College of Computing and Informatics
DIVERSITY in IT INSTITUTE
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Research Experiences for Undergraduates Annual Report 2007

FINAL EVALUATION REPORT

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Summers 2006 and 2007

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1. Executive Summary

2007 Highlights:

- Strong knowledge gains were made in ALL academic areas
- 89% of participants would recommend the Summer REU to peers
- Most important factors reported by students in their decisions to pursue computing were that **computing/IT is enjoyable and interesting**, and that **it affords career opportunities**.
- A strong level of teamwork was reported across projects
- 90% of students found their research experiences to be challenging and fun
- 70% of students indicated after the program that they plan to pursue a doctorate in computing

"What I learned in general from this program is that research is used to better people's lives."
"I feel like this program is going to help me open up a lot of doors, and I have decided that I really want to go to grad school."
"I can't believe we get paid to play with robots!"

2006 Highlights:

- 78% of students reported having an immediate family member involved in research
- 100% agreed with the statement that they are interested in attending graduate school to do research
- All participants agreed that they place a high value on the role of research in their future careers

"[The REU] gave me an open mind to future research. I had never before considered it."
"I just recently discovered an interest in research. The experience this summer has gotten me more interested in research as well as graduate school."
" [The social activities] were very useful in getting to know all of the researchers and faculty in a stress free environment."

2. Program Overview

2.1 Goals

The primary objective for our summer REU Site were to broaden the participation in computing doctoral programs, specifically for under-represented populations such as women, minorities, and persons with disabilities. Our project goals were to: **1)** provide a summer research experience that immerses each student into the activities and culture of a research lab; **2)** increase students' understanding of computing research methodologies; **3)** increase students' awareness of the broad array of computing research disciplines; **4)** provide students with multiple points of support from a diverse group of peers and faculty mentors; **5)** increase students' understanding of the process to apply to and prepare for entrance and success in computing doctoral programs. Nineteen students participated in a 10-week summer Research Experiences for Undergraduates program from May 29-August 3, 2007. Fifteen students participated in the 2006 program.

The **intellectual focus** of our REU Site is on computing research that is being conducted within four UNC Charlotte labs housed within the College of Information Technology (COIT): the Charlotte Visualization Center (CVC) www.viscenter.uncc.edu, led by Bank of America Distinguished Chair Dr. Bill Ribarsky; the Future Computing Lab (FCL) http://www.cs.uncc.edu/fcl/, led by Computer Science department Chair Dr. Larry Hodges, the Games + Learning Lab led by Assistant Professors Dr. Tiffany Barnes and Dr. Michael Youngblood; and the Networking Research Lab (NRL) http://www.cs.uncc.edu/~tdahlber, led by Associate Professor, Dr. Teresa Dahlberg. REU student projects will focus on research in data visualization (Ribarsky), virtual environments (Hodges), digital gaming (Barnes), mobile robotics and networking (Dahlberg). Students initially undertake hands-on activities that support ongoing research within a designated lab (e.g., developing supporting software tools or conducting experiments via established simulation environments or experimentation testbeds). After becoming acclimated to the laboratory environment and focus, students are guided through the process of performing a literature review for the purpose of motivating a novel research topic that complements the focus of their lab. Ultimately, students are encouraged to independently pursue their own line of inquiry and to articulate their results in a publishable paper to be presented at an annual Student Research Conference, held in conjunction with the McNair Scholars Program.

The **intellectual merit** of this project resides in the contributions to computing research that will be produced by the undergraduate students participating in the REU Site. Additionally, the comprehensive program evaluation will inform efforts to recruit undergraduate students to doctoral programs by demonstrating the success and challenges of our REU Site structure for motivating students to apply to doctoral programs in computing.

The **broader impact** of the project will be evidenced by the increased numbers of students from under-represented populations in computing who successfully participate in research and who apply and are accepted into graduate programs in computing.
Our evaluation of the REU focuses on the following outcomes: 1) overall program effectiveness (including formative and summative feedback), 2) ratings of professors and

graduate assistants involved in the program, 3) REU training environment satisfaction, and 4) self-efficacy and attitudes about computing.

2.2 Organizational Structure

The REU Site is housed within the Diversity in Information Technology Institute (DITI), www.coit.uncc.edu/diti, and managed by PI Teresa Dahlberg, who is Director of the DITI. The DITI coordinates all aspects of student recruiting, housing and activities, and project management and reporting. The REU students were organized into four REU teams, with each team comprised of 4-6 students, one graduate student mentor, and one-two faculty advisors. REU students participated in all activities within their labs and were provided with many informal and formal opportunities to interact with the diverse group of graduate students and junior and senior faculty within their labs. The team assignments were designed to ensure adequate access to peer and faculty mentors for each student.

Our REU Site program provides undergraduates with a full-time summer research experience for 8-10 weeks. We encourage students to live on campus, and provide team-building and social activities to welcome students and build community. Our NSF grant provides support for 10-12 students annually, but we combined students supported by the Computing Research Association - Women's Distributed Mentoring Project, McNair Scholars, and other funding sources, into a cohort of 15 (year 1) and 19 (year 2) students.

Our REU Site structure supports situated learning by providing a realistic setting for lab research. Each summer cohort is organized into four REU teams, each working within a research lab: the Charlotte Visualization Center, the Future Computing Lab, the Games + Learning Lab, and the Networking Research Lab. Each team includes three to six REU students, one to three graduate students, and at least one faculty advisor. REU students participate in all activities within their labs and have many informal and formal opportunities to interact with the diverse graduate students and junior and senior faculty in the program.

Dr. Teresa Dahlberg of The University of North Carolina at Charlotte serves as the Director, who administers the program, handling recruiting, housing, scheduling, and engaging other campus resources. This separation of administration and research direction enables faculty to focus on providing students with a quality research experience.

2.3 Recruitment

Our recruitment efforts focus on reaching students from groups that are underrepresented in computer science and from local undergraduate institutions. Because our situated learning approach encourages an apprentice-like model, we focus on rising sophomores and juniors, and encourage students to participate with their research labs for two consecutive summer REUs, or through other academic year programs.

Our recruiting efforts were performed through flyers, email, and particularly through personal visits and contacts at regional institutions. We also advertised online through university and NSF websites, and applicants were directed to our website for project descriptions and applications.

Most effective were our personal visits to regional institutions where our own students shared their excitement about participating in our research labs. Similarly, we leveraged our role as leaders of the STARS Alliance, Students in Technology, Academia, Research and Service, to personally recruit students during our annual STARS Celebration conference.

2.4 Budget

The budget allocations for the summer REU program is listed below in Table 2.4. This budget reflects the expenditures for the student participants.

2007 Budget

				Totals
Stipends	17 students	$4,000	each	$68,000
Housing	13 student	$750	each	$9,750
Food	17 students	$500	each	$8,500
Parking	6 cars at	$107	each	$642
	1 hang tag	$122	each	$122
Student Activities Center	13 students	$65.90	each	$856.75
Awards				$500
GRE	1 teaching pkg.	$113.95		$113.95
	18 coursebooks	$122.95	each	$2,213.10
	report fee	$78.00		$78.00
	shipping	$185.06		$185.06
Luncheon				$354
Total				**$91,315**

3. Project Participants

During the 2006 and 2007 programs there were a total of 34 participants. In 2006 there were 13 applicants, all of whom were accepted into the program, but one student did not attend, while three additional students were added to the cohort through the CRA-DMP program, for a total of 15 students. In 2007 there were 48 applicants, of whom 17 were accepted. Three declined the invitation and an additional three students were accepted, and 1 student applied late to be an unpaid intern, and one CRA-DMP student was added to the program, for a total of 19 students. A total of 10 faculty advisors and 4 graduate student mentors oversaw and assisted the student researchers in their project planning and implementation. Home institutions for student participants were UNC Charlotte, JC Smith University, Winthrop University, Elon University, North Carolina State University, College of Charleston, Oberlin College, Penn State, and the Computing Research Association. These partner organizations assisted in the recruitment and selection of applicants for the summer REU.

- In 2006, there were 6 men and 9 women, with 4 African American students; in 2007, 10 men and 9 women, with 4 African American students and 1 Hispanic student.
- The age range for the students was from 18-33 years old.
- Four of the 2007 participants were returning students from 2006, while one 2007 graduate mentor was an REU participant in 2006.
- In 2006, 40% of students came from UNC Charlotte, while 53% came from other schools in NC, SC, and VA, and 7% outside of these states. In 2007, 42% of participants were from UNC Charlotte, while 42% were from other NC, SC, or VA schools, and 16% outside of these states, reflecting the larger applicant pool.
- During 2006, 53% of students resided on campus, while 84% of 2007 participants were on campus.
- Students were younger in 2006, with 4 rising sophomores, 7 juniors, and 4 seniors, while in 2007 there were 2 rising sophomores, 2 juniors, and 15 seniors.
- Seventy-eight percent of the 2006 participants had family members in research, while 27% of 2007 participants had researchers in their families.

Table 3.1 Participant Demographics

University			Class Standing			Race			Gender		
	06	07		06	07		06	07		06	07
UNC Charlotte	6	11	Freshmen		4	Black	8	4	Males	6	10
JC Smith University	2	1	Sophomores	4	3	White	4	12	Females	6	9
Winthrop University	2	2	Juniors	4	3	Hispanic		1	CRA Females	3	
NC State University	1		Seniors	4	5	Asian		1			
Elon University	1	2	Grad Students		4	No response		1			
College of Charleston		1									
Penn State		1									
Oberlin		1									

Each year in the program, 3-6 students were assigned to one of four computing labs, where students were mentored by graduate students and faculty. In 2006, mentors included 3 senior faculty (Ribarsky, Hodges, Dahlberg), 3 junior faculty (Barnes, Wartell, Richter), and 3 graduate students. In 2007, mentors included 3 senior faculty (Ribarsky, Hodges, Dahlberg), 5 junior faculty (Barnes, Wartell, Youngblood, Payton, Wilson), and 4 graduate mentors (Doman, Dixit, Chaffin, Ulinski). Table 3.1.2 shows the distribution of student and faculty lab project teams. Our program practices tiered mentoring at multiple levels; in 2007 a number of new junior faculty members were added to the program.

Table 3.1.2 Project Areas by Laboratory

Project Area	2006 Faculty	2006 Students	2007 Faculty	2007 Students
Game2Learn: Usability study to determine most effective way to learn programming in context of vieogame	Dr. Tiffany Barnes Dr. Heather Richter	Amanda Chaffin Alex Godwin Hyun Jordan Paige Matthews Eve Powell Tiffany Ralph	Dr. Tiffany Barnes Dr. Michael Youngblood GA: Amanda Chaffin	Michelle Chamberlain Abigail Corfman Jason Deering Taylor Dubois Michael Eagle Jordana Hodges
Drowning in Data:Visualization Techniques	Dr. Aidong Lu	Josh Jones	Dr. Aidong Lu	
Fuzzy Data Collection: Examined wireless sensor networks data collection	Dr. Teresa Dahlberg	Lee Cranford	Dr. Teresa Dahlberg Dr. Jamie Payton GA: Marguerite Doman	Brandon Cooper Robert Goodrich Elaine Thinglestad Ebonie Williams
Virtual Reality: Measured how an immersive environment is different from two dimensional environment		Louis Fletcher		
Wireless Sensory Networks: Taught middle and high school students how sensory networks warn for natural disaster		Monique Kearson		
Digital Human: Study of whether students learn how to tie a tie from digital human tutor	Dr. Larry Hodges	Brandon Miller	Dr. Larry Hodges Dr. Dale-Marie Wilson GA: Amy Ulinski	Toni Bloodworth Lauren Cairco Louis Flethcer Vicky Fowler Morris LeBlanc
Interactive Shakespeare: Study of effectiveness of virtual actress to rehearse and prepare for performance		Lauren Cairco		
3D Virtual Model of Charlotte: Designed virtual city model to enhance business marketing	Dr. Bill Ribarsky Dr. Zach Wartell	Daniel Fregosi	Dr. Bill Ribarsky Dr. Zach Wartell	William Fulmer Tera Green Lane Harrison Josh Jones

4. Activities

Student activities were structured around the research project, for community building, outreach, academic preparation, and professional development. There were several clusters of activities designed to support the REU students. Orientation, research and academic training, community building, and professional development served as the primary components of the students of the UNC Charlotte REU site. Summative and formative evaluation research is a primary administrative component of the site, so that student retention and success can be measured, best practices be determined, and we can inform the academic community. Activities and findings for each area are discussed in the following sections.

4.1 Research Projects

The research labs involved in the project are:

- Visualization: Projects in this lab are centered on visualization to analyze problems in scientific and geospatial contexts.
- Future Computing: Projects in this lab are centered on the use of virtual humans for training.
- Games + Learning: Projects in this lab are centered on building games for learning computer science, math, and culture through interactive games and media.
- Mobile robotics and networking: Projects in this lab are centered on building mobile robotics applications that use sensor networks.

We showcase two projects that demonstrate the depth and breadth of our REU experience of computing research.

4.1.1 Game2Learn

Game2Learn is a project in the Games + Learning Lab seeks to build games for teaching introductory computing concepts.
More here… with pics, etc.

4.1.2 AVARI

AVARI is a project in the Future Computing Lab, which seeks to build a persistent, interactive agent who interacts with visitors to the department of Computer Science at University of North Carolina at Charlotte. Many applications have been built to investigate various aspects of how people interact with virtual agents in social, informational, and learning settings. However, most virtual agents never see the outside of a lab, interacting only with the computer-literate developers and other members of their lab. At best, some virtual agents interact with participants of an experiment, but only for a short amount of time under restricted conditions. With such a limited audience, it is hard to get an accurate idea of what interaction between a virtual agent and members of the population in general would be like. This summer, five students worked to develop a virtual agent that could be deployed in a public setting so that data about interaction between an agent and a broader sample of the population could be collected. The end result of their work is a virtual character named Avari (Animated Virtual Agent Retrieving Information).

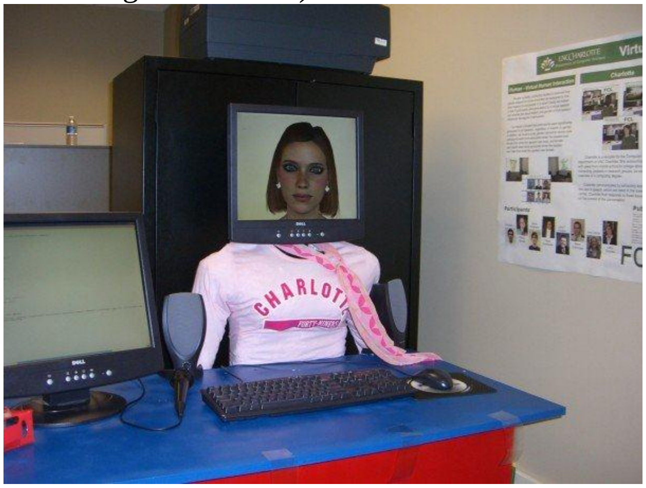

Figure 4.1.2: Avari: Computer Science Virtual Receptionist

Using text-to-speech and voice recognition, Avari holds a conversation with users who approach her. She talks about members of the computer science faculty at [University of North Carolina at Charlotte, guiding the user to choose a professor and a category of information about them, then answering questions that the user asks. Avari keeps a record of all interaction she has with others. She was designed to be placed in a building hallway where typical students can interact with her.

The computer Avari runs on is enclosed inside of a desk that the students and mentors built together. A model of a person's shoulders covered by a stuffed shirt is attached behind the desk, and the monitor used for Avari's face is mounted on top of this, making it look like Avari is a person standing behind a desk (see figure 4.1.2). Another monitor used for keyword and picture display is mounted beside Avari on the desk. Speakers, a microphone, and a camera are also attached to the desk.

Avari's underlying framework is mostly web-based. Her appearance, behavior, and speech are implemented using Haptek. She uses MySQL to store her knowledge database, and PHP to match user questions to stored questions in the database, and to retrieve and update the database. SALT (Speech Application Language Tags) is used for speech recognition, and vision processing is done using Matlab. Javascript allows all these components to communicate with each other, and defines Avari's conversational structure. Each member of the team working on Avari was responsible for the design and implementation of one or more of these components.

4.2 Outreach

Several of the research projects were designed as community outreach. The Game2Learn projects are designed to teach programming skills to undergraduates and school aged children through interactive, fun video games. The digital human tutor teaches children how to tie a tie, or how to tie shoes. The wireless sensor project was demonstrated at a middle and high school to increase awareness of computing careers, as well as show the importance of technology in helping humanity.

4.3 Community Building

4.3.1 Orientation

During the REU orientation, students engaged in team building ice-breaker activities, met with faculty, toured lab facilities, and participated in a Pre REU Survey. Students were welcomed to campus through a social cookout with faculty. Information packets about the campus and the city were provided to help them learn about the larger community as well.

4.3.2 Community Building

Students engaged in several events with the intent to build a sense of community among participants. Students engaged in a ropes course event, on and off campus social events, and several were housed together in on campus residences. At the start of the program, an ice-breaker event was conducted with the students and faculty by the university's outdoor programming office, Ventures. Faculty hosted both a welcome cookout and an end of summer party for all students and faculty, each held at faculty members' homes. Students joined with visiting international students to participate in a ropes course team building exercise, and also participated in social outings in the Charlotte area together. Students reported that the social activities contributed to the quality of the REU experience (89%).

4.4. Academic Preparation

4.4.1 Research and Academic Preparation

A GRE preparation course was offered to students to foster competitive scoring for graduate school acceptance. Pre and Post course scores indicated significant improvement for each student after completing the course.

The research projects were in the following areas: utilizing video game design as a method of teaching and learning computer programming, building a video game to teach native Australian cultural practices, using virtual reality to develop a 3D design of a cityscape, using a digital human for instruction, using digital human to rehearse theater performance, enhancing wireless sensor networks for data collection, and teaching middle school and high school students about the impact of wireless sensor networks on natural disaster alerting.

4.5 Professional Development

4.5.1 Weekly Seminars

Each week throughout the summer, students attended professional development workshops and seminars that focused on skill building. Topics ranged from research practices and career opportunities, to time management, diversity awareness and personality type in team work. These workshops were provided by various campus resources such as faculty members and Leadership Development professionals.

Table 4.5.1 Seminar series topics for REU year 2

Seminar 1	**Scientific research and technical writing tips**
Seminar 2	**Faculty research presentations**
Seminar 3	**Time management workshop**, through the University Leadership Development office.
Seminar 4	**Computing graduate and career opportunities**: the need for broader participation in computing, as well as methods for funding graduate school.
Seminar 5	**Facilitated cross-cultural discussion** with visiting Korean students on attitudes towards volunteerism, outreach, and community service.
Seminar 6	**Diversity training**
Seminar 7	**Faculty research presentations**
Seminar 8	**Personality and teamwork workshop**

4.5.2 Professional Presentations

Students worked with faculty to prepare, practice, and deliver professional presentations of their research projects at the end of the summer. Students, parents, and faculty from students' institutions were invited to attend the final presentations of student research projects. Each student presented an overview of the project outcomes. Mention award recipients

5. Findings

Evaluation:

Formative. New for the 2007 program, several formative instruments were utilized throughout the summer to maintain program efficacy. Students submitted bi-weekly reports to highlight their activities and to denote what areas of additional research support may have been necessary. Weekly professional development seminars were also evaluated to determine how effective and useful the topics were to students. An exit survey was also conducted for general purposes regarding administration of the summer program.

Summative. The 2007 Pre-REU and Post-REU survey instrument was designed to measure student expectations, exposure to research, self efficacy, help seeking behavior, and computing identity so that overall program affects could be determined. These constructs were compared during the Post-REU Survey to measure transition in individuals, the group, so that patterns could be discerned. Fifteen students responded to the pre survey, and eight responded to the post survey; a response rate of 79% and 50% respectively. Longitudinal follow up surveys will be conducted to measure long term impact of the summer research experience on participants' academic and career preparation.

During the 2006 program, a post-program survey was administered. The 2007 instrument, based upon the prior year survey, was an expansion to gain further information from participants and increased measurement capacity. Therefore, only a few items can be compared between year 1 and year 2 at post-assessment. Comparisons are noted when applicable.

5.1 Pre REU Survey Findings

Exposure to Research:

Academic: The large majority of students reported that they had completed computing courses and been required to make presentations (80%) at the start of the program. However, only 13% reported having taken a research methods course, and 27% having been involved in prior research projects. Almost half (40%) had taken a statistics course prior to the summer. The majority of students reported that they knew "**little" or "nothing**" in the areas of: **science of design**, **research proposal write up**, **project management**, and **applying to graduate school**. Most students reported satisfaction in the following areas of knowledge at the beginning of the program: ethics in science, finding research articles, research presentation preparation and presenting. **Strong knowledge gains were reported in all areas of content** (Table 5.1). Theory/algorithms, Software engineering were content areas with the strongest reported gains in exposure with gains of 24% and 20% respectively. Table 5.1 reveals the computing research areas that students reported prior exposure to during the REU orientation week in comparison to their exposure at the close of the program. All but three areas increased strongly in level of knowledge.

Chart 5.1. Knowledge Content Awareness 2007

Knowledge Areas	Pre-Program	Post-Program
Science of Design	43%	80%
Research Proposal Write Up	29%	60%
Application to Graduate School	29%	70%
Technical & Scientific Writing Tools	57%	70%
Authorship Citations	57%	90%
Project Management	50%	70%
Gantt Chart Design	14%	20%
Research Process	57%	80%
Poster Design	43%	80%
Conference Participation	36%	70%

Initial interest in computing began in high school and college for most students, and in elementary school for a small number of students. Perhaps most surprising about students' reported encouragement was that the **majority** of students reported that **encouragement from teachers, friends, and relatives <u>was not</u> important** in their decisions to pursue computing interests. Most important factors which were indicated were that **computing/IT is enjoyable and interesting**, and that **it affords career opportunities**. Liking the idea of being a computer professional, along with the salary potential, were also indicated as important factors. In the open-ended question about what sparked their initial interest, themes of ***play, being good at something***, and ***tinkering*** and ***fixing*** emerged. **Problem solving and creativity appear to have motivated students towards computing research.**

Table 5.1.2. Prior Computing Research Exposure 2007

Research Areas	Pre-Program	Post-Program
Artificial Intelligence/Robotics	40%	50%
Hardware/Architecture	13%	0
Numerical Analysis/Scientific Computing	20%	20%
Programming Languages/Compilers	53%	60%
OS/Networks	13%	10%
Software Engineering	20%	40%
Theory/Algorithms	27%	50%
Graphics/Human Interfaces	53%	60%
Databases/Information Systems	33%	40%

Family/Friends/Other: The majority of our student participants have been exposed to research through a family member, friend, or other adult acquaintance. Sixty-seven percent of students indicated that they know a friend in research and an adult in research. Only 27% indicted that they have an immediate family member involved in research.

In 2006, most of the students reported having an immediate family member involved in research (78%), and 67% reported having friends involved in research. When asked how long they had been interested in research, half noted that their interest was longstanding. Of those that noted the research interest to be new, a theme emerged from respondents that they were surprised at their interest in research. As one student noted, “I just recently discovered an interest in research. The experience this summer has gotten me more interested in research as well as graduate school.” This comment directly supports the hypothesis that research experience cultivates graduate school interest.

Faculty Contact:

Prior to REU. Most students have been advised by faculty as to what courses to take, discussed research, and graduate school potential. A few indicated that they have discussed career decisions with faculty. Only 7% indicated that they have had no outside class contact with faculty. **Over half** (53%) indicated at least **weekly contact** with faculty in their departments.

Post REU. Students indicated that they felt they spent “about the right amount of time” with their faculty mentor, their graduate student assistant, and the other REU students. Responses indicated a strong level of teamwork across projects, with the large majority (60% and 70%) indicating that faculty, graduate assistants and their team determined together what research techniques to use and what steps along the process to take. As one respondent stated, the REU experience “helped [me] overcome anxiety of approaching faculty for help.”

Expectations: Top expectations from students as they began their summer research projects were to be challenged and have fun, to better understand how to do research, and to connect with faculty. When asked “I expect the REU experience to:,” the two highest strongly agree choices were: “Explore whether research and graduate school may be the right path for me,” and “Gain exposure to research literature in my field.” Open-ended responses to what they most hope to gain from the experience showed themes of gaining hands-on experience, and making new friends.
Results from the post-REU survey indicate that these expectations were met. **Students reported at the project end that the REU experience was challenging and fun (90%).** A large majority found the experience helpful in providing mentoring, understanding research, connecting to students like themselves, and deciding if computing is a good career path for them. An area for program improvement was indicated to be in developing students’ understanding of statistics, as evident by the lower percentage of students who indicated increased understanding of statistics (30%).

Self Efficacy

Computing: Self efficacy was overall moderate for the REU students at the start of the summer projects. Most students responded to items in this section with ‘moderately agree,’ an indication that confidence levels were modest at the start of their research. However, a few items stood out as needed areas for significant areas of improved efficacy: evaluating research studies, designing research studies, knowledge of computing research methods, and writing research results. **Gains were made** in all but two **academic items (Table 5.1.3)**. Students reported a decrease in their presentation confidence, and increase in frustration regarding research. Sixty-six percent reported that they found research to be challenging and exciting (moderate and strongly agreed), and **87% thought that learning to do research would be enjoyable**. In terms of feeling like they "fit" into computing, significant increases between pre and post survey responses were indicated.

Table 5.1.3 2006-2007 REU Participant Academic Self-efficacy

Academic Self-Efficacy	2007 Pre	2007 Post	2006 Post
I am confident in my ability to discuss computing research.	73%	90%	99%
I am confident in my ability to design a computing research study.	13%	60%	99%
I find research to be challenging and exciting.	66%	80%	99%
I am confident in my knowledge of computing research methods.	26%	60%	99%
I am easily frustrated when doing research.	7%	20%	33%
I am confident in my ability to present research findings.	66%	60%	N/A
I thought learning to do research was enjoyable	67%	87%	99%
I feel like I "fit" in the field of computing.	73%	80%	N/A
I would like to obtain a PhD in computing.	80%	90%	N/A
Research in computing is important for identifying problems and solutions of value to society.	94%	90%	100%

Career: A high majority of students indicated strong agreement with the items regarding career efficacy, and thus, show a well developed sense of career efficacy at the onset of their research projects. They believed overall that they will be successful in computing fields, that they fit in, and that they can cope with being a minority in their chosen field. Only 3 students indicated lower career efficacy than the overall group. 80% indicated that developing research skills is important to their career goals.

As far as academic plans were concerned, all students indicated an interest in graduate school at the start of the program, however one student indicated at the end of the program that graduate school was no longer an interest. An encouraging finding was that 70% of the students indicated an interest in **pursuing a doctoral degree in computing at the end of the program**, up from only 46% at the start. Eighty percent of students expressed an interest in pursing a masters degree in computing at the close of the summer program, up from 73% prior to beginning the REU. Plans to remain in the computing field increased from 73% to 80%.

An interesting theme emerged from the open-ended question regarding concerns that the students had for the summer experience. All but three students indicated their **concern was their own inadequate skills preparation**. Several mentioned the **short time period as a concern**, given their project goals.

Help Seeking/Coping Behaviors: Overall, the help seeking behaviors of incoming REU participants were strong at the beginning of the summer program, which is an indicator of degree persistence and academic success. Forty-five percent stated that they would often or always discuss problems with faculty directly with that faculty member. Switching sections of the course or doing nothing would never be the choice for 44% and 67%, respectively, of respondents, but by the end of the summer, 67% indicated they would never switch sections, instead, 66% would talk to the professor directly. Students were more likely to talk to the team member themselves (61%) than to a TA or professor about a problem with a team member (56%).

Computing Identity/Value of Computing Research: An overwhelming majority of the students entered the summer REU with the understanding that computing research is helpful to society at large. **Eighty-seven percent believe that computing research should focus on research which can be used to improve the lives of others**. A significant change in post survey responses indicate that students learned that research in computing is important for identifying problems and solutions of value to society (90%, up from 74). In measuring attitudes and beliefs of the students regarding research, student open-ended responses all shared a theme of innovation and creativity. Several students mentioned limitless possibilities and helping people through computing. This is a strong indication of the inherent value of altruism in our student attitudes toward computing.

Site Administration: Demographics of the students are reflective of our overall mission for the Summer REU, that of **serving/recruiting/retaining** under-represented students in computing. Table 3.1 above indicates the ethnicity distribution of our students. Just over half of the students were male (54%), with 47% female; ages ranged between 18 to 35 years old. Self reported GPAs were in general higher in major than in overall academics. As incoming first year college students, 38% of students were considering computing related majors. Of those that were not (32%), or were undecided (32%), most were considering math as a major. Ninety percent indicated confidence that they will graduate with their present major of choice.

Students reported high levels of satisfaction regarding professor ratings. The students strongly agreed with statements that faculty were accessible, interested in their work, helpful and supportive. Statement agreements regarding the graduate assistants were equally positive. In terms of the overall research project, students were highly stimulated by their projects and satisfied with their learning outcomes overall. One area of potential enhancement for upcoming REUs is to increase students' exposure to the variety of research approaches, as the student feedback was mixed as to their satisfaction with this exposure.

In response to an open ended item of what was frustrating about the experience, one theme emerged. Students indicated that the most frustrating component was encountering project glitches and feeling unable to resolve the issue. However, in response to what was most rewarding, the emergent theme from respondents was the confidence achieved from project completion. A secondary theme was problem solving.

Our overall hypothesis that the summer REU experience would increase the students' academic understanding of research, and will thereby increase their self efficacy has been indicated by the above mentioned outcomes. A significant positive shift in student responses to our construct variables of research exposure, computing efficacy, career efficacy, help seeking behaviors, computing identity and the value of computing were obtained. We believe that the continued success of the summer REU site is enhanced by the formative and summative data obtained.

6. Discussion of Findings

A majority of students (60%) indicated knowing an adult in a research career area, however, only 27% indicated that a family member is involved in research. This finding suggests that our marketing of the REU program is primarily attracting students who have knowledge of research as a profession. However, the authors note that the survey question could have been interpreted by respondents in such a way that they were reporting that they know faculty involved in research. In knowledge acquisition, while all areas improved significantly, the slightest gains were made in technical and scientific writing tools, project management, and Gantt chart design. It may be necessary to devote more attention to these areas in professional development seminars and/or through advising in future REU programs.

A somewhat surprising finding was that students reported a decrease in their confidence levels toward presenting research findings at the close of summer. Students reported anecdotally that they experienced some anxiety regarding their final presentations, which the principal investigators believe contributed to their decrease in confidence levels for making presentations. A slight increase in student levels of frustration regarding research was also noted, which was not surprising given that each research team experienced setbacks common in research projects. This reported increase in frustration however, did not deter students from long term commitments to computing; a large majority reported interest in graduate school and conducting research in particular.

Several themes emerged as to what research, teaching, and experience was provided by the REU experience: obtaining constructive feedback, working directly with faculty, and the endeavor of conducting research itself. Students reported an increase in knowledge and understanding of research design and implementation. Presentation and teamwork skills were reported to improve as a result of the experience by the majority of the students. Students reported that they had the opportunity to learn about other computing research during the program students reported that they did gain experience in how research is planned, conducted and reported. The professional development seminars were well received and students would recommend them for future REU students.

7. Publications and Contributions

At the time of the post REU survey, students were uncertain of where they would publish, but all commented that they had tentative plans to submit publications. Faculty and students indicated that one or more papers on AVARI are planned for submission. One paper has been accepted:

Barnes, T., H. Richter, E. Powell, A. Chaffin, A. Godwin. (2007). "Game2Learn: Building CS1 learning games for retention," Proc. ACM Conference on Innovation and Technology in Computer Science Education (ITiCSE2007), Dundee, Scotland, June 25-27, 2007. Others are planned but not yet specified.

Educational aids have been created for outreach in secondary and primary education: the digital human tutor, wireless sensor network demonstration, Game2Learn video games for primary, secondary and post secondary computer programming education. Several students attended a Digital Games Expo at Wake Forest University.

The principal disciplines of the research projects were computing, particularly video games, virtual reality, and wireless sensor networks. The conference presentations inform the profession of innovations and research developments, as well as market educational programs to the community. The educational products will serve several critical needs in computing: outreach to primary and secondary students to increase their awareness of computing, and to foster interest in computing careers, as well as to enhance learning for undergraduate retention in computing. These educational tools serve to teach programming skills and to attract student interest, therefore impacting recruiting and retention, in the effort of broadening participation in computing in under-represented populations. Research outcomes have supported the existing literature that research experience attracts students to graduate education. The impact from these research projects will address social problems of decreasing enrollments in computing education, will innovate commercial virtual training technology and wireless detection systems.

8. Where They Are Now

Of the fifteen 2006 participants, 5 have entered the computing graduate program at University of North Carolina at Charlotte, 7 are continuing their undergraduate computing studies. Four of the undergraduates returned for the 2007 REU, and one student obtained a Google internship. All 15 participants were invited to join the STARS Leadership Corps, and 10 of them did so. Of these 10, four are continuing in the SLC for the 2007-2008 school year. Of the nineteen 2007 participants, 9 were eligible to join the SLC and 7 of these have joined for 2007-2008. Three of these students applied for scholarships to attend the 2007 Grace Hopper and Tapia conferences. One of these students will be funded to present a poster at Tapia, and plans to enroll in the PhD. program at University of North Carolina at Charlotte in January 2008.

9. Summary and Conclusions

Our project goals were to: 1) provide a summer research experience that immerses each student into the activities and culture of a research lab; 2) increase students' understanding of computing research methodologies; 3) increase students' awareness of the broad array of computing research disciplines; 4) provide students with multiple points of support from a diverse group of peers and faculty mentors; 5) increase students' understanding of the process to apply to and prepare for entrance and success in computing doctoral programs. The findings from 2006 and 2007 indicate that we are achieving these goals, due in large part to learning lessons from formative evaluations in year 1 of the project.

Although the sample size is small, the survey information has been useful in measuring impact of the program on student graduate school and career plans. The data has also been instrumental in determining what enhancements can be made in order to expand our knowledge base of program impact for both student and faculty participants. Based upon the present evaluations, the student program, faculty participation, and research plan will be modified for future implementation to address issues raised from the current survey and to enhance the items to contain a wider scope of questions. These modifications will enable increased knowledge of what specific facets of the REU are helpful for both students and faculty.

Lessons from year 1. Several themes emerged from the survey that were addressed through program modifications in future sites: student research backgrounds, understanding of the importance of research, faculty advisor availability, and knowing someone involved in a research career. Since students participating in the REU originate from different university programs, they posses differing academic backgrounds regarding research preparation and knowledge of computing. As the surveys indicated, student exposure to research coursework and implementation process was various. To address the disparity between research backgrounds, students received formalized information on the research process during REU orientation. This research overview was designed to clarify misconceptions about the nature of research, to address topics on planning, conducting, implementing and reporting research, and to clarify how research is valuable to the both field of computing and to the larger community. Students also received information on the role of faculty and graduate student advising, to foster awareness of individual responsibility for seeking guidance. Of particular interest was the finding that the majority of students had been exposed to research either by a family member or by a friend. This finding was a clear indication that recruiting efforts have been most successful with students already familiar with research careers. Recruiting efforts were redesigned to appeal to students with no prior research exposure. To that end, follow up information will be obtained from students without previous exposure in an effort to determine what originally attracted them to research.

Faculty concerns about student preparation were addressed in the orientation to the REU site with focus on research education. Based upon faculty recommendation, the overall program format remained the same, however, additional time was given to the preliminary stages of project brainstorming and prototype design, allowing for clear project definitions. The consensus that small group interactions were deemed helpful for student work, team environment were formalized in future research projects to group students according to background, projects, and interests. Small group interaction facilitated the students' research education, as well as reduced faculty work load for remedial needs.

The combination of qualitative and quantitative survey items was expanded across survey sections (prior exposure to research, professor ratings, graduate assistant ratings, research training environment, self efficacy and attitudes, and site administration). By aligning additional quantitative items to the existing qualitative items, greater cross comparisons can be extracted for statistical analyses. The survey was offered prior to student participation in the research project, and again after the completion of the project so that attitude transitions can be measured.

The analysis from 2007 indicate the program had impact on student satisfaction, plans to attend graduate school, and attitudes toward computing, both before and after REU participation. With more data collection in subsequent years of the REU program, the program components of interest for comparison will be team environment versus individual environment, faculty mentoring styles, prior exposure to research, future career plans, social and academic activities. Measuring the degree of impact from the program components will inform us of which particular aspects contribute to broadening participation in computing. Comparing the before and after responses will inform us what student expectations are, how they are met, and how they are transformed, to facilitate program development. Measuring faculty attitudes toward participation and advising styles will be useful in defining the characteristics of student faculty relationships and in examining the types of interactions most conducive to increasing student interest in graduate education, research and computing in general.

In summary, the REU site was shown to be effective at enhancing student plans to pursue further graduate education. Students found their experiences to be rewarding and interesting in ways they had not anticipated. Faculty found the program to be overall effective at professional development for the students. In continuing to host a successful and mature REU site, future research endeavors can provide greater understanding of the program impact on both students and faculty. With the additional questionnaire items, the outcomes analyses can become more rigorous in allowing comparison of program elements across time. In examining faculty experience and student experience, we can begin to form a complete picture of the impact of REU on the academic environment as a whole.