Internet without stringent requirements on the bandwidth, which means that the workstations that actually do the computation need not to be located at WSU. This allows dual use of the involved computers and *sharing the computational infrastructure* with other institutions, such as local Detroit high schools.

To accomplish this, *I propose the project HiSchool DiSCo: High School Distributed Scientific Computing* [46]. The idea is to set up a network of Linux and Windows-powered computers at the participating high schools (see Fig. 7). These computers would be used for the dual purposes of teaching high school students the basics of Linux/Windows administration and scientific computational methods and as a commodity cluster for high energy physics computations running FORM with enabled Message Passing Interface (MPI) [47] or using BOINC software [48], fully utilizing the potential of computers. Even though these computing clusters will be initially used for the symbolic computations of matrix elements needed for interperetation of FNAL and LHC experiments described in this proposal, the proposed "mini-grid" is easily scalable. With more schools involved in the project, other computational projects could utilize this network, including projects in chemistry and biology, thus having a *broader impact* on the way scientific computing is done.

Since most of the applications used in high school instructions are Windows-based, practical realization of the project [49] would require one Linux-based server managing a local network of "dual-boot" computers capable of booting up as Windows or Linux machines (this is a routine

modification). These computers would also be used for instruction in scientific computation for high school students and teachers during the daytime. They would automatically reboot into a Linux cluster capable of running high energy physics applications at night, when no one is using them for educational purposes.

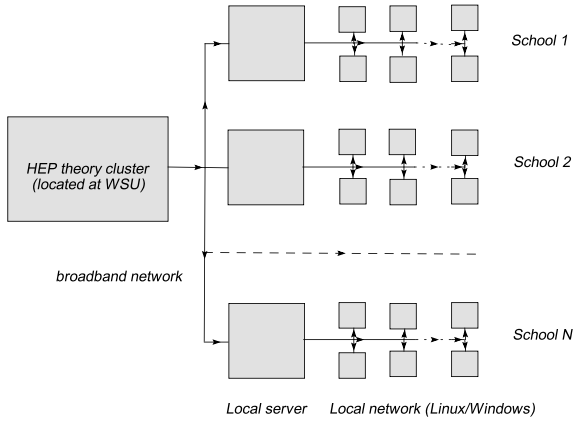

Figure 7: A diagram representing HiSchool DiSCo project.

The project HiSchool DiSCo would introduce students to Linux/Windows administration, as they would be responsible for the hardware involved in the research project. I will train the students and teachers in the basics of Linux/Windows administration. In addition, I will prepare and present a set of lectures on the basics of scientific computing (as part of "History of the Universe" enhancement course, see section 6.1.1) and help with installation and running of the cluster. The students will be given small parts (tasks) of the real research project, which will allow them to learn some basic techiques used in scientific computation. Some tasks related to the proposed project (see section 5.1.1) are

- to use Excel and/or Mathematica to plot and perform least squares fit of the data (numerical values of the moments of the correlation function)
- to collect and maintain database of "standard integrals,"
- to complete parts of the FORM code.

This initiative will provide the students with important experience in "real-world" computations.

Initial phase of the project will involve two sites, each deploying three computers (one Linux server and two dual-boot systems). Initially, these sites will be located at the inner-city Murray Wright High School and International Academy in Metro Detroit (see enclosed letters), connected to the computing cluster of the WSU particle theory group. The resources to purchase these workstations are included in this request. After successful setup more computers will be purchased with non-NSF moneys. The recruitment of teachers into the program is addressed in section 6.1.1.

The outcomes of this project will be evaluated and broadly disseminated. I will compare the number of students who participated in this project and chose science or engineering careers to the number students from comparable schools in the area, including statistics before and after the project is implemented, taking into account already existing trends. Special attention will be paid to the number of minority students who chose science-related careers. In addition, funds are requested for teachers and physics undergraduate student involved with this project to attend APS conferences to present obtained results. I believe it is important for science teachers to participate in APS research conferences to get a feel of the current state of physics research and, in turn, communicate it to their students.

6.1.1 Recruitment and teacher enhancement for HiSchool DiSCo

RET program. WSU runs a succesful REU/RET program in particle and nuclear physics (see section 4.2), which usually involves one-to-three teachers. They are usually matched with the summer research projects at Cornell, Fermilab, and BNL. The HiSchool DiSCo project would allow

us to use WSU as an effective site for RET. My continuing participation in the WSU REU/RET program also provides important contact points with Metro Detroit teachers.

"History of the Universe:" teacher career-development course in Modern Physics. Another important vehicle for recruitment of teachers into the proposed program is career-development courses. It is important for science teachers of Metro Detroit to be acquainted with current developments in physical sciences. A one-credit course in modern physics will serve this purpose with the added benefit of recruitment of teachers into the HiSchool DiSCo project.

I propose a development of a one-credit teacher enhancement course titled "History of the Universe." Indeed, the job of a physicist is in a way similar to that of an archeologist: by doing collider experiments we effectively "go back in time" to figure out how the Universe was formed. The goal is to create a course that shows the "big picture" of modern physics research. This course will be structured as a "time-travel expedition:" by going "back in time" we will discuss many questions addressed by modern researchers such as *How do we know that the Universe is accelerating?* or *Where did all the antimatter go?* We shall discuss major discoveries and their relevance to our understanding of the Universe.

Collaborating with Prof. Maria Ferreira of the Wayne State College of Education, the course will be later developed into the full course in Modern Physics. This course is ideally suited for the application of *Teaching by Inquiry* method (TbIM) [2], as TbIM is designed to develop scientific reasoning skills and to provide practice in relating scientific concepts and models to real world phenomena. *Until now TbIM has not been applied to teaching of Modern Physics.* In the second year of the project, I will develop the appropriate course material. This work will be conducted with the help of a graduate student, either from physics or science education (whose major is physics), to be supported by requested funds. A pilot course will be offered the next year, followed by a revised final version of the course.

7 Broader Impact

The proposed research program will *advance discovery while promoting teaching and learning*, as it allows for effective integration of Wayne State undergraduates as well as local Detroit high school students into research projects. The deployment of the HiSchool DiSCo project will enahance *educational infrastructure* at the University and at Metro Detroit high schools, particularily with respect to research and education of *underrepresented groups*. Placement of several nodes of the DiSCo project in inner city schools is important in this respect, as African-American students represent over 90% of the whole student body. The intent is to increase students' interst in developing a strong background in physical sciences and, for some, motivate them to pursue careers in science and engineering. Results of the proposed reserach will be *broadly disseminated*. In addition to publication in peer-review journals, results will be presented at various conferences, both by the PI and by graduate and undergraduate students and teachers involved in the implementation of the proposed program. As part of the program, *a collaborative effort with Prof. Ken Kiers of Taylor University, an undergraduate college in Indiana* is set up. Cutting-edge research results will also be included in the educational curiculum of the teacher enhancement course "History of the Universe" that uses inquiry approaches and real-world contexts. Finally, the integrated research and educational program will *benefit society as a whole*, primarily through the development of a grass-root computing effort. Massive computational problems arising in many areas of science and engineering could be solved without building large University- or lab-based computer centers.