

## 2.3 **Activities, Findings, and Recent Developments of the National Weather Center Research Experiences for Undergraduates Program**

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### 1. INTRODUCTION

The National Weather Center Research Experiences for Undergraduates (REU) program in Norman, Oklahoma, is a unique undergraduate career exploration experience, drawing upon the resources available in the National Weather Center's (NWC) state, federal, and university groups. The National Science Foundation funds REU programs to increase opportunities for undergraduate students to try research first-hand. Such experience is one of the most effective to attract and retain students in math, science, and technology fields (NSF 2004).

The purposes of this paper are to overview administration of the program, provide analysis of recent applications, share what we've learned in recent years, and introduce innovations recently added to the program under a 2-Year Extension for Special Creativity Award from the National Science Foundation.

The NWC REU program, and its predecessors, have been reported on previously (Lewis and Maddox 1991, Cortinas et al. 1996, Palmer 1998, and Palmer et al. 2000).

### 2. ADMINISTRATION

#### Recruitment:

Posters advertising the program are sent to over 200 US colleges and universities including all known meteorology programs, Historically Black Colleges and Universities, Tribal Colleges, many Hispanic Serving Institutions, and several individuals and organizations. E-mail is sent to UNIDATA and many

other professional and student E-mail lists, as well as to colleagues for networking. Application materials are posted to the NWC REU web site each December:

<http://www.caps.ou.edu/reu/application.html>

Several NOAA groups, AMS, and others link to our web site. NSF lists this program in their REU search.

#### Selection:

A committee composed of professional meteorologists with the varying degrees and levels of research experience found in Norman select ten students from across the country who represent the diversity of that year's applicant pool. Students are individually paired according to mutual interest with a professional meteorologist in the National Weather Center who mentors them through a 10-week research project.

#### Program Activities:

Each participant writes a 10-page paper and gives an American Meteorological Society conference-style presentation at the end of the program. Numerous field trips, lectures, and workshops expose the students to a broad spectrum of research topics and careers and provide an introduction to UNIX computers, statistics, severe weather forecasting, and scientific communication. Please refer to web pages for each year to see the broad range of lectures and other activities:

<http://www.caps.ou.edu/reu/>

### 3. ANALYSIS OF APPLICATIONS

The analysis of 365 applications received since 2001 provides a sample of the characteristics of undergraduates in over 60 colleges and universities interested in severe weather research. Data from these applica-

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**Table 1: Gender and Race/Ethnicity of Recent Applicants**

REU Year	# apps	# com	Gender		Race/Ethnicity				Year			
			M	F	W	H	NW	unk	Fr	So	Jr	Sr
1998	109	unk	63%	37%				?	3-7%	20-25%	45-55%	5-20%
1999-2000	80-100	unk	55-60%	40-45%	5-10% of applications							
2001	86	74	60%	40%	61%	6%		33%	6%	19%	52%	19%
2002	100	95	46%	54%	70%	3%	11%	17%	4%	25%	48%	21%
2003	106	95	49%	51%	55%	7%	13%	18%	6%	14%	57%	22%
2004	116											

*In the table above, # apps=number of applications, # com= number of complete and eligible applications, M=male, F=female, W=white, H=Hispanic, NW=non-white (applications indicating a race underrepresented in the atmospheric sciences), unk=race/ethnicity unknown, Year=year in school at time of application, Fr=freshman, So=sophomore, Jr=junior, and Sr=senior.*

tions have been entered into a statistical analysis software package.

Table 1 shows basic information about applications including: the number received, number complete/eligible, gender, race/ethnicity, and year completed in school. The number of applications had been fluctuating between 80-100 until the most recent two years, when 106 and 116 were received. The number of applicants indicating a race or ethnicity underrepresented in the atmospheric sciences fluctuates and may be correlated to efforts to recruit these groups. Finally, the majority of applicants are completing their junior year when they apply to the program.

Table 2 shows the first major listed on application forms. Most students are meteorology or atmospheric science majors, and most others are in complementary fields such as math or physics.

Gender and race/ethnicity information for our participants is shown in Table 3 and approximately parallels our applicant pool.

In order to better understand how to effectively recruit for the program we began asking students how they heard about the program in 2003. Networking, such as through an advisor, professor, past participant, academic department, friend, professional society, or professional network was most frequently cited (60%), followed by use of the Internet (34%). The American Meteorological

Society was cited for both the annual meeting and the student resources section of the web site (6%).

Finally, the 1998-2000 applications were analyzed to see how many students came from schools that did not have graduate meteorology programs (52-65%), and how many applicants were certain or seriously considering graduate school (30-35%). Because we seek students who are capable, but unsure about graduate school, it is important for our selection process that references address the ability of the student to succeed in graduate school. Two-thirds of applications did not include a reference letter addressing their capability for graduate school, despite references being asked to do so. About half of the remaining third of applicants were unsure about going to graduate school, despite their references indicating to us that they had the capability to succeed. This latter group may especially benefit from an opportunity like REU to help solidify their graduate school and career choices.

#### **4. BEST PRACTICES LEARNED SINCE 2001**

The National Weather Center REU program is the result of the collective energy of many of my colleagues. I could certainly have a dozen or more co-authors on this paper!

**Table 2: Major of Applicants**

Major	2001	2002	2003
meteor./ atm. sci.	73%	69%	59%
physics	10%	9%	12%
geo/earth/env. sci.	5%	6%	15%
engineering	-	-	5%
math	4%	5%	3%
comp. sci	-	2%	3%
education	-	2%	-
chemistry	1%	1%	1%
biology	1%	0	1%
science	-	1%	-
political sci	-	1%	-
sociology	-	-	1%
unknown	5%	2%	-

**Table 3: Gender and Race/Ethnicity of Participants**

Year	M	F	# U	DNA
1998	6	4	1	
1999	5	5	2	
2000	6	4	unk	
2001	4	6	1	3
2002	5	5	1	1
2003	5	5	1	3
2004	6	4	0	2

*As before, M=male, F=female, #U=number of applications indicating a race or ethnicity underrepresented in the Atmospheric Sciences, DNA=did not answer race/ethnicity.*

While our program activities are constantly evolving, the following are particularly valued by our participants. Many of these activities have developed through iterations between our ideas and our participants' feedback.

**4.a. Practice Talks:**

Practice talks were added to periodic pizza lunches in 2001 and have continued to the present. Several objectives are met through this activity. In the first talk on their overall project goals, students are forced early in the program to retain a macroscopic view of their work while struggling to learn computers, data processing techniques, and more. The second talk occurs mid-way through the program and includes a project status and challenges both overcome and still in progress. Networking between students and mentors has proven incredibly helpful to a few students each year and all students are relieved to learn that *all* their fellow students are also facing computer, data, and other challenges in their work. This particular lunch results in an incredible increase in morale. A third lunch, near the end of the program, initially included reflection on their experiences with the nature of research. The third talk is now a 5-7 minute piece of an hour-long talk. While left to the discretion of individual stu-

dent-mentor teams, I suggested this talk might cover background for their study (literature search) or a discussion of methodology. Other student feedback resulted in talks being progressively longer (1-2 minutes, 3-5 minutes, and 5-7 minutes) and adding anonymous feedback on presentation style and delivery to the second and third talks at the request of participants. Finally, because students experience a great deal of stress in anticipation of questions after their final presentation talks, we now include a few questions to each student after their third practice talk.

**4.b. Improvements to the Application Form:**

The selection committee struggles to narrow our highly-qualified, large applicant pool to only ten students each year. One of many challenges is evaluating the nature and quality of the research experiences some applicants have. These experiences range from data-entry or other nominal supporting roles to fully-engaged, hands-on experiences. The application was modified to ask students to explain, if they had research experience, why they wanted to be in our program. This has been effective in encouraging those students to elaborate on their research experience. Students are also asked to describe how they are exploring or pursuing their interest in mete-

orology outside the requirements of their curriculum. Knowing students are quite busy and also valuing all extra-curricular activities, we do not hold an absence of activity against a student, but this question has provided interesting insight into some students the application would not otherwise have provided. For example, a recent applicant had chosen a small school without a meteorology degree program, but had taken time to build a weather station with his dad.

The reference form instructions were also modified to clarify that REU programs seek students who have demonstrated characteristics necessary to be successful in a research career, but who have not had an opportunity to explore or seriously consider this career. Additional research experience is certainly beneficial to students who have had research opportunities, but we do not wish to turn down an inexperienced, highly-qualified student in favor of someone who has already had the experiences necessary to clarify career direction.

#### 4.c. Participation in Field Programs:

Local principle investigators for the International H<sub>2</sub>O Project (IHOP) worked with me to leverage their proposal with my existing REU grant to provide opportunities for students in their project. Our REU students were important participants in the mobile mesonet and photographing vehicles. Mentors and students alike agreed it was a valuable experience, even though it would hamper students' progress on their projects. Projects were scaled back accordingly and students were encouraged to make as much progress on their projects as possible between deployments. IHOP also allowed a unique opportunity for students in a supplemental REU at Pennsylvania State University to join us for several activities.

A few NWC REU students also staffed mobile mesonet vehicles in the final few days of STEPS, the Severe Thunderstorm Electrification and Precipitation Study, in 2000.

Field projects sometimes bring scientists and equipment from elsewhere to Norman. We have taken advantage of this several times, asking visitors to provide lectures or tours of their equipment for our students.

#### 4.d. Communication Between Programs:

Although the NWC REU program works closely with the NOAA Storm Prediction Center's ORISE students, students did not seem to relate as closely across-program as within-program in some years. Even before beginning to pursue a Ph.D. in adult education, I found that simply engaging students via E-mail accomplished this task. Further inspiration, however, came from reading about an activity Knowles (1975) routinely did in his workshops. I now start E-mail introductions between all students and myself by introducing *what* I am - my work or student status and what experiences, knowledge, or skills I have that are relevant to this particular situation (REU), and *who* I am - a few things that make me different from any other person, such as my aspirations, feelings, needs, and values. [Note that "*self-directed learning*" is a complex phenomenon, is relevant to group settings, and requires support to be accomplished well (e.g. a recent, comprehensive summary describing how to effectively facilitate self-directed learning is described by Mann and Gelula 2003).] This worked so well I repeated the activity between mentors at the mentor meeting and between students and mentors at the welcome picnic. I will continue this approach in the future.

#### 4.e. Workshops

Several workshops have become permanent features of our program, providing needed skills or knowledge or supplementing the overall REU experience. These include: *Introduction to UNIX* (Dr. Mark Lawfersweiler, OU/SOM), *Being a Scientist* (Dr. David Schultz, OU/CIMMS), *Introduction to Statistics* (Dr. Mike Richman, OU/SOM, and Dr. Kim Elmore, OU/CIMMS), *Scientific Communication* (Dr. David Schultz), and *Severe Weather Forecasting* (Mr. Robert H. Johns, retired NOAA/SPC).

#### 4.f. Participation and Presentation at a National Conference

End-of-year funding has often been sufficient to allow at least a few students to present at and attend the American Meteorological Society's annual meeting. Their experiences prompted me to add this as a formal component in the extension of this grant. At a past annual meeting, for example, one student discovered a way to combine her interests in

meteorology and astronomy. She is now pursuing a graduate degree space weather.

#### 4.g. Critical Thinking:

After taking a course titled *Research on the College Student*, I began seeking ways to add critical thinking activities to the REU program. Pascarella and Terenzini (1991) provide a summary of research in the development of critical thinking and formal operational reasoning (the capacity for scientific reasoning). Most gains in these skills occur during the first two years of college. Because REU participants are generally juniors and seniors, they are likely to have already experienced the largest gains in formal reasoning, but are not likely to have had much opportunity to apply those skills to scientific problems. I base my supposition upon my own experience as an undergraduate physics major in a small college, what I hear my program participants relate to each other as they compare their undergraduate programs, and upon a tendency for references in applications to my program to indicate they have no basis upon which to judge the writing or creative skills of the applicant. When three colleagues realized the potential for the movie *The Day After Tomorrow* to become an REU activity, I agreed, and we quickly contacted local experts on the science and policy of climate change to see if we could arrange a time to discuss the movie. Our panel discussion was lead by Dr. Joe Friday (OU/SOM and SAMRI), Dr. David Karoly (OU/SOM), Dr. Dave Jorgensen (NOAA/NSSL), Dr. Dave Stensrud (NOAA/NSSL), and Dr. Kim Elmore (OU/CIMMS). In program evaluations students rated this activity as one of their favorites and greatly appreciated the opportunity to learn more about what is real (and not) about climate change, when/how science can or should translate into public policy, and what other considerations come into play during policy-setting processes.

## **5. TWO-YEAR EXTENSION ADDITIONS**

The NWC REU program is now in the first year of a Two-Year Extension for Special Creativity from the National Science Foundation through which we will attempt to 1) stimulate increased opportunity for undergraduate research by bringing in two visiting

faculty to co-mentor students in the 2005 summer program, 2) explore how these programs are effective in helping students make a career choice, 3) help our participants network with each other and with the broader atmospheric science community, and 4) send all participants to a national conference to present their research.

#### Visiting Faculty Positions:

As previously stated, this program is forced to turn down more good students than we can accept each year. Through this idea, we seek to increase opportunities for undergraduates to participate in research in other institutions. We are actively recruiting to bring in two visiting faculty to co-mentor students in the 2005 program. This activity may also accomplish a number of additional objectives: invigorate the career of someone in a smaller institution with few resources for research, provide a unique opportunity for professional growth of non-tenured and/or non-tenure track faculty at any size institution, or infuse new research techniques from other fields.

We are seeking faculty employed in meteorology or a related field, or in a field where research methodologies might apply to meteorological problems. Tenured, tenure-track, nontenured, and nontenure-track faculty are all welcome to apply.

<http://www.caps.ou.edu/reu/application-fac.html>

#### Clarity on Career Choice:

Happy confusion about career direction is a common survey response at the end of the 10-week National Weather Center REU program. Students learn there are far more career possibilities than they were previously aware of, and many of them are appealing. The NWC REU program did not attempt to measure how each participant comes to clarity on career direction through the program. Student evaluations simply asked whether the student has a better idea about their career and graduate school plans at the end of the 10-week program. Note that clarification in any direction - toward research in meteorology, research in another field, or away from research - is the desired outcome of REU programs.

Students who choose to participate will keep Career Journey Journals, a modification of the learning journal (Brookfield 1990), to

help them become aware of their likes and dislikes of research activities and develop awareness of how their self-efficacy is affected by their experiences. These journals will be kept throughout the 10-week REU program to provide longitudinal information on the paths each student takes to clarity on career aspirations. Six students agreed to participate in this project in 2004; three completed the activity and partial information is available for a fourth. Journals will be analyzed to trace the path each individual student takes through the myriad of activities and experiences that constitute the REU to come to clarity on career direction. Regular program surveys will provide additional information and triangulation. Mentor surveys will provide insight into possible influences the mentor may have had on the participants.

Previous evaluations REU-type programs indicate that high-quality personal interaction with respected mentors and program directors, meeting like-minded fellow students, giving talks and presentations, and conducting research strongly affect confidence levels in undergraduate students (Seymour et al. 2004). The importance of confidence becomes clear in light of social cognitive career theory; specifically, the complex interplay between interests, ability, and self-efficacy (Bandura 1977, 1986) explains career aspirations of young people.

Recent research in vocational psychology supports this common finding of REU-type program evaluations. Nauta et al. (2002) document how recent advances in the field have found a positive correlation between self-efficacy and career interests. One of many suggestions posed by the researcher was that a longitudinal approach might help better understand association between personal and environmental variables, career interest and self-efficacy, as well as how these four factors interact. Understanding a path of causality might assist in student selection processes and in understanding how activities in REU programs drive the outcomes of those programs.

#### Enhancing Student Networking:

While some groups of students maintain friendships for many years after REU ends, they will ask about other students from their program year, and few students meet

across years unless they attend the same undergraduate or graduate school. The 2-Year Extension has provided funding to explore two ideas to help students network both online and in person. We are building a web site bulletin board and directory and will hold an REUnion in 2005.

By providing an opportunity to reconnect with old friends and acquaintances started during the program, as well as establish new ones, we will help the students network. Rogers (2003) explains how various kinds of social networks function to spread information. Close friends or colleagues are generally a fairly tight social group, so they tend to share the same information. The spread of new information, which could be called the *diffusion of innovations* (the title of his book), has been proven to come through weak ties, such as acquaintances. For example, weak ties, which can be thought of as bridges between social networks, were far more likely to be responsible for how people found new jobs than any other social tie.

#### Participation in a National Conference:

Students will start to truly see themselves as scientists as they're welcomed in a larger venue of professionals, such as can be found at a national conference. While a few of our student projects each year are worthy of a professional conference (two of several examples: Mazur et al., 2004, and Sears-Colins et al., 2003), the American Meteorological Society has recently added a venue for all student research, the Student Conference, now in its fourth year at this 2005 conference. Other professional societies also provide student venues, including the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS), and the Sigma-Xi Student Research Conference. Participants who have presented at past meetings cite the following benefits: a chance to meet many people in the field, to see the breadth of research being conducted, to learn new things about the science of meteorology, to learn about job opportunities, to meet graduate students and faculty from schools they are interested in attending, and to present their work to a wider audience. In these two extension years, funding is set aside specifically to allow all participants to present their research at a national conference.

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