INTRODUCTION:

Research constitutes an intrinsic part of the intellectual activity of any faculty. Many times, however, heavy teaching loads and lack of incentives (such as institutional support and time releases) negatively affect the faculty’s research work. Often, the knowledge level required in the research also limits the involvement of undergraduate students. Nevertheless, computer science faculty find innovative ways to attract the students and to extract benefits.

This panel presents considerations on how faculty from four different institutions view the challenges and the rewards of involving undergraduate students in research programs. Time constraints are solved by allotting the intermission periods for intense research, by setting regular weekly time aside throughout the semesters or by including small projects within the courses that are taught. Good management skills are recommended with clear research plans and objectives and constant interaction with the students. Through the research process, both the faculty and the students are set to gain. The faculty’s research agenda is advanced and the student is exposed to new topics and
has the chance to participate in an independent innovative process. The panelists’ varied backgrounds and experiences provide a wide array of opinions on the role of undergraduate research in computer science. They illustrate their views through an array of diverse undergraduate research initiatives that is diverse and are of interest to a large audience of computer science faculty.

**Stefan A. Robila**

Research should constitute an active component of the academic life. However, this component is often in competition for time and resources with teaching and service activities. In this context, institutional research incentives such as reduced teaching loads (such as Faculty Scholarship Incentive Program) and small research grants (such as Faculty – Student research grants) provide a support system for the faculty’s active research program, at the same time, increasing the requirements on the productivity. I find undergraduate research to be a challenging endeavor since many of the topics related to my main work require long commitment and often knowledge beyond regular computer science curriculum. However, I believe that a bi-directional approach to undergraduate research usually yields positive results. In the first one, simplified parts of a large project can be extracted to accommodate individual student research. Code implementations and practical experiments could constitute the core of such projects. In the second approach, the projects answer to the student’s interests expressed in the courses. In this case, the research becomes intrinsic part of the class experience. Through this, the faculty’s research is also extended in new directions.

Currently, I have two directions of work involving undergraduate students. The first relates to my research in multispectral/hyperspectral imagery. This is a continuation of the work first undertaken in my graduate studies. Given the complexity of the subject I tried to attract students by presenting them the wide area of applications available as a result of the research. With funds from an internal faculty-research grant I have engaged a student to write new image processing routines that allow real time processing of multispectral data. The work has allowed the student to get a better understanding of the graphics programming and also obtain basic knowledge in remote sensing. The second direction stems from the various courses I have taught. Of particular interest to me was computer and data security, a newly developed course presented as special topics in my department. I have included as part of the class objectives the development of an individual research project. This has resulted in a variety of topics that were investigated by the students. Some of them have expressed interest to work beyond the class and continue through independent studies.

**Amruth N. Kumar**

A heavy teaching load leaves little time for research. During the semester, between teaching, grading, advising and committees, I find that little time remains at the end of the day for research. Summer turns out to provide the only uninterrupted time I can dedicate to research. One solution to this problem is to involve undergraduate students in research. The work done by the students helps advance research. More importantly, the commitment to advise undergraduate student researchers forces a regimen for research
during the semester, and helps me set aside time every week for work that would otherwise go unattended. This is on top of all the advantages that accrue to the students who participate in the research.

Some lessons that I have learned from engaging undergraduate students in my research are: 1) The student must have the right mix of bright and motivated – just one or the other will not suffice. 2) Approaching select students may be better than waiting for students to approach you; 3) Some students need structure - weekly meetings, presentations etc. Others need flexibility - of schedule, reporting etc. It is important to identify the needs of each student. 4) It is helpful to draw up a contract at the start and use it to measure progress and determine completion. A list of deliverables may also be included if appropriate. 5) Free-ranging students usually produce free-standing work that cannot be reused or integrated. If reuse is important, it is necessary to vet everything, and leave nothing to chance. 6) Let peer pressure work for you - hold group meetings if possible. 7) Almost everything about a professional conference is a learning experience for undergraduate students, and surprisingly many things do catch their fancy! So, it is a good idea to encourage students to publish. 8) Writing up the results will require at least three revise-rewrite cycles – it is necessary to impress this upon the students. 9) Successful student research projects can be an attractive tool for recruiting additional students. 10) There is many a slip between the cup and the lip.

Doug Baldwin

Research is the discovery or development of new knowledge. The usual place in higher education to develop research skills is at the doctoral level. However, either or both of two conditions can make research experience available to undergraduates: the student is attempting small increments in human knowledge (e.g., applying previously known ideas in slightly new contexts), or is working mainly as an assistant to an experienced researcher (e.g., a faculty member or graduate student). These conditions are often easy to achieve in computer science and related fields, where there is still considerable "low-hanging fruit" among the research problems, and students with a few years of study can attain a level of knowledge that can contribute to solving those problems. Research is an extremely valuable experience for those undergraduates who do it: it instills in the students some of their research mentors' excitement for their field; it gives students practice solving authentic and challenging problems, whose solutions, by definition, cannot simply be looked up; the end-to-end research experience provides not only opportunities for challenging problem-solving, but also opportunities to learn to read professional literature, and to present results to others. All of these experiences lead to considerable intellectual growth in students, often giving them new visions of their professional future.

My own research is in computer graphics and scientific visualization. For four years I have worked with members of Geneseo's physics department on a project whose computer science research component is in software architecture and algorithms for highly customizable, interactive, visualization. Undergraduate researchers have been essential members of this project since its inception. Most operate as assistants to me. For example, I designed the basic architecture of our visualization program, which students then implemented. Even as assistants, however, I give students considerable flexibility
to work on problems they find intriguing, and I encourage students to identify and pursue problems in, or improvements to, my ideas. Occasionally, the students have developed independent, if small scale, research of their own. For example, one of my recent assistants invented, and implemented in prototype form, a set of variations on an approach to rendering constructive solid geometry found in the literature.

Clare Bates Congdon

For those of us who teach at exclusively or primarily undergraduate institutions, conducting research with undergraduates can enhance our own research programs in meaningful ways while also providing undergraduates with valuable learning experiences. Through mentoring undergraduate research projects, I've been able to explore and maintain a broader range of research activities than I would have been able to support on my own. Thus, I feel that working with undergraduates on research is a mutually beneficial undertaking. Part of me is frustrated that there is little institutional support for mentoring undergraduates in research projects (there is no teaching credit for supervising independent study projects at Colby), but I am rewarded by the work conducted with students. In considering new projects, I've developed a rule of thumb: The work must be something that could possibly lead to publication. Far from meaning that every project I take on with undergrads gets to this point, this is merely my own rubric for determining whether I want to take on a particular student or project.

My own work with undergraduates has spanned several different sorts of projects. First, my primary research project is currently in bioinformatics. The work I've done with students in this area has primarily been supported by summer research assistantships, where students are in effect hired by me to work on my project. Secondly, I have supervised several students in thesis work on projects concerning small robotics. I worked with robotics in graduate school, but simply would not have the time or energy to pursue this path now were it not for student interest. This pattern of current student interest connecting with past work and interests of my own also extends to projects in complex adaptive systems and in interactive art. Finally, my Machine Learning class and Bioinformatics class have as one of their goals to teach undergraduates how to conduct research; through the projects begun in these courses, there is a huge variety of additional projects I have been able to explore with students.

BIOGRAPHIES:

Stefan Robila, is an Assistant Professor in Computer Science and the director of the newly formed Center for Imaging and Optics at Montclair State University. His interests lie within pattern recognition with applications in computer security (steganography) and image processing (in particular multispectral and hyperspectral imagery).

Amruth Kumar is Professor of Computer Science at Ramapo College of New Jersey. His research interests include Intelligent Tutoring Systems and Computer Science education research. He is on the eastern and northeastern boards of the Consortium for Computing Sciences in Colleges.
Doug Baldwin is associate professor of computer science at the State University of New York at Geneseo. His research interests include computer graphics and scientific visualization, computer science education, and programming languages and methods. He also serves as a member of Geneseo's 'research council,' which, among other things, provides internal funds for undergraduate research projects.

Clare Bates Congdon is an Assistant Professor of Computer Science at Colby College. Her research interests focus on bioinformatics (with funding through an NIH INBRE grant), genetic algorithms, and machine learning.

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