AC 2008-753: LESSONS LEARNED FROM MINORITY COMPUTATIONAL SCIENCE RESEARCH AND EDUCATION PROJECT

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Lessons Learned from Minority Computational Science Research and Education Project

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Abstract

This paper describes lessons learned from U.S. Department of Energy (DOE) sponsored minority computational science research and education project at Alabama A&M University (AAMU). Project strategies, activities and outcomes were evaluated in the following areas: (1) High Performance Computing Research and training using the high performance computing laboratory at AAMU; (2) DOE Computational Science scholarship program at AAMU; and (3) Minority undergraduate summer research interns at the computational science division of Oak Ridge National Lab (ORNL). The collected data in the past six years were analyzed. Challenges and improvement strategies to get average student involvement in the summer research internship and scholarship programs were presented.

Background

According to the US 1990 census, the total US population was 248,709,873 in 1990. Of these, approximately 51% were women, 29,986,060 (or 12%) were African American, 22,354,059 (or 9%) Hispanic, and 1,878,285 (or 1%) Native American. In 1995, of the total 132 million U.S. civilian labor forces, only 5500 African American who had Ph.D. degree in Science, Mathematics, Engineering and Technology (SMET) were employed in the SMET field. Only 5.6% of the enrollment in SMET of graduate schools were African American, Hispanic American and Native American (AAHANA) students. There is an urgent need to train minority students in SMET field. Historically Black Colleges and Universities (HBCUs) are the primary source of African-American scientists in the US, and HBCU participation in training of students in SMET field is critical.

To respond to this critical need, the Mathematics, Information and Computational Sciences (MICS) division of the U.S. Department of Energy created an Alliance for Computational Science Collaboration in 1997. In 1999, the office of Advanced Scientific Computing at DOE awarded a grant to Alabama A&M University to conduct High performance computational science research and education. In 2005, a continuation grant was awarded. The objective of the project at AAMU was to enhance computational science research and education activities in AAMU. Specifically, collaborative research and education efforts between ORNL and AAMU were created. AAMU also provided computational science training to minority students, and to prepare top minority science and engineering students for computational science graduate study and future employment with DOE.

To achieve these goals, AAMU established a high performance parallel computing lab. Graduate and undergraduate students were trained through participating research and workshops in computational science. AAMU also conducted DOE Computational Science program and summer research internship program[1,2] at ORNL.

The following sections discuss lessons learned from this DOE project.

Establishment and Enhancement of High Performance Parallel Computing Laboratory

Under the sponsorship of DOE, AAMU School of Engineering and Technology established a high performance computing (HPC) lab using a cluster of LINUX workstations. The laboratory has eight workstations. Two workstations have advanced duo-processor. These workstations were networked through a 10/100 Base-T Ethernet system. Parallel computation was performed using MPI or PVM. In the past six years, research activities have been centered on the micro-scale fluid dynamics and multi-scale plasma dynamics. Many research presentations were given to visitors and potential collaborators. The HPC Laboratory is available to project participants and researchers, faculty and students at Alabama A&M University. Students from Mechanical Engineering, Electrical Engineering, Civil Engineering, Chemistry, and the Computer Science Departments, were encouraged to use the LINUX cluster for parallel computing. The HPC lab was proved to be a showcase of the university for government and industry visitors and researchers.

It is important to know that research in computational science requires intensive training in mathematics, science and engineering as well as programming. Prior to January 2008, the School of Engineering and Technology at AAMU does not have graduate engineering programs. It is a challenge for us to introduce high performance computing into undergraduate engineering curriculum. In the past six years, high Performance Computing concept was introduced in undergraduate curriculum through two classes: Mathematical Methods in Mechanical Engineering, and Heat Transfer. In the math methods class, numerical algorithms were introduced. In heat transfer class, students are required to develop a computer program to model two-dimensional heat conduction. Parallel computing concepts were introduced. As a result of this teaching effort, the summer interns of 2002 and 2003 at ORNL were able to extend the heat transfer computing project to conduct parallel computation for three-dimensional heat conduction.

In order to maintain the operation of the high performance computing laboratory, we recruit three top computer science graduate students and five engineering undergraduate students as research assistants. Notice that most graduate students in computer science did not have the background in parallel computing. Construction of the parallel network using PVM or MPI is a challenge. In addition to the program challenge, only a few students were exposed to LINUX operating system and programming environment. Intensive training of parallel computing and LINUX operating system were provided required to the graduate and undergraduate research assistants.

Most of scientific and engineering computing codes were written in FORTRAN language. However, FORTRAN was not taught or used in most of the computer science curriculum. In order to prepare students in the area of computational science, we introduced FORTRAN programming to all students in mechanical engineering and train students using FORTRAN to solve engineering application problems. It is our opinion that FORTRAN should be taught or introduced in the undergraduate engineering curriculum.

DOE Computational Science Scholarship

The DOE Computational science scholarship program was created in 2000. Over the years more than 70 scholarships were awarded to top science, engineering and mathematics students at AAMU. This scholarship program was proved to be a huge success in attracting top minority science and engineering students working in the area of computational science. It also enhanced engineering education to minority students. Figure 1 shows the overall averaged GPA distribution of the scholarship recipients between 2001 and 2007. In the past seven years, 12% of scholarship recipients have GPA in the range of 3.0-3.2. 12% of the recipients have GPA in the range of 3.2-3.4. 34% of the recipients have GPA in the range of 3.8-4.0. Figure 2 shows the GPA history of scholarship recipients in academic years of 2000-2001, 2003-2004, 2005-2006 and 2006-2007. In academic year of 200-2001, 50% of the recipients have GPA between 3.0-3.2. As the program developed, more and more students with higher GPAs applied for the scholarship. Recipients with GPA 3.0-3.2 decreases to zero in 2005-2007 academic years. In the same time, recipients with GPA of 3.8-4.0 increased from 12.5% in 200-2001 academic year to 57.1% in 2006-2007 academic years.

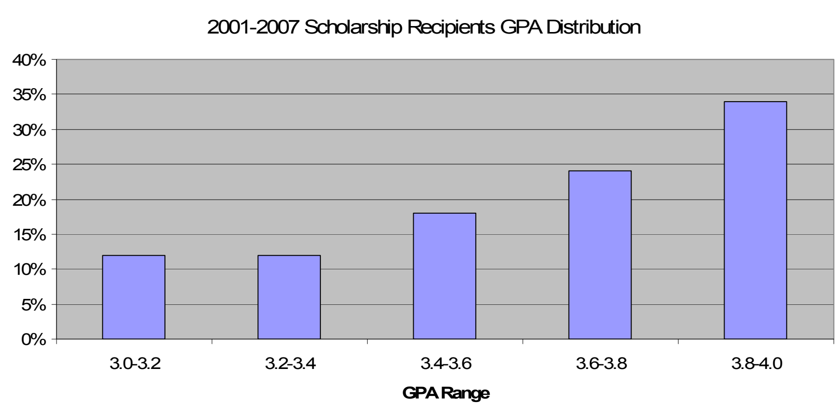

Figure 1. Computational Science Scholarship Recipients averaged GPA Distribution in 2001-2007 based on GPA of 50 recipients.

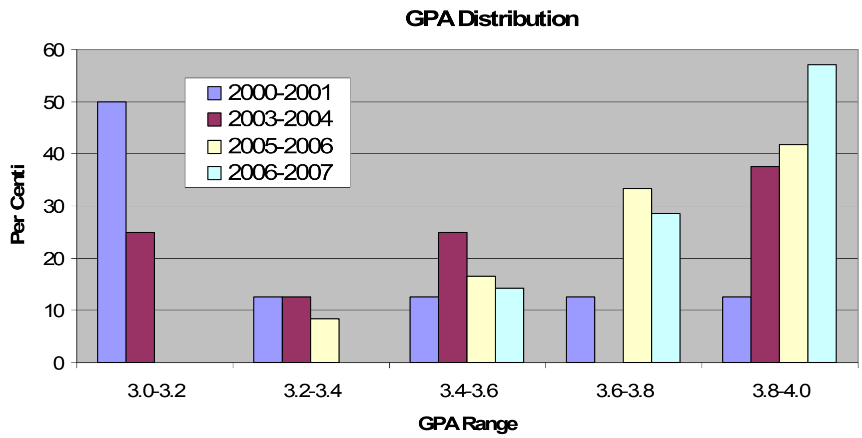

Figure 2. Actual GPA history in academic year of 200-2001, 2003-2004, 2005-2006 and 2006-2007.

Due to the strong competition, the minimum GPA required for receiving scholarship was increased from 3.0 to 3.25 in 2006. To apply for the scholarship, students need to fill out the application form, write an essay about their goal towards high performance computing, along with a faculty recommendation letter. Upon receipt of the scholarship, students agree to maintain a GPA of 3.25, successfully complete a minimum of 12 credit hours per semester, and maintain a major in science, mathematics or engineering. Recipients are also required to work on assigned computational science project with faculty advisors. Recipients are required to accept employment with the DOE and work for DOE for at least a year if a job is offered.

It is noticed that students with high GPA's have high potential to receive other academic scholarships, especially in AAMU where many high-tech research companies are located nearby. It is common that students may receive scholarships that exceeded the scholarship limits. This posted a challenge to us: how to attract "average" African American students with low GPA's to the field of computational science? What is the necessary modification to our scholarship criteria that we have to make to achieve this? One ultimate question we have to ask: do science and engineering students with high GPA's perform better in computational science?

In order to attract more averaged science and engineering students to computational science, we emphasized on faculty recommendations for students with lower GPA's. Faculty evaluated applicant's academic strength, student's interest on computational science and student's programming capability. Faculty recommendation also assesses potential success of the students in the academic field. If a student demonstrated a great potential and interest in computational science, but currently suffered by low GPA, we recommend that the student apply for the summer research internship program offered through this DOE project.

In the past six years, it was proven that the computational science scholarship program created a huge attraction to top minority engineering students. It is a good recruiting and retention tool and greatly enhanced engineering education to minority students.

Student Summer Internship at ORNL

AAMU has been collaborating with the computational science division of ORNL since 2000 to conduct undergraduate research summer internship program. ORNL Computational Science summer internship programs (RAMS) announcement was posted around AAMU campus in early February of each year in the department of physics, mathematics, chemistry, biology, mechanical engineering, electrical engineering, civil engineering and computer science. Applications were peer reviewed by AAMU faculty and ORNL mentors. Summer Interns were selected to participate 10 weeks of research and study at ORNL. Through the DOE project, AAMU was able to support ten students to participate the summer research at ORNL. In summer 2005, one student published a research paper with ORNL scientists entitled, "Discovery of New Global Minima for Lennard – Jones Atomic Clusters Using TRUST Simulations". Student performance was closely monitored by joint effort of AAMU faculty mentor and ORNL project director and mentor. At the end of their summer interns, outcome of the research was evaluated by written report and oral presentation, which was judged by ORNL scientists and faculty mentors from HBCUs in Tennessee, Alabama, North Carolina and Georgia. Summer interns from AAMU were also required to present their research results at the workshop on AAMU campus.

RAMS summer intern research program provided excellent training to minority science and engineering students in the area of computational science. In addition to their research project, students attended series of seminars in leading edge computational science research. It opened student's eye in the fascinating world of scientific computing. Many interns expressed their willingness to return to ORNL and work in the area of computational science. The RAMS program created significant impact to AAMU computational science education. When RAMS interns return to school in the Fall semester, they bring their research papers and posters back to school. Interns were provided a chance to present their research project and experience at ORNL to fellow science and engineering students. Most importantly, they promote computational science and bring positive influence to fellow students in science and engineering. This dynamics keeps going on and on.

Assessment

The high-performance computing research and education activities were externally evaluated annually by a panel formed by DOE Computational Science Division. The project outcome was evaluated by DOE, and continuous funding depends on results of program evaluation. The key factors determining success of the program is to attract and educate top minority graduate and undergraduate students in the field related to computational science. Each scholarship recipient's academic performance is evaluated annually by faculty members. Graduate and undergraduate research assistant's performance was evaluated based primarily on required research tasks. Summer internship performance was assessed by DOE Scientist and HBCU faculty mentor.

Conclusion

It was proven that the computational science research and education at AAMU was improved significantly through the support of DOE project. This DOE project created a huge attraction to top minority science and engineering students and greatly enhanced science and engineering education to minority students. Our experience indicated that the high performance computing laboratory provided a local platform for computational science application. To better train minority students in computational science, LINUX environment and FORTRAN programming should be taught. DOE Computational Science scholarship program and RAMS summer research internship program play important roles in recruiting top minority students to prepare themselves in the area of computational science. More attention should be given to averaged GPA students who have strong interest working in computational science.

Bibliography

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