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REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PREPROPOSAL NO., IF APPLICABLE
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PI/PD DEPARTMENT Department of Mathematics & Computer Sci	PI/PD POSTAL ADDRESS Grinnell College Grinnell, IA 501121690 United States
PI/PD FAX NUMBER 641-269-4285	

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CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

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CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 02-2. Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of Grant Policy Manual Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

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(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.

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A Project Summary

Not only are there few women computer science majors, but also the number and percent of women computer science majors has been decreasing rather than increasing. The lack of participation negatively affects women (who have fewer job opportunities), the nation (which lacks technologists), and the discipline (which lacks important perspectives). This project demonstrates a model for computer science education that attracts more women to the discipline. Rather than emphasizing classroom experiences, which are the traditional mechanism for increasing the participation of women in science, it emphasizes a reward and mentoring system that is separated from the classroom.

In this multi-institutional demonstration project, based on a successful early research program in Physics at Grinnell and summer research programs in the sciences at a variety of institutions, Computer Science faculty at four liberal arts colleges (Grinnell College, Hope College, Macalester College, and the College at the University of Chicago) will mentor and support first-year women college students in significant collaborative research experiences. We call such projects MERiCS: Mentored Early Research in Computer Sciences. The faculty will recruit the women into and from introductory computer science courses, which a wide variety of students take at these institutions.

The project's primary thesis is that women who learn more about computer science through significant out-of-class research experiences will have more confidence in themselves and be more likely to take further courses in CS and to select it is a major. That is, by intervening early and significantly in students' careers, they receive the information and encouragement to continue in computer science. The project also hopes to show that these women's success will affect other students' perceptions of the roles of women in computer science. We call these the primary "merits" of MERiCS.

The MERiCS project builds upon a variety of successful projects. Its starting point is Grinnell's successful early research program in Physics. That program has made such a difference that half of Grinnell's Physics majors are women (ten to fifteen students graduate with a Physics degree each year; Grinnell graduates about 300 students each year across all disciplines). However, that project has not yet been replicated at other institutions or in other disciplines. Hence, this project provides one step in generalizing and expanding that result. The project also draws upon a number of successful projects in disciplines outside of CS or at more advanced levels, including Grinnell College's New Science Project, Dartmouth College's Women in Science Project, and the Computing Research Association's Collaborative Research Experiences for Undergraduate Women Initiative. However, those projects rarely target first-year students or computer science.

The project takes advantage of resources at the collaborating institutions, including NSF AIRE projects at Grinnell and Hope, an NSF REU program at Hope, an NSF CCLI project at Macalester, a multi-institution project (including both Hope and Grinnell) to examine the effects of summer research experiences, and a growing early research in computer science program at Grinnell.

The project involves two primary forms of evaluation: (1) an analysis on the effects of these experiences on women's decisions to major (or not to major) in computer science and (2) a study of the effects of these experiences on students' perception of the discipline and the roles of women in the discipline. While some aspects of the study are quantitative (e.g., we can measure the number of women students who go on), we will also rely on ethnographic studies of the students. The project is designed to include a variety of experiences: replicating the early research experiences at different institutions makes it possible to determine whether the early collaborative research experiences can work in a variety of settings (e.g., with different styles of introductory courses, different types of supervisors, and different levels of experience supervising summer research). Limiting the institutions to liberal arts colleges makes it possible to obtain comparative data from non-participating institutions to validate hypotheses on the effects of the early research experiences.

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For font size and page formatting specifications, see GPG section II.C.

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C Project Description

C.1 Results from Prior Support

Professor Rebelsky was PI on NSF grant DUE #98-50546, Extending Introductory Computer Science with Algorithmic Multimedia ($33,600), funded under the Instrumentation and Laboratory Improvement Program. The grant provided equipment (six computers, two video cameras, and some display equipment) to support innovation in the teaching of introductory computer science. To motivate students better, the introductory courses now emphasize the algorithms that underlie many multimedia applications. While such examples bear many similarities to traditional introductory algorithms (e.g., a simple form of blurring can be phrased in terms of averaging pixel values), the presentation of these algorithms in a new domain adds excitement and interest. Students who study these algorithms may also move on to studying other techniques for achieving similar. This emphasis on algorithmic multimedia also supports learning of traditional introductory topics, such as iteration, arrays, and lists.

The use of multimedia may also encourage students to study the research literature, to improve their understanding of mathematics, and to engage more fully in the experimental aspect of computer science. We draw many examples from the research literature so that students understand both the importance and the accessibility of that literature. Many multimedia algorithms require substantial, although not overly complicated, mathematical manipulation; students will come to find that they both can and must bring some mathematical sophistication to bear on their work. The project also allows students to engage more fully in experimental aspects of computer science. For example, as they consider the effects of different parameters, such as weighting factors, on the performance of these algorithms, they will engage more fully in experimental aspects of computer science.

The project ran from summer 1998 to spring 2001. An upper-level undergraduate seminar in which students developed libraries and exercises to support the project was well received. The PI's presentation in April 1999 to the Iowa Undergraduate Computer Science Consortium generated significant interest. In Spring 2001, Rebelsky developed a number of Scheme-based graphics exercises using the GNU Image Manipulation Program. As an offshoot of this project, the PIs have introduced a significant multi-team project experience into the CS2 course. In these experiences, students work in teams to build parts of a larger project (Flynt and Rebelsky 2000). In past semesters, students have built a distributed auction system, an IMAP email client, and an online Scheme testing system for the CS1 course. Other products derived from the project include a Web site devoted to programming the GNU Image Manipulation Program (GIMP) that is designed for functional programmers and avoids the use of "unclean" operations, like set!, that populate the traditional GIMP documentation.

C.2 Background

C.2.a A Problem: Decreasing Participation of Women in Computer Science

This project addresses a significant problem: the atrociously small numbers of women graduating with undergraduate degrees in computer science. While almost all SMET disciplines have problems attracting and retaining women students, the problem is particularly acute in computer science: Most SMET disciplines have seen increased participation by women over the past decades, the number and percent of women participating in computer science has decreased (Camp 1997). Why is this decreased participation problematic? First, computer science careers provide comparatively high salaries. Low participation by women keeps them from these attractive careers. As Makedon (1995) notes,

> Information is a commodity, and information is exchanged via computer literacy, being able to master it, [...] catalogue it, and process it. [...] If you're out of the scheme of things, out of the computer science way of things, [...] then you are not as employable. You're not going to be as competitive.

Decreased participation by women also affects the nation. Many articles and reports, such as (Freeman and Aspray 1999), have documented America's lack of technologically skilled workers. Hence, computer science needs to attract more students of both genders. Since women are beginning to outnumber men in college (particularly at small liberal-arts colleges), departments need to be particularly careful to attract and retain women. The discipline also suffers when different perspectives are not available. Other scientific fields that successfully increased the participation of women have found that different genders bring different perspectives to similar problems. For example, in biology, women researchers helped demonstrate that isolation had more of an effect on health in spider monkeys than did many of the medical interventions being tested. Similarly, women researchers significantly changed the understanding of the relationship of sperm and egg from one in which eggs are primarily passive. Many other examples are documented in (Schiebinger 1999) and (Rosser 1997). Rosser calls such expansion of the field to include different perspectives and approaches "Stage 5" in the transformation of science.

Finally, the lack of women in computing can have a detrimental effect on the future of the global society. The next decade will involve the design and crafting of technology and policies for the global computing and communications infrastructure. This infrastructure will have a profound impact on the structure of future society, and hence needs input from many voices.

Many reasons have been given for the limited participation of women in computer science, including a perception of computing as a solitary activity, concern over the time commitments required by the computing profession, a view of computer science as primarily involving programming, negative reinforcement from teachers in early computing, and unpleasant experiences in typical computing activities (Seymour and Hewitt 1997, reporting on all sciences) (Makedon 1995, reporting on computer science) (O'Leary 1999, reporting on computer science) (AAUW 2000, reporting more generally on technology). As one of our women students said, "I really like computer games; but after a while, all the women in chain-mail bikinis are really offensive". While biased teachers and sexist games need to be addressed, it is equally important to help students overcome misconceptions. Section C.3.b addresses many of these misconceptions and suggests how the proposed project may help students overcome them.

C.2.b Some Hope: Successful Projects

Fortunately, there have been a number of successful projects. For example, the Computing Research Association's Collaborative Research Experiences for Undergraduate Women (CREW) program (Castaneda 1999) encourages women to continue in computing by funding group research experiences for juniors and seniors. The project has had great success in encouraging women to go on to graduate school. Similarly, the faculty members from the Hope REU program have found that summer research experiences are more likely to influence women to go on to graduate school. In particular, there is a significantly higher rate of graduate school attendance among female participants than among male participants over the past nine years.

Many multi-disciplinary projects have also shown some success. For example, the Dartmouth Women in Science Project (WISP) provides first-year women with research experiences. That program has had a significantly positive effect on women's decisions to stay in the sciences (Muller and Pavone 1997). However, it seems to have had less success in computer science: Only 12% of Dartmouth CS majors are women (Knapp 2001). At Grinnell, the New Science Project (NSP) provides an infrastructure for traditionally underserved students (women, minorities, and first-generation college students) to succeed in the natural sciences (Schneider et al. 1994) (Swartz et al. 1998). The program includes a pre-orientation session to acclimate students to college culture and to introduce them to science faculty; an active peer-mentoring program; and a number of community-building activities. The New Science Project has had particular success in Physics. Grinnell's Physics department now graduates ten to fifteen students each year (out of a Grinnell's graduating class of slightly more than 300 students), half of which are women. These numbers are high, both for Physics graduates at a small institution and for percentage of women majoring in Physics. Many factors contribute to the success of this program, including not just the core NSP activities, but also a workshop-style introductory sequence and an early, significant research experience available during the summer after a students' first year (Schneider 2001).

The successes of these experiences suggest that approaches to the recruitment and retention of women must be more than just curricular. Because these extracurricular experiences have been particularly successful, disciplines should consider ways to regularize such experiences. These experiences also echo Tobias's (1990) recommendations that attempts to broaden science education should involve recruitment, rewards, and opportunity structures. We propose a project involving mentored early research experiences in computer science (MERiCS), focusing on summer research projects. Our MERiCS project includes a significant recruitment component, provides students with many opportunities, and rewards them through the opportunity and the associated stipend

C.3 *The Proposed Project: Early Research Experiences*

In this multi-institutional *demonstration* project, the collaborating faculty plan to develop early significant research experiences and show their efficacy in building communities, leading women to choose to pursue further study or a major in computer science, and changing perceptions about the roles of women in computer science. The MERiCS project extends previous work to consider a different community at a different stage. The project also draws upon resources and experiences at a variety of institutions, which are described further in Section C.3.c. The early research experiences will take the form of group research projects held during the summer, with both student and faculty mentors.

C.3.a The Need for Further Study

Although there have been many successful projects on the impact of research experiences on undergraduates (e.g., the projects discussed in Section C.2.b), there is a significant need for careful study of the impact of early research experiences for women in computer science for three key reasons: (1) most projects emphasize the natural and physical sciences, and, as many have noted, computer science is substantially different than the other sciences; (2) most projects study students later in their undergraduate careers, rather than early in their careers; and (3) most projects consider research experiences as a tool for retaining students in the sciences, rather than recruiting students to the a discipline.

Computer Science is not a Natural or Physical Science

While there have been a number of studies of the effects of undergraduate research, most of these studies focus on the natural and physical sciences and therefore exclude computer science. In part, this exclusion is because computer science is in the awkward position of being often grouped with either mathematics (e.g., the Council for Undergraduate Research treats them as a unit) or with engineering. In fact, research in computer science is substantially different from research in the natural and physical sciences. Because computers are man-made objects, it is rarely appropriate to use the scientific method to explore issues in computing.

For the purpose of this project, there is an even more important difference: Although most introductory courses in the natural and physical sciences provide grounding in the techniques and methods of research in those sciences (e.g., the elements of the scientific method; laboratory techniques), most introductory computer science courses emphasize programming and thereby ignore many of the key issues of research in computer science.

Early Research Experiences vs. Mid- or Late-Career Experiences

While there are some important projects and studies that involve early research experiences (e.g., the WISP program at Dartmouth (Muller and Pavone 1997) and the UROP Program at the University of Michigan (Nagda et al. 1998)), the primary focus of most studies of the impacts of undergraduate research involve students at the middle or later stages of their undergraduate careers. For example, in a broad study of the National Science Foundation's Research Experience for Undergraduates (REU) program, only 4% of the participants were first-year students (Fitzsimmons et al. 1990, Table 4.11, p. 98). While there is value in first-year research experiences, most substantial (e.g., summer-long) research experiences seem to be left to later in students' careers.

Because of the mismatch between the introductory courses and the research process in computer science mentioned above, substantial first-year research experiences in computer science seem particularly rare. The most prominent research experiences for undergraduate women—CRA's Distributed Mentor Project (Alexander et al. 1996) (Alexander et al. 1997) and CRA's Collaborative

Research Experiences for Undergraduate Women (Castenada 1999)—do not permit students to participate in their first year, and primarily take students in their junior and senior years. However, if we are to make an impact on student's choice of disciplines, we much catch them early in their careers. Lopatto (1999) suggests that experiences after the first year are unlikely to have an effect on students' choice of major.

It is not easy to design substantial research experiences for first-year students, in part because of the mismatch between the first-year course and research techniques mentioned above. The expectations for first-year students seem to be different than for students later in their undergraduate careers. Consider the two large first-year research programs, WISP and UROP, which focus on academic-year research projects. In the early years of the WISP program, many students working in computer science ended up doing little more than building Web pages, which may be why the program was less successful in computer science than in other disciplines, with only 12% women majors by 2001 (Knapp 2001). Similarly, UROP students seem to focus on support tasks for research, In neither case does there seem to be an expectation that students will present their work, as there is in many of the mid- or late-career substantial research experiences.

Does this mean that first-year students cannot undertake significant research in computer science? Certainly not! As we hope to demonstrate in this project, all that is required is an appropriate choice of research projects and an appropriate support network. In fact, computer science is particularly amenable to early research experiences. While first-year students may not have the programming skills necessary for large programming projects, many other kinds of activities are available. For example, students quickly learn to gather and analyze data on large systems (e.g., networks) with much less background than is necessary in bench-top sciences. Many projects can involve aspects of user-centered design in which students can design and conduct interviews. Perhaps most importantly, even first-year students can design and test algorithms and heuristics. Section C.4 describes a variety of possible experiences.

A Tool for Recruitment

Finally, we choose a different focus than many studies. Typical studies of the effects of undergraduate research treat research as a tool for retaining students, either as students within the institution (Nagda et al. 1998), within their undergraduate majors or the sciences (Margolis et al. 2000) or within the sciences by encouraging them to go on to graduate school (Fitzsimmons et al. 1990). Although we consider all three types of retention to be quite important, we emphasize MERiCS as a tool for *recruiting* women to the discipline. This ability to recruit students is an attribute of our type of institutions, in which students enter college with both a preference for certain fields but also a willingness to experiment with others. Most do not declare a major until their second year. Given that women typically have less experience with computing prior to college (Margolis et al. 2000), we consider the ability to recruit women to computer science a particularly important part of this project. The designs of our curricula are such that a student can major in computer science even if she does not take her first computer science course until the second semester of her first year, or even the first semester of her second year.

C.3.b Components of the Project

The focus of this project is early intensive research experiences for women in computer science as a mechanism for recruitment of women and changing perceptions about women in computer science. However, these experiences are supported by and support a number of ancillary activities. Table 1 summarizes the various activities, which are described further in the following paragraphs.

At the core of the program are substantial research experiences for first-year women. Students will work with faculty on real projects related to the expertise of the faculty. In some cases, the students will work in teams. In others, they will work individually. Section C.4 provides a list of potential projects. In addition to the first-year students and the supervising faculty, we will include some upper-division students to act as mentors for the first-year students. After the first year of the program, these student mentors will be students returning from previous summers. The values of near-peer mentoring for both the mentor and the mentees have been well documented (e.g., Heller and Martin 1997) and should strengthen the experiences for the first-year students. Table 2 documents the number of summer research participants at each institution.

Component	Time Period	Participants	Affects
First-Year Research Experiences (MERiCS)	Summer	First-Year Women (Rising Sophomores) (15 per year)	First-Year Students
Returning Mentors	Summer	Upper-Division Women (6 per year)	Mentors First-Year Students
Summer Faculty Meeting	Early Summer	Faculty	Design of program
Participant Research Conference	Late Summer	Summer students; Faculty	
Conference Travel	Varies	Summer students with faculty chaperones	Participating students; Conference attendees
Teaching Assistants	Academic Year	Prior Summer Students	Class Members (300/year)
Women in CS Lunches	Academic Year; Weekly	Current and potential majors	Current and potential majors
Web Site	Continuous	Women in CS Collaborating Faculty	Women in CS Mentors
Assessment (Interviews, Analysis, etc.)	Continuous	External Evaluator Peer Ethnographers (2)	Many groups

Table 1: Primary Components of the Project

College	Groups	First-Year Students	Student Mentors	Faculty
Grinnell	2	4	2	1
Hope	1	3	1	1
Macalester	2	5	2	2
U. Chicago	1	3	1	1
Total	*6*	*15*	*6*	*5*

Table 2: MERiCS Summer Research Participants Per Year

We expect to give students a number of opportunities to present their research. During the summer, they will regularly present their work to their research team. At the end of the summer, the students and faculty from the collaborating institutions will meet for a public research fair in which they will present their work and discuss the experiences. When possible, they will also present their work at institutional events (e.g., science poster sessions or departmental seminars) and at regional meetings (e.g., the Pew Midstates Science and Mathematics Consortium's Annual Undergraduate Research Symposium). We will also encourage students to submit their work to national and international conferences. Many of the participating faculty have had great success in having student work accepted. Presenting work at these many types of venues gives students experience writing and speaking about their work. More importantly, it helps the students build confidence. As Seymour (2002) notes,

> The most frequently reported benefit of summer research was increased self-confidence, particularly in the ability to do science. All the programs we studied required students to present their work and students noted that these presentations were highlights of their research experiences. They needed to work hard preparing for a presentation, giving the presentation, and answering questions. By presenting their work and answering questions about it, students learned that they knew a great deal about their topic, often more than those they were presenting to.

These presentations can also provide a mechanism to help change perspectives about the ability of women and of undergraduates to do research. For example, at a recent conference program committee meeting Rebelsky attended, one of the steering committee members requested that the submission form be updated so that it was clear that "student" meant "student in graduate school", since in many countries, "student" means "undergraduate". A colleague quickly pointed out that the form must still include undergraduates as undergraduates can do successful research in computer science. The colleague then supported the claim by noting that a paper by undergraduates (Heck et al. 2000) had recently won an outstanding paper award.

Both the summer experiences and the presentations target a key issue in the retention of women in computer science: *confidence*. As Margolis et al. (2000) note "issues of women's confidence have been shown to have a significant impact on women's interest in majoring in computer science". As discussed above, presentations give students great confidence in their abilities to work in a discipline. In addition, the mentoring relationships that are a core part of these summer research experiences have been shown to have a positive impact on women students' confidence (Seymour and Hewitt 1997).

We plan to affect more students than just the 28 per year that do summer research. In particular, we hope that these students will show other women that it is both possible and worthwhile to study computer science. We also expect that these students will show men that women can "do" computer science. Male student and faculty perceptions of women as being less capable in CS are key stumbling blocks to women in CS (Margolis et al.2000) (O'Leary 1999). Presentations in colloquia and poster sessions will have some effect. However, we plan to further broaden the effect by having the summer students serve as teaching assistants, tutors, or lab assistants in our introductory computer science courses.[1] Undergraduate teaching assistants are not only an excellent resource for helping students learn, they also serve as role models for potential majors (Roberts 1995). As "near peers" their role is particularly valuable for both recruitment and retention (Heller and Martin 1997) (Martin and Heller 1994a, 1994b).

Schneider (2001) tells us that his students build community in their classes, in their group research experiences, and in regular lunchtime meetings. These weekly lunchtime meetings give the women a real sense of being a community, and seem core to Schneider's success. Hence, each institution will hold weekly "Women in Computer Science" lunches. While such lunches are clearly a simple activity to undertake, they provide many tangible benefits. Women in science groups help women students form a support network since not all students necessarily know each other, even at small institutions like ours. Students who are "out of synch" (e.g., who have started in different semesters or different years) in the curriculum may not have met, as Rebelsky discovered when creating a Women in Computer Science lunch group at Grinnell. The lunches also provide an opportunity for new students to explore the discipline and to receive mentoring without committing to the major. Such meetings can attract other supporters from outside the discipline. At Grinnell, the director of student advising asked to join the CS group because she had done a concentration in computing as an undergraduate. Finally, these meetings help form the student-faculty bonds necessary to initiate and continue the mentoring that the early research experiences both rely and build upon. They help faculty meet students early in their careers. Lunches also help students realize that summer research is an interesting option.

We will also work with the students to build and maintain a Web site that provides a number of resources for women in computer science and those that mentor them.

The assessment of the project, described further in Section C.5, provides the final component of the project. The project relies on an outside evaluator, Kathy Garvin-Doxas of the University of Colorado, along with two *student ethnographers*. We expect that the assessment of the project will provide supporting information for others who want to improve the environment for women in computer science.

C.3.c Recruitment

A key aspect of this program is the recruitment of students into the introductory courses (to give them the first "taste" of computer science) and from the introductory courses into the summer research experiences. Each kind of recruitment will require different techniques.

Recruiting First-Year Women to Introductory Computer Science Courses

During preregistration periods, the collaborating faculty (that is, the PI and the senior investigators) will make an extra effort to promote the introductory courses. In promoting those courses, the collaborating faculty will emphasize key issues (group work, multiple modes of thinking) and note that summer research opportunities are available for women who choose to continue through the first year of the computer science curriculum. We will use a variety of techniques to recruit these students, including,

[1] These positions will be funded internally and not through this grant.

(1) mailings to students; (2) mailings to advisors; (3) radio spots on campus radio stations; (4) "why study CS" seminars with refreshments; and (5) a Web site. When possible, we will also use information from the admissions office to target particularly promising candidates.

Building Relationships and Recruit Research Students

During each semester, the collaborating faculty will regularly meet with the women in the introductory courses to learn more about their interests, skills, and concerns. Some of these meetings may come in a weekly "Women in Computer Science" lunch (described in Section C.3.b), but other meetings will be one-on-one. Toward the end of each semester, the faculty and student teaching assistants will identify appropriate candidates. Some students will be recruited in the fall (giving them incentive to go on to the second course) and some in the spring (thereby encouraging students who did not take computer science in first semester). During the semester, the collaborating faculty at each institution will also identify an appropriate upper-level student to act as a summer research mentor for the first-year students. Preferably, this student will be someone returning from a prior year of the program.

C.3.d Addressing Students' Misconceptions and Concerns

The MERiCS opportunities can address a number of key misconceptions that students have about computer science as a career. Addressing these concerns is particularly important because they correlate closely with many of the reasons that women leave the sciences. As Seymour and Hewitt (1997) report, "[Y]oung women show a greater concern to make their education, their career goals and their personal priorities fit coherently together". Hence, the misconception that a career in computer science is overly time-consuming may lead some away from computer science. Similarly, women are more likely to prefer group work and may be concerned that computing is primarily a solitary activity.

***Misconception**: A career in computer science is so time-consuming that it will interfere with family life.*

***Reality**: While all professions require significant time commitment, careers in computing (particularly academic careers) can offer flexibility not available in other careers.*

For example, many industrial computing areas offer flexible hours or permit some telecommuting and faculty members, while busy, do have freedom to set their hours. In an interview in (Makedon 1995), Joan Feigenbaum reports

> Like any demanding career, scientific research requires long hours of hard work, and hence makes a dent in the time you can spend with your family and friends. However, there are distinct advantages offered by a career in computer science research as opposed to, say, a career in law, medicine or business. First and foremost, research offers a flexible schedule. Most scientists are judged on what we produce and how we present it. A scientist is not generally expected by her employer to sit in boring meetings all day, to fly off to Hong Kong at a moment's notice, or to function for 48 consecutive hours without sleep in a hospital emergency room—and those are activities that can really make a dent in your personal life.

Maria Klawe echoes these views in another interview in (Makedon 1995) as she contrasts computer science to other scientific disciplines. She notes

> [It is difficult] to combine family with, say, a biological field because you have to spend all of the time in the lab. There would be little time left to nourish young children or babies. With computer science, you can take courses and do a lot of your work at home. All you need is a computer to stimulate the experiments that you have to run and do programming at home. So the field of computer science allows combining family and career. This led me into the field, as opposed to going into a field that requires that I'm physically in the lab.

By helping students understand the benefits a career in computing provides to those who want to balance career and personal lives, Computer science faculty may be able to attract and retain more students. The early research experiences will help students understand the benefits and limitations of a career in computing by, in effect, placing them in the reality of computing. They will see that it is possible to work deeply and for long periods of time on a project, make significant progress on the project, and still have time for other activities.

In addition, the MERiCS experiences give students an opportunity to observe more closely how "real" computer scientists (their mentoring faculty) balance work and family. Since most of the collaborating faculty members have successfully balanced home life and work life, they can serve as positive role models. By working closely with faculty, students will assimilate the behaviors of computer scientists and learn about the benefits of working in computer science. In a study of student research experiences (Seymour 2002), Elaine Seymour reports that

> Women students watch both their men and women faculty carefully to see how they balance their personal and professional lives. The significance of both female and male faculty role modeling of ways in which a balance may be achieved between work as a professional scientist on one hand and family and personal life on the other seems likely to emerge as an issue influencing the career decisions of women.

Misconception*: Computing is primarily a solitary activity*

Reality*: Most significant computing activities require a group of people working together.*

Most research in computer science involves many people working together; co-authored papers are much more common than single- author papers. While industrial projects rarely list authors, it is equally clear the most modern software projects are of the size that would prevent the creation by one person.

Because the MERiCS experiences will be designed primarily as collaborative activities, they will demonstrate to the students that computing is, in fact, a collaborative activity. Making it clear that collaboration is central to computing (and including it in the curriculum) can attract students. One of our women majors reported that she chose a major in computer science in part because it offered many more opportunities for group work than did other majors.

However, there are some disadvantages to teaching students that computing is primarily collaborative. As recent discussion in the SIGCSE (Computer Science Education) mailing list suggest, many faculty are reluctant to allow significant group work in the undergraduate curriculum because of concerns of cheating and students who do not pull their weight. Hence, the collaborating faculty will also work to ensure that colleagues support group work in their courses and provide suggestions for doing so in the MERiCS Web site.

Misconception*: Computer science is primarily computer programming*

Reality*: While computer science can involve programming, it also requires and permits many other activities.*

As suggested earlier, computer science can (and often should) involve much more than just programming. In both research and practice, computer scientists must design and analyze algorithms, experiment with heuristics, measure operations, interview users, and architect large systems. Such activities can draw upon a wide variety of skills, making computing accessible to many different students.

However, these activities do share a common feature: Computer science emphasizes problem solving. While some solutions are expressed as programs, most computer scientists treat the translation of a solution into code as secondary to the development of the solution. As Faith Fich reports in another WISKIT interview (Makedon 1995),

> The good thing about computer science is that having studied it you can go into politics, you can become a lawyer, you can advise the stock market, or you can work as a consultant. It's a problem-solving field. You just have to understand the problem and identify a theoretical solution for it.

Misconception*: Research in computer science has little impact on real people's lives*

Reality *Particularly as the reach of computing as grown, research in computer science has the ability to provide great impact.*

Fisher et al. (1997) report that "[women students] contextualize their interest in computer science, instead, within a larger purpose: what *they can do for the world*". O'Leary (1999) seconds this recommendation as she suggests that introductory computer science courses should "communicate the broad applicability of computer science to life and societal issue". Because we have primarily chosen projects with ties outside of computer science we can show to a variety of people the applicability of computer science. Because our students will be presenting their work in a number of venues, there are a number opportunities for others to see this applicability. We have also included some theoretical projects to see if these students react differently to the experience.

C.3.e A Multi-Institutional Endeavor

The project involves different structures for the early research experience program at different institutions. These diverse implementations will provide broader data on the likely success or failure of such experiences. Faculty at four colleges have already committed to participating: Grinnell (Samuel Rebelsky), Hope (Herbert Dershem), Macalester (Susan Fox and Elizabeth Shoop), and the University of Chicago (Michael O'Donnell).

The variety of institutions can provide clues as to whether the experiences can be successful in many contexts. At Grinnell, students will also be able to participate in a workshop-style[2] introductory computer science course and benefit from New Science Project activities, particularly the pre-orientation session. At Hope, first-year students will be able to join a larger existing REU program. At Macalester, two sets of first-year students will participate in summer research so that there are opportunities for mixing between groups. At Grinnell, two sets of students will participate in research projects with one faculty supervisor for both projects. At Chicago, the students will have the added infrastructure of a Carnegie-I research institution. There are also some opportunities for cross-institutional student collaboration as some topics are shared between institutions (e.g., visualization at Grinnell and Hope).

These institutions also share many similarities that will further the success of the project. All are moderately small liberal arts colleges (Chicago is a moderately-small liberal arts college in the midst of a moderate-sized research university; the rest are primarily undergraduate institutions). As such, they emphasize the close student-faculty relationships that are important in these research experiences. Students also expect to take a broad variety of courses, which gives us the chance to catch students who are still experimenting with a variety of subjects. Perhaps most importantly, students at liberal arts colleges typically enter college without having selected a particular major. Hence, these experiences can affect students' decisions as to which disciplines to pursue.

Note that the project is intended to recruit students once they have selected an institution, not to recruit students to the institution. As Schneider (2001) suggests, "If we desire to make a change nationally in terms of women participating in [the discipline], it is pointless simply to rob other programs of students who are already destined to succeed". As such, this study differs significantly from the successful work at Carnegie Mellon, which primarily deals with high-performing students who have already applied to and been admitted to a top program in computer science (Margolis et al. 2000).

C.5.f Expected Outcomes

Through the project, we hope to affect five distinct groups in somewhat different ways. (1) The *first-year women participants* are directly affected by the project and will gain increased confidence in their ability to do computer science and will increasingly choose computer science as a major as compared to their peers. (2) The *other women in introductory computer science* will see these successful participants and encounter them as teaching assistants. They will find a more comforting environment for women in CS and will be more likely to choose computer science as a major. (3) The *undergraduate men in computer science* will see these successful participants encounter them as teaching assistants. The will change their attitudes about the roles of women in computing, which will also have an added effect on other women in computer science. (4) The *scholars* who encounter these women at professional conferences will learn more about the success of women, of undergraduates, and of first year students in doing scholarly work in computer science. (5) *Computer science faculty* at various institutions will learn of the success of the project and will adopt various aspects of the project.

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[2] Workshop-style courses emphasize collaborative, experimental learning experiences rather than lecture-style experiences

C.4 *Sample Projects*

Faculty at each institution will develop and mentor projects that are appropriate for first-year students and that typically relate to the faculty members' own areas of research. As Rosser (1997) suggests, the projects are large enough to require collaboration, often emphasize social applications and implications, and typically bridge disciplines. In some cases, the research topics permit students to ask questions that pertain to the relationship of the project to women (something Rosser treats as important for many projects). Short summaries of potential projects follow.

C.4.a Dershem: Program Visualization

The ability to visualize program execution is valuable in a number of different settings. In the instructional setting, when students are learning how to program, it is helpful for them to be able to visualize the execution of their program and see how different design and implementation choices affect the actions taken by the computer. When debugging a program it is often helpful to be able to visualize what is happening in order to identify problem areas. And in program maintenance, the maintainer often needs to understand what is happening when the code is unhelpful in this regard. Visualization can be useful in that situation as well.

This project will extend and consolidate previous work done in the area of visualization and animation of executing Java programs. The earlier work developed unique approaches to visualizing class and object method execution, function execution, and event-driven actions. Future work will be directed toward consolidating the earlier work under a common interface and extending it to browser-ready applets. In addition, future projects will extend this work to working with exceptions and threads and study how students and programmers make use of these tools to improve learning and performance.

C.4.b Fox: Robotics

Susan Fox has created a robotics and artificial intelligence laboratory (funded by NSF-DUE grant number 9972414 through summer 2001) that contains a suite of Lego-based robots as well as two Pioneer 2 DX robots. One of the goals of this laboratory is to support summer research by students. Many projects exist which are suitable for students early in their careers, both related to and tangential to Fox's own research.

Students working with the Lego robots could explore issues that include searching mazes, creating and using internal maps, seeking a light source, recognizing other robots. The Lego robots are programmed in a variant of the C language. A current project would create a Scheme interface as well. Fox's research uses the Pioneer robots, which are much more sophisticated. Even beginning students can learn to use and program the Pioneer robots using some of the built-in software from ActivMedia, or software created by Fox.

Fox's research project involves the integration of "reactive" and "deliberative" planning and control. The project integrates many low-level behaviors, which early students could implement and test, with higher-level reasoning methods. Additional projects, such as mapping areas, collecting objects, robot soccer, surveillance, and image processing are also possible. In addition, many specific non-robotic topics in artificial intelligence are within the grasp of a first-year student: e.g., game playing, search, and scheduling.

C.4.c O'Donnell: Digital Sound Analysis and Synthesis

Michael O'Donnell will supervise college student research on digital sound analysis and synthesis, in connection with his long-term research agenda in digital sound modeling. Depending on students' background and talents, they will:

(1) Design and/or execute analysis protocols for the comprehensive archive of orchestral instrument samples under construction at the University of Iowa (http://theremin.music.uiowa.edu/);

(2) Explore the use of experimental sound-synthesis software, then design and/or execute evaluation protocols;

(3) Perform library research, collecting and systematizing the scattered data and studies of interesting sound sources, starting with the orchestral instruments;

(4) Execute their own creative compositions using music synthesis software.

The scope of the project allows a broad range of research activities, including conventional programming and software development as well as creative use of existing (mostly experimental) software, artistic creation, and library research. Item (1) provided very successful research topics for one man and one woman student in the University of Iowa's 1997 summer REU session. Mr. O'Donnell has gathered a research coalition including faculty and laboratory scientists engaged in research on speech recognition, software systems, optimization, sonification of scientific data, musical composition, linguistics, audiology, and animal sounds, who will help advise students whose interests expand beyond his own expertise. The University of Chicago's student ACM chapter enjoys strong participation by women, providing a pool of candidates for senior mentors.

C.4.d Rebelsky: Interactive Hypermedia

Rebelsky's research focuses on hypermedia systems, particularly the use of the World Wide Web in educational contexts. Topics include technologies for constructing and transforming Web pages; systems that add interactivity to Web usage; and techniques for analyzing Web page usage. These projects are intended to address a significant gap between the goals of hypertext and the reality of the Web.

While hypermedia is promoted as an interactive medium, the Web falls far short of the interactivity promoted by hypertext visionaries, such as Vannevar Bush (1945) and Ted Nelson (1974). Early visions suggested a medium in which readers would not only be able to read nonlinear collections of information, but also take and share notes on individual pages, make and share their own links, and add new pages to particular collections. Some Web sites add these capabilities (most typically, for a restricted portion of the site). However, readers cannot easily add notes or links to arbitrary pages. Rebelsky's team of undergraduate students (some early in their careers, some near the end of their undergraduate careers), have developed a number of projects in support of interactive hypermedia, including an infrastructure for modifying arbitrary Web pages (Kensler and Rebelsky 2000); systems that permit readers to annotate pages (Luebke et al. 1999), link pages (Glynn et al. 2000), and summarize the links on pages (Kmiec et al. 2002); and a collection of utilities to permit closer analysis of the ways in which students use course webs (Becker et al. 1999) (Fuller et al. 2002). Future projects will build further about these past projects, providing new forms of interactivity and better analyses of usage.

Because the work is published in international conferences, students also have the opportunity to present their work to a broader community and get a further sense of what it means to be a computer scientist. Some of the experiences are astounding. For example, when Rachel Heck, the senior researcher on (Glynn et al. 2000), presented her work at the EdMedia 2000 World Conference on Educational Multimedia and Hypermedia, the talk was "standing room only". Ms. Heck's experience highlights the efficacy of early and continued research experiences as she began working on the project in her first year.

These projects have been successful for the wide variety of students because they permit students to use a wide variety of skills. While students often do a significant amount of programming, they support each other in the programming and can draw upon procedures and techniques developed by other students. More importantly, they also engage in a number of other activities, particularly relating to user-centered design. External comments on these projects tend to emphasize the strength of the design work, which helps distinguish this work from other projects. Many of the projects involve measurement of the costs of applying transformations to Web pages and of heuristics for decreasing those costs. Finally, students also engage in philosophical discussions of the work. For example, students regularly consider issues of intellectual property as they work on software that makes it possible to change the way another person's page is viewed in a browser (e.g., by adding links or annotations). Similarly, they ask about the invasion of privacy inherent in the analysis of Web usage.

These projects also permit many of the characteristics of science education that Rosser (1997) promotes. They draw upon knowledge and skills from many disciplines, consider societal impact of the research, and consider the particular impact of the research on women (e.g., whether men and women react differently to interfaces and technologies). Maso (1996) suggests that hypertext is a particularly female-friendly area, particularly because it is non-hierarchical and collaborative.

C.4.e Shoop: Data Exploration Research

Dr. Shoop recently set up a computational research laboratory for data exploration at Macalester. Students will use this lab to work on research projects, assignments for database systems and Java programming classes, and capstone projects (every senior must complete a research project as a requirement for graduation at Macalester). For this proposal, the research projects conducted by the first-year students and their junior or senior mentors will mainly be related to bioinformatics, but may also be used for other types of scientific or business data. This lab will be a student training ground for thin-client Java programming and a stepping-stone for some of the students to continue their education in graduate school. My emphasis when creating this lab will be to use it as a mechanism for attracting female computer science students and providing them with a place where they can work together on research projects. The equipment we will have available for our research projects will include one Sun Microsystems E250 as an Oracle database server and another as a SunRay and Web application server. Students will be able to work on data exploration projects using any of 8 SunRay net appliances or 1 Sun Ultra 60 workstation.

The main purpose for the lab will be as a place for students to work on data exploration projects, using the Java programming language (with special emphasis on graphics for data visualization) and the Oracle DBMS. Students will design and build Web-based programs for exploring distributed data warehouses. We will start by replicating key portions of data from my existing genomics data warehouse at CCGB, and leaving other portions there. For example, we have created a warehouse of protein family data that can be accessed with a java exploration tool (http://metafam.ahc.umn.edu). In the student lab at Macalester, we will study replication mechanisms and methods for enabling users to explore the local data and retrieve distantly located data when necessary. Close ties will be maintained with the University of Minnesota Center for Computational Genomics and Bioinformatics (CCGB). The goal of our research work will be to show how thin-client tools can allow genome researchers to interactively explore large amounts of data distributed at various bioinformatics sites.

C.5 Evaluation

This proposal seeks to attract more women to CS majors and to address commonly held misconceptions that many people (especially women) hold about computing as a career. The proposed means of reaching these goals is to build confidence and counteract common-misconceptions about a computing career by providing female undergraduates with intensive summer research experiences; to encourage female students who participate in research projects to function as mentors and role models for other women, men and faculty on their campuses; and to build community among women in computing by providing a support network for female computing students and their mentors through "Women in Computing" lunches and a student-developed and maintained Web site. While evaluation will examine all relevant aspects of the project, much of the success of this effort hinges on the impact of the summer research experience and thus many of the questions used in evaluating its success will focus on students' decision to declare the major and their perceptions of the field of computing science.

- What impact does the project have on the decision of the first-year research students to pursue or not to pursue a computer science major?
- What impact does the project have on the decisions of *other* women students to pursue or not to pursue a computer science major?
- How does the project affect the ways in which students (both men and women) describe computer science?

- Are the students who participated in the summer research programs visible on their campuses and how does their visibility affect the ways that other students and faculty perceive the roles of women in computer science?

Evaluation will also examine the summer research experiences themselves and the success of the community building activities described in C.3.d. Questions guiding this portion of the evaluation will include:

- In what ways, if any, do the summer research experiences address the common misconceptions about computing science that are listed section C.3.d?
- What are the essential elements of the summer research experience?
- Were some research experiences better at achieving the goals of the project than others; why or why not?
- What level and quality of participation occurs at the "Women in Computing" lunches and the Web site?
- What impact do the luncheons and Web site have on participants? On non-participants?

The primary method of data collection for this project will be through ethnographic-style, moderately-scheduled interviews with samples of (1) women – those who participate in summer research and declare computer science as a major, those who participate in summer research and do not declare a computer science major, those who do not participate in summer research and declare computer science as a major, those who neither participate nor declare computer science majors; (2) males in courses with women who participated in summer research; (3) faculty – those who are involved in the summer research program and those who were not, but who teach courses taken by women who participate in summer research. While ethnographic data tends to provide a great deal of depth, sample sizes tend to be small. To supplement the data gathered using ethnographic methods, a survey will be developed based on the analysis of interviews conducted during the first year of the project. By year two of the project, the survey can be administered to a wider subject population. In years two and three, interview data will continue to be collected to enhance our understanding of the survey data (and, when needed, to refine the survey instrument itself). Both individual and group interview formats will be used. The group interviews will focus on eliciting peer discussion among participants. These sorts of discussions often lead to a far greater understanding of participants' attitudes and experiences as they respond to one another rather than participants responding one at a time to questions. Interviews will be tape-recorded and transcribed with the prior permission of the interviewees. These data will then be coded and content analyzed using the Ethnograph (Seidel et al. 1988).

Other data that will be gathered includes the number of women students who declare the major, changes in grades, level of confidence, and degree attainment (when possible, given the time constraints of the grant period). This data will be compared to data from other, non-participating institutions through the Liberal Arts Consortium and the Pew Midstates Science and Mathematics Consortium. By tracking changes in numbers of women majors at all institutions in conjunction with interview data, it will be possible to consider the effect of this project on decisions to declare a computer science major. In addition, this multi-institutional data will provide added context to the interview data. For example, while many students may say that the experiences led them to declare a computer science major, the actual change in numbers of majors may remain the same as that of peer institutions (suggesting some other stimulus for change, external to this project). This project focuses on attracting more women to the major and thus we will not explore their postgraduate plans or postgraduate status.

Interview data will primarily be collected by two student ethnographers (from sociology, social psychology, anthropology or other related discipline). This peer ethnographer approach has been used in a wide variety of settings (e.g., Swartz and Voyles, 1998) and often meets with a great deal of success. Evaluation will be coordinated and supervised by Dr. Kathy Garvin-Doxas of the University of Colorado, Boulder. She will also analyze and interpret all data. Dr. Garvin-Doxas will report findings in addition to any suggestions for improvements to project team members on a semi-annual basis. The student ethnographers will be trained both by Dr. Garvin-Doxas and by Dr. David Lopatto of Grinnell's

Psychology Department. Dr. Garvin-Doxas regularly trains graduate students in ethnographic techniques and Professor Lopatto regularly trains undergraduate student ethnographers who conduct interviews as part of an NSF-funded ROLE (Research on Learning and Education) project on the efficacy of summer research (Lopatto and Seymour, 2000). The student ethnographers will also be responsible for transcribing the interviews.

C.6 Broadening the Impact: Outreach, Replication, and Dissemination

We expect that these research experiences will have a direct impact on the participating students and an indirect impact on the perceptions and actions of those they encounter in classes (where they will serve as TAs) and elsewhere. However, we also plan to use this project to encourage other faculty to undertake similar projects and to encourage other women students to select computer science as a discipline. To those ends, we have identified a number of mechanisms to help other faculty and to support women in CS. Table 3 summarizes these mechanisms, which are described further in the paragraphs below.

Target	**Mechanisms**
CS Faculty	Conference Presentations: SIGCSE, CCSC, Pew Midstates Consortium
	Web Site and Community
	Guide to Designing Early Research Experiences
	Guide to Funding Early Research Experiences
Other Faculty	Project Kaleidoscope, Pew Midstates Consortium
Administrators	Guide to Funding Early Research Experiences
Women Students	Web Site
Broader Community	Student Presentations
	Web Site

Table 3: Mechanisms for Broadening the Impact

Conference Presentations: If we are to convince other faculty to adopt these early research experiences, we must inform them about the experiences. Because the primary audience is the computer science community, primary dissemination about the success of the early-research-experience technique will be through avenues most seen by computer science educators. The Association for Computing Machinery (ACM) Special Interest Group in Computer Science Education (SIGCSE) hosts an annual symposium on computer science education, which serves as the primary outlet for research on computer science education. Many of the collaborators on the proposal (including the PI) have significant experience with SIGCSE and regularly review papers for the conference. We will to disseminate results at the symposium in a variety of forms, including (1) formal paper presentations, (2) panel discussions on undergraduate research, and (3) workshops to help other faculty develop early research programs. The proceedings of the SIGCSE Symposium are published and serve as a further vehicle for dissemination.

To further broaden the impact of the work, faculty and students will present results of this project at regional conferences, primarily those hosted by the Consortium for Computing and Small Colleges (CCSC). These smaller conferences often attract faculty members who are unable to attend the SIGCSE Symposium. While these faculty members will likely read about the results in the SIGCSE Proceedings, workshops at CCSC meetings will give faculty the opportunity to think more closely about these issues. Works presented at CCSC are published in the *Journal of Computing at Small Colleges*, providing an additional mechanism for disseminating results. Consortia of peer institutions provide another avenue for broader impact. The collaborating faculty will make sure to discuss the early research experiences and weekly lunches at the annual meetings of the Liberal Arts Computing Consortium.

"How To" Guides: Once other faculty members learn about these experiences, we expect them to have two key questions: (1) *How do I design appropriate first-year research experiences?* and (2) *How do I fund such experiences?* We will write two "How To" guides: One on designing first-year experiences and one on funding those experiences. We will also discuss these issues at the workshops (mentioned above). The guide to designing first-year research experiences will be based on our experiences designing such experiences and our research on the efficacy of those experiences.

Early research experiences seem relatively expensive (typically requiring student stipends of $3200 to $3800 or more per summer student). Is it really possible that they can be adopted at a variety of institutions? We think so. In disseminating results, the collaborating faculty will emphasize ways that the early research experiences can be incorporated into existing infrastructures (e.g., REU programs, institutional undergraduate research programs) and can be adapted to other format (e.g., academic year research in independent study, in courses, or funded assistantship programs offered at the beginning of a student's second year). That is, successful demonstration of the benefits of these intensive early research experiences should provide others with incentive to adopt such experiences; suggestions on other mechanisms will provide added support for such adoption. In writing the guide, we will also work with our grants offices in identifying other potential funding sources. We expect that this "Funding Early Research Experiences" guide will be helpful to administrators as well as to faculty.

Presentations Beyond Computer Science: While the focus for dissemination will be computer science faculty, the success of the project in computer science along with the already-documented success of the early research model in Physics suggests that the model should be encouraged in a wider community. The primary avenue for this broader dissemination will be Project Kaleidoscope (PKAL), particularly the PKAL Faculty for the 21st Century (F21), which have as a core goal the dissemination of new styles for teaching science. The collaborating faculty members also plan to hold a weekend workshop on early research experiences for women for the Pew Midstates Science and Mathematics Consortium.

Web Sites: To further broaden the impact the collaborating students and faculty will develop and promote Web sites related to the project. Because many sites already help women learn about computing and about misconceptions, the dissemination sites will primarily emphasize support for faculty and students in early research experiences and tips for building community.

Our Students: Finally, the students will be among the foremost mechanisms for disseminating the results. By presenting at conferences and at talks at institutions, they show that women can succeed in computer science. By selecting careers in computer science and by their success, they will provide role models for future students. As they go on to careers inside and outside academe they will bring the idea of early research experiences with them.

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Professional Preparation

University of Chicago	Mathematics	S.B. w/honors	1985
University of Chicago	Computer Science	S.M.	1987
University of Chicago	Computer Science	Ph.D.	1993

Dissertation: *Tours, A System for Lazy Term-Based Communication*
Advisor: Michael J. O'Donnell, University of Chicago

Appointments

Associate Professor of Computer Science, Grinnell College, Effective August 2002.
Chair, Technology Studies, Grinnell College, June 2001 to present.
Assistant Professor of Computer Science, Grinnell College, August 1997 to present.
Director, Grinnell Lab for Interactive Multimedia Experimentation and Research, August 1997 to present.
Adjunct Assistant Professor of Computer Science, Dartmouth College, June 1997 to June 2000.
Assistant Director, Dartmouth Experimental Visualization Laboratory, January 1994 to June 1997.
Visiting Assistant Professor, Dartmouth College, March 1993 to June 1997.
Instructor, University of Chicago Publishing Program, 1990 to 1991.
Research Assistant, Michael J. O'Donnell, University of Chicago Dept. of Computer Science, 1987 to 1993.
Lecturer, University of Chicago Department of Computer Science, 1985 to 1987.

Selected Relevant Publications *(* indicates undergraduate co-author)*

R. Becker*, K. McLaughlin*, and S. A. Rebelsky. Project Clio: Tools for Tracking Student Use of Course Webs. In B. Collis and R. Oliver (Eds.), *Proceedings of the EdMedia 99 World Conference on Educational Multimedia, Hypermedia, and Telecommunications* (Seattle, Washington, June 19-24, 1999), pp. 981-986.

C. Flynt and S. A. Rebelsky. Real-World Program Design in CS2: The Roles of a Large-Scale, Multi-Group Class Project. In *Proceedings of the Thirty-First SIGCSE Technical Symposium on Computer Science Education* (Austin, Texas, March 8-12, 2000), pp. 192-196.

C. Glynn*, R. Heck*, S. Luebke*, W. Ma*, H. Mason*, E. Nichols*, E. Raulerson*, I. Staicut*, and Samuel A. Rebelsky. Blazing Trails on the World Wide Web. In J. Bourdeau and S. Heller (Eds.) *Proceedings of the EdMedia 2000 World Conference on Educational Multimedia, Hypermedia, and Telecommunications* (June 26-July 1, 2000, Montreal, Quebec, Canada), pp. 335-340. Charlottesville, VA: AACE, 2000. Received *outstanding paper* award.

A. Kensler* and S. A. Rebelsky. Web Raveler: An Infrastructure for Transforming Hypermedia. In J. Bourdeau and S. Heller (Eds.) *Proceedings of the EdMedia 2000 World Conference on Educational Multimedia, Hypermedia, and Telecommunications* (June 26-July 1, 2000, Montreal, Quebec, Canada), 479-484. Charlottesville, VA: AACE, 2000.

S. Luebke*, H. Mason*, and S. A. Rebelsky. Annotating the World Wide Web. *CSS Journal* 7 (5), November/December 1999.

Selected Additional Publications

J. Ford, F. Makedon, and S. A. Rebelsky. Resource-Limited Hyper-Reproductions. *Journal of Multimedia Tools and Applications* 6(2), pp. 181-197.

F. Makedon and S. A. Rebelsky (editors). Electronic Multimedia Publishing: Enabling Technologies and Authoring Issues. Boston, MA: Kluwer Academic Publishers. 1998.

S. A. Rebelsky. Evaluating and Improving WWW-Aided Instruction. *Journal for Universal Computer Science*, 2 (12), December 1996, pp. 829-841.

S. A. Rebelsky. *Experiments in Java*. Reading, MA: Addison-Wesley. 2000

S. A. Rebelsky, J. Ford, F. Makedon, and C. Owen. Multimedia Publishing Systems. Chapter 21 of B. Furht (Ed.), *Handbook of Internet and Multimedia Systems and Applications*, pp. 457-482. CRC and IEEE Press. 1998.

Selected Synergistic Activities

Mentor, Dartmouth Women in Science Program [WISP]. Received award and commendation for commitments to mentoring women in computer science.

Conference Co-Chair, EdMedia 2002 World Conference on Educational Multimedia and Hypermedia. Organization of conference and selection of papers for a moderate-sized (about 1400 attendees from 50 countries) conference.

Faculty Mentor, Trailblazing Tools for the World-Wide Web. A research project by undergraduate women sponsored by the Computing Research Association's Collaborative Research Experience for Undergraduate Women (CREW) project. I also obtained institutional funding to continue this project. The students and I received an outstanding paper award at the EdMedia 2000 World Conference for this work.. (Glynn et al. 2000 above.)

Member, PKAL Faculty for the 21st Century (F21). F21 is a consortium of science faculty at primarily undergraduate institutions who are leading changes in undergraduate teaching and research.

Mentor, Grinnell Women in Computer Science. Formed group, obtained funding for lunches, schedule and participate in weekly lunches.

Courses Taught

Grinnell College: Fundamentals of Computer Science I, Fundamentals of Computer Science II (Data Structures and Algorithms), Software Design, Compilers, Programming Languages, Computing and Problem Solving, Computer Networks, A Social and Algorithmic Overview of Computer Science, First-year seminar (Hypertext: Some Technology, Some Implications); Special Topics: Web Software Engineering; Various independent studies and guided reading courses.

Dartmouth College: Computer Networks, Concepts in Computing, Compilers, Operating Systems, Programming Languages (Undergraduate and Graduate); Various independent studies and guided reading courses.

University of Chicago: Introduction to Computer Programming, Data Structures and Algorithms, Calculus I, Calculus II

Collaborators and Other Affiliations

Thesis Advisor: Michael J. O'Donnell, University of Chicago (thesis advisor)

Faculty Collaborators: Nell Dale (U. Texas Austin), Herbert Dershem (Hope), R. Scot Drysdale (Dartmouth), Clif Flynt (Flynt Consulting), James Ford (Dartmouth), Susan Fox (Macalester), Peter Gloor (Coopers-Lybrand), Ben Gum (Grinnell), Rachelle Heller (George Washington University), Fillia Makedon (Dartmouth), P. Takis Metaxas (Wellesley College), David Musicant (Carleton), Jeffrey Ondich (Carleton), Charles Owen (Michigan State), David Sherman (U. Bordeaux), Elizabeth Shoop (Macalester), Robert Strandh (U. Bordeaux), John Stone (Grinnell), Henry Walker (Grinnell), Chip Weems (U. Mass Amherst)

Recent Former Undergraduate Research Students: Raphen Becker (U. Mass.), Rachel Heck (U. Wisconsin), Andrew Kensler (OpenText), Sarah Luebke (Independent Consultant), Weichao Ma (Boston U.), Hilary Mason (Brown), Kevin McLaughlin (Tribune Interactive), Jared Seaman (U. Iowa Medical Schools), V. Venugopal (Independent Consultant)

[Current Grinnell undergraduates advisees and research students not listed.]

Herbert L. Dershem

a. Professional Preparation:

University of Dayton, Mathematics, B.S., 1965
Purdue University, Computer Science, M.S., 1967
Purdue University, Computer Science, Ph.D., 1969

b. Appointments:

Hope College, Assistant Professor, 1969-1974, Associate Professor, 1974-1981, Professor, 1981-present, Chair, Computer Science Dept, 1976-present.
United States Air Force Academy, Distinguished Visiting Professor, 1993-1994.
Boston University Overseas Program, Visiting Professor, 1982-1983
Oak Ridge National Laboratories, Visiting Research Scientist, 1977-1978

c. Publications:

Dershem, H.L. and N. Uti, "Animation of Java Linked Lists," *SIGCSE Bulletin*, 34,1(Feb, 2002), 53-57.

Dershem, H.L., Dykstra, J., and K. Suppes, "An Abstract Window Toolkit Visualizer for Computer Science Instruction," *Proceedings of the 33rd Midwest Instruction and Computing Symposium (CD-ROM)*, April 14-15, 2000, Minneapolis, MN.

Dershem, H.L., Parker, D.E., and R. Weinhold, "A Java Function Visualizer," *Journal of Computing in Small Colleges*, 15,1(Oct, 1999), 221-230.

Dershem, H.L. and J. Vanderhyde, "Java Class Visualization for Teaching Object-Oriented Concepts," *SIGCSE Bulletin*, 30,1(Mar, 1998), to appear.

Dershem, H.L. and P. Brummund, "Tools for Web-Based Sorting Animation," *SIGCSE Bulletin*, 30,1(Mar, 1998), to appear

Dershem, H.L., Barth, W., Bowsher, C, and D. Brown, "Data Structures with Ada Packages, Laboratories, and Animations," *Proceedings of the First Australasian Conference on Computer Science Education*, July, 1996, 32-38.

Dershem, H.L. and M.J. Jipping, *Programming Languages: Models and Structures: Second Edition,* PWS Kent Publishing Co., 1995.

Dershem, H.L., and R. McFall, "Finite State Machine Simulation in an Introductory Lab," *SIGCSE Bulletin,* 26,1(Mar, 1994).

d. Synergistic Activities:

Director, "Computer Science Undergraduate Research Program", NSF REU Program,1992-1994, \$86,550; 1995-1997, \$114,393; 1998-2000, \$146,700.

Director, "Use of Ada, Laboratories, and Visualization in the Teaching of Data Structures and Discrete Mathematics", DARPA Curriculum Development Grant, 1993-1994, \$23,010.

Co-Director, "An Integrated Classroom/Laboratory for Introducing Students to Object Oriented Concepts", NSF ILI Program, 1996-1998, \$46,356.

Councilor, Council for Undergraduate Research, 1994-2000.

Program Chair, SIGCSE Technical Symposium, Atlanta, GA, 1988.

e. Collaborators and Other Affiliations:

(i) Collaborators: Peter Brummund (Eli Lilly), Gordon Davies (Open University), Josiah Dykstra (Hope College), Susan Fox (Macalester), Michael J. Jipping(Hope College), Ryan McFall(Hope College), Dave Musicant (Carleton College), Jeff Ondich (Carleton College), Erin Parker (University of North Carolina), Mike O'Donnell (University of Chicago), Sam Rebelsky (Grinnell College), Hugh Robinson (Open University), Libby Shoop (Macalester College), James Vanderhyde (Michigan State University), Timothy Vroom (Hope College), Rebecca Weinhold (unknown)

(ii) Graduate and Postdoctoral Advisors: Robert E. Lynch (Purdue University)

(iii) Thesis Advisor and Postgraduate-Scholar Sponsor: none