A Look at OUr GAANN Program in Civil Engineering

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Abstract.

Congress authorized the GAANN (Graduate Assistantships in Areas of National Need) Fellowship program under Title IX of the Higher Education Act of 1965; it was first enacted with the Educational Amendments of 1980, and was amended by the Higher Education Amendments of 1992. The purpose of the program is to "sustain and enhance the capacity for teaching and research in areas of national need," and it is administered by the Department of Education. Here, "need" has a dual meaning: students must demonstrate financial need, and fellowships are awarded to disciplines viewed as traditionally having a shortage of well-qualified domestic students. Engineering is one such discipline. Since, from the outset, the program has targeted students who are interested in academic careers, statutory requirements dictate the course of study that GAANN Fellows pursue must include a structured education component, so that, upon graduation, they are prepared for both the educational and research missions of academia. Herein, we present an overview of OUr (University of Oklahoma) GAANN program, which we have been offering for the last seven years. A key feature of the program is an educational activity sequence that spans every year of the Ph.D. track; it includes components ranging from traditional TA (teaching assistant) duties to educational coursework on subjects in higher education to team teaching. Herein, we discuss this activity sequence in detail, and we also include observations by students who have progressed through various stages of the program.

1. Background, goals, and objectives of OUr GAANN program.

Those who participate in ASEE meetings know that research and teaching in academia are rapidly changing. On the educational front, teaching paradigms are undergoing profound changes: the average age of the student body is increasing; distance learning is becoming more commonplace; high technology is altering the role of the instructor in the classroom; active learning in team environments, which fosters communication and interpersonal skills, is replacing the traditional lecture mode[1,3,7,9,10,12,18,23]. Merging of the teaching and research fronts is also needed. Boyer[4] has called for moving beyond the "teaching versus research" debate by focusing on scholarship, which is an outgrowth of the full range of academic endeavors. In pursuit of scholarship, the integration and inter-relation of teaching, research, technology transfer, and service are all acknowledged and valued.

Thus, given this state of transition, we in CEES (School of Civil Engineering and Environmental Science) re-evaluated the traditional Ph.D. program and have identified what, we believe, a Ph.D. program should entail in order for the United States to maintain its lead in the highly competitive and economically important field of sustainable technologies, the theme of the GAANN program at OU ("OUr" program). The overall goal, then, of the program is to *fully* educate specialists in civil and environmental systems for the 21st century, so that they may assume leadership roles. To be fully educated, GAANN Fellows are immersed in a rich, interdisciplinary research program and engaged in a multi-year, structured educational methods component. The experience includes the following: holistic, interdisciplinary approach to civil and environmental infrastructure problems; collaborative research within and outside CEES that teaches valuable partnering skills; participation in CEES's novel educational efforts, including integrated curriculum projects, multidisciplinary design experiences, team learning, team teaching, and K-12 alliances; a full year in the classroom team teaching with a faculty member; and participation in new faculty seminars and at least two educational methods courses. Table 1 below lists 10 measurable objectives taken from our GAANN contract, that we are using to track progress of the fellowship program. Our broad-based program exposes GAANN Fellows to all of the rigors associated with a faculty appointment at a research-oriented university, viz, teaching, research, publications, technology transfer, and service. In essence, they function as aspiring colleagues.

Table 1: GAANN Program Objectives.

	Objective
1	Recruit ten well-qualified Doctoral students as GAANN Fellows in CEES to carry out research in sustainable technologies.
2	Target recruitment and retention of underrepresented students in engineering and science, especially women, Hispanics, and Native Americans.
3	Increase Ph.D. enrollment in CEES by more than the number of GAANN Fellows.
4	Select only Fellows who have outstanding academic records, who have indicated a desire to pursue careers in teaching and research, and who are interested in and excited about new research and education paradigms.
5	Advise Fellows so that programs of study lead to a Ph.D. within 3 to 5 years.
6	Provide education for Fellows in methods of instruction, including alternative and innovative pedagogical techniques, via a practicum and coursework.
7	Encourage (and support) Fellows to attend and make presentations at one educational and two technical conferences during their period of study.
8	Ensure that Fellows submit at least three articles for publication on their Doctoral research and help prepare one research proposal; encourage them to submit an article or conference paper related to their teaching experience.
9	Require Fellows to develop and maintain a portfolio of their research and teaching experiences and help graduating Fellows secure teaching or research appointments.
10	Ensure proper use of program funds, following all relevant Federal regulations.

2. A little bit about the chosen theme of OUr GAANN project.

While physicists often speak of the grand challenge of a unified theory, we believe that CEES

graduates face an equally-intimidating challenge: providing for expanding populations at lower costs while simultaneously protecting the natural environment. But currently, the US is not doing a very good job. One does not have to look far to see the deplorable condition of some of our nation's infrastructure: deteriorating roadways, crowded highways, water rationing, a backlog of Superfund sites, and outdated sewer systems are but a few examples. This is documented in the American Society of Civil Engineers (ASCE) 2001 Report Card for America's Infrastructure[25]. Grades from A to F (exceptional to inadequate) were given in 12 primary categories, where the grading considered condition, performance, capacity, and funding; example grades include roads (D+), transit (C-), schools (D-), drinking water (D), and energy (D+). The average grade was D+, and it was estimated that $1.3 trillion is needed to address the problems. A 2003 update revealed that conditions in many categories had deteriorated further and that estimated costs inflated to $1.6 trillion. Recent natural disasters and terrorist acts have added a new dimension: now infrastructure must not only be adequate, it must be robust, it must be resilient, and it must minimize risk.

Relative to the natural environment, the National Research Council estimates that between 300,000-400,000 sites with soil and ground-water contamination exist in the US, and that the cost of cleaning up these sites using traditional technologies will be up to $1 trillion[20]. The enormity of this problem alone dictates that lower-cost, sustainable technologies for soil and ground water remediation be identified. As another example, the US spends more than $120 billion/year for pollution control[22], yet a comprehensive study by the Heinz Foundation reports a significant gap in the availability and understanding of sustainable ecosystem function and recovery[11].

Obviously there is a great need for civil/environmental engineering and environmental science research that will develop more efficient, sustainable, and environmentally sound technologies to address these critical needs. Hence, the rationale for the theme of the GAANN project: "Sustainable Technologies in Civil and Environmental Systems." For purposes of the project, we define "civil and environmental systems" as the large, integrated components of the natural and built environment whose function is to support and sustain our society. Examples of these types of systems include civil infrastructure, such as bridges and water supplies, along with ecosystem management and environmental policy. We define "sustainable" in a broad sense, meaning technologies that are low cost and easy to maintain and that minimize adverse environmental impacts; we define "technologies" as either processes, products, or organizational strategies that are used to understand, design, and operate the systems.

3. OUr GAANN's educational program.

Many instructional preparation or development efforts center on short courses, such as ASCE's ExCEED[26]. However, we believe an even better model is to instill a *continuous* educational component across the Ph.D. program, beginning in the first year. This approach is similar to the NSF-sponsored PFF (Preparing Future Faculty) program[27], but we supplement it with innovative opportunities. Table 2 outlines our education plan for the GAANN Fellows; the plan assumes a four-year timeline for the Ph.D., but milestones are flexible in order to meet the needs of a diverse

group of students. A description of each year's educational activities follow.

Table 2: Instructional Activity Sequence.

Year	*Educational Activity*
1	IDP courses and programs; TA; Start teaching and research portfolios.
2	Apprenticeship; TA; EDU course 1; Update teaching and research portfolios.
3	Mentorship; IDP Programs; Update teaching and research portfolios; Mentoring.
4	Practicum; EDU course 2; Educational conference; Submit final teaching and research portfolios; Mentoring.

Instructional Activity Sequence - Year 1. OU has a nationally-recognized Instructional Development Program (IDP), headed by Dr. L. Dee Fink, that offers regular seminars on all aspects of university life and teaching methods. GAANN Fellows must attend one for teaching assistants and one that introduces new faculty to OU's organization and resources. Also, all GAANN Fellows serve as a teaching assistant (TA) for two semesters. We believe that being a TA is an important step in the maturation of future instructors; consequently, TAs are closely supervised and evaluated by faculty mentors. Increasingly, universities are using teaching portfolios, along with traditional research portfolios, as a part of the tenure dossier. GAANN Fellows are encouraged to keep a portfolio throughout. Portfolios are reviewed and critiqued annually by the GAANN committee.

Instructional Activity Sequence - Year 2. CEES is a progressive department and has a history of innovative instructional measures. Student evaluations that are consistently better than the college average and our numerous university and national awards provide evidence that the innovations we have developed are effective. For their apprenticeship GAANN Fellows participate in one the CEES initiatives listed below.

- At OU, CEES pioneered the use of technology (laptop computers with wireless communications) in the classroom[5], and we continue to lead the college. We use evaluation results to refine our approach to optimize the benefits of technology.
- NSF has heavily supported the "Sooner City" project, whose objective is to restructure the undergraduate curriculum around a common design (i.e., "open-ended") project[21,24]. Sooner City provides a venue for other initiatives, including just-in-time learning, problem-based learning, and technology-based education.
- Many CEES courses are replacing the traditional lecture/note-taking passive format, which has dominated engineering education for the past five decades, with active team learning[2,13], which places renewed emphasis on communication and interpersonal skills.
- Since 1992, our senior capstone course has been truly multi-disciplinary, where interaction among students models the typical consulting firm. This award-winning format (e.g., 2000 National Society of Professional Engineers' Education Excellence Award) has won praise from the students, faculty, alumni, and local practitioners[14,15].
- CEES has administered two NSF K-12 outreach projects: Adventure Engineering uses challenging and fun engineering scenarios to promote the discipline, and the Authentic Teaching Alliance uses teacher/student partnerships in a community-based setting. Students must complete a rigorous teacher training program.

Also in Year 2, Fellows take their first education course; two are recommended AME 5020 - Preparing for College-Level Teaching, or EDAH 5103 - Instructional Strategies in Adult and Higher Education. All of these courses, and the course, EDAH 5123 - Issues in Adult and Higher Education (Year 4) come highly recommended by IDP personnel for academia-bound students.

Instructional Activity Sequence - Year 3. During Year 3, GAANN Fellows team teach at least one course with their major professor. CEES has practiced team teaching for a number of years and has found the method to be more rewarding, for both faculty and students, than the traditional single instructor lecture mode[6,17]. Also, it allows the faculty mentor to provide immediate feedback.

IDP organizes faculty discussion groups on topics such as "Writing Good Tests," "Teaching Critical Thinking," and "Observing Outstanding Teachers." They have agreed to open these to GAANN Fellows, who attend one of their choice. The latter is particularly appropriate as it allows GAANN Fellows to observe teaching styles *outside* of the College of Engineering.

If a particular student's research topic and lab environment permits it, Fellows are encouraged to help mentor undergraduate researchers or even M.S. students. OU, and CEES in particular, has been encouraging the undergraduate research enterprise long before the Boyer commission report[4]. Undergraduates participate in research through three primary mechanisms: UROP, an OU-sponsored undergraduate research program that culminates with a campus-wide research symposium every spring; NSF-REU programs, which we have hosted over the summer for the last eight years; and students hired to work on single-investigator projects. Mentoring requires a much different skill set than teaching, so carrying out this activity in conjunction with their major professor is excellent preparation for academic life.

Instructional Activity Sequence - Year 4. In the fourth year, GAANN Fellows serve as one of the following: 1) primary instructor for a team-taught course; 2) sole instructor for a laboratory or recitation section; or 3) team leader for one CEES's K-12 programs (see above). Also, GAANN Fellows will take the second of the two required education courses (EDAH 5123).

Year 4 educational tasks culminate with GAANN Fellows submitting their completed teaching portfolio and presenting a paper at an education conference on some aspect of their teaching experience. One possible forum is ASEE (American Association for Engineering Education); many CEES faculty are active in ASEE, and GAANN Fellows are encouraged to join.

4. GAANN project administration.

As shown in Figure 1, all administrative activities are carried out by the GAANN Project Committee, which consists of six faculty members who represent the various subdisciplines with CEES. The Project Director is assisted by CEES staff. He attends to the day-to-day details, organizes committee meetings, and prepares reports. Each committee member coordinates one aspect of the program, as indicated in Figure 1. The Project Committee meets regularly to outline marketing activities, review application materials, offer awards, and monitor the program; it meets with each Fellow annually to review portfolios and evaluate progress toward their degree. Feedback is used to continually adjust the program. A Fellowship Oversight Committee (FOC) meets as needed and provides guidance to assure that project objectives are being met.

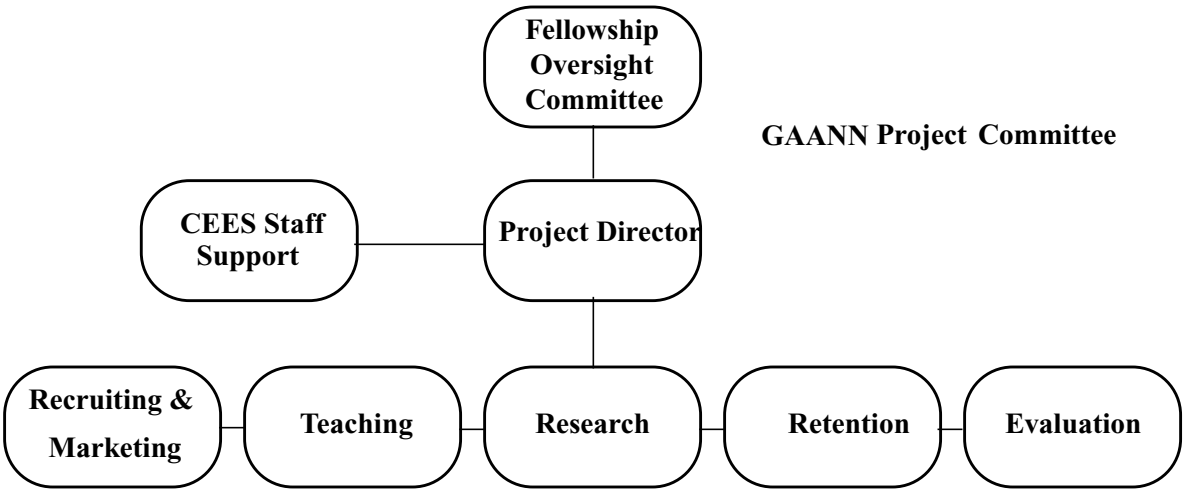

Figure 1. GAANN Administrative Structure.

5. Selection of Fellows.

Interested students are asked to submit a standard application for admission to the Ph.D. program, including transcripts, GRE scores, three letters of reference, a financial needs statement, and a statement of educational and career goals. Applications are screened by members of the GAANN Project Committee. Highly qualified applicants who demonstrate a serious interest are offered the opportunity to visit OU for an interview. Fellowships are offered to applicants who meet the selection criteria in Table 3.

Table 3: Selection Criteria for GAANN Fellows.

	Criteria
1	Demonstrate financial need, as determined under Title IV, Part F, of the HEA.
2	Are accepted into OU's Graduate College or are currently enrolled.
3	Have excellent academic potential as indicated by their GPA and GRE test scores.
4	Indicate plans to pursue a Ph.D. in CEES.
5	Show a strong interest in engineering and science pedagogy.
6	Identify areas of research interest related to the objectives of this proposal.
7	Plan to pursue a career in teaching or research.
8	Have strong letters of support.
9	Meet citizenship or residency requirements.

6. How are we doing?

6.1. Statistics.

CEES is currently administering their second successive GAANN Award. Since 2000, GAANN

has provided financial support for 17 students with the following demographic breakdown: *59% female* and 41% male; *12% Black, 12% Hispanic*, and 76% White. Of these, 35% have graduated with an M.S. or Ph.D., 53% are still in-progress, and 12% have dropped out of the graduate program (due to personal reasons). We believe this demographic data is not an anomaly; we have seen similar trends with our NSF REU Site program, which we have been running for the past eight summers. Over those eight years, *70% of the participants have been female*, 30% male. Also, approximately *27% of the participants have been minority. Five of these REU's were Native Americans*, one of the most underrepresented groups in science and engineering.

6.2. Student Perspectives.

*(Kendra Dresback: Three-year Fellow and Recent Ph.D. Graduate.)*As mentioned earlier, one of the educational components for the GAANN program is a teaching mentorship, which allows a Ph.D. student to team teach with their faculty mentor as a co-instructor of the class. Team teaching in this case means that the Ph.D. student helps in all facets of the class preparation. Though the course of my three years, I participated in a mentorship in two different semesters with my faculty advisor and also participated in one of the IDP seminars mentioned earlier. First, I will discuss my team teaching experience and then conclude with a discussion on the seminar.

The setting for my team teaching experience is an upper division course on open channel hydraulics, which serves as a professional elective for undergraduates and for many, serves as an initial introduction to the subject. Throughout this course, my faculty advisor and I utilized Readiness Assessment Tests (RATs)[18,19], which provide a way of covering the basic concepts that we felt can easily be obtained from the students reading on their own without added lectures on the material. RATs provided a way for us to include more team-based activities though the course of the semester. Further discussion of the class and the active learning or team-based activities of the course can be found in a paper devoted entirely to the topic[6].

Throughout this process, my faculty advisor and I met before each class to discuss the class activities and the topics to be covered in the upcoming class period. This meeting gave us an opportunity to plan our respective roles in directing the activities for the next class period. Further, this meeting provided a time for my faculty advisor to indicate which points he felt should be emphasized in the subject and to indicate which material he felt the students would find difficult. I also participated in preparing homework assignments, quizzes (RATs) and test questions, so that my experience include all aspects of the class preparation.

I feel that my team teaching experience has helped me to understand all facets of class preparation and has shown me how both passive and active-learning can be accomplished in the class. The mentorship from team teaching helped me gain experience and develop confidence in my own abilities. The feedback from my faculty advisor, indicating my strengths and weaknesses and how I could improve, was a valuable aspect of the team teaching experience. The team teaching experience helps to develop a personal teaching style and promotes self-evaluation. I feel that this team teaching experience was rewarding for all who were involved and has provided me with a solid foundation for teaching a class on my own.

Next, I also participated in one of the aforementioned IDP seminars, which is another aspect of

the GAANN educational component. The seminar I attended was entitled "Observing Outstanding Teachers" and is open to both experienced and novice instructors, along with GAANN Fellows. The format of the seminar was as follows: 1) The attendees identified several instructors' classes, which they felt were examples of outstanding teaching; 2) These instructors are notified that the attendees would like to observe one of their classes during some portion of the semester; 3) After the attendees observed the classroom instruction, the instructors are invited to a meeting of the seminar to discuss their teaching philosophy and the class. At this time, the attendees can ask the instructors questions about the class and what was observed.

In this workshop, I was able further my instructional development by observing several different fields of instruction and several different teaching styles. One of the courses that we chose to examine was an online literature class. This was quite interesting, considering the current debate over online education vs. traditional education. I also found our observation of a religion class interesting due to the lively discussions. It was beneficial to discuss how the instructor handled differing opinions in the class. I feel that for me this workshop provided a chance to observe several different teaching styles in areas other than engineering. It also allowed me to observe how different instructors handled classroom situations.

(Evan Tromble: First-year Fellow.) One of the reasons I decided to attend graduate school is because I would like to eventually become a college professor. The course, "Preparing for College-Level Teaching," was my first GAANN educational endeavor aimed at enhancing my abilities to lead college classes.

The overriding theme of the course was that student learning should be the focus of college professors, not the instruction itself. This theme was presented early in the course in readings on the changing paradigms in higher education, from teacher- to learner-centered. The readings indicated that college-level teachers need to be aware of different kinds of learning, as well as different instructional mechanisms to address the various learning categories. This is a large change in the pedagogy from the current state of most engineering education, which stresses transfer of knowledge through lectures by professors.

Another major theme in the course was preparation before entering the classroom. Rather than outline the subjects to be covered in lectures, professors should generate learning goals for each major section of a course. The learning goals should address the different kinds of learning in the taxonomy of significant learning[8]: (1) foundation knowledge; (2) application; (3) integration; (4) human dimension; (5) caring; (6) learning how to learn. Furthermore, learning activities should be planned to help students meet the learning goals, and feedback and assessment procedures must be in place to evaluate student (and teacher) performance and to provide feedback to the students. Dr. Fink outlined his learning goals for the course during the first class period, and did an outstanding job of designing learning activities to attain the goals and address different types of learning. For example, out-of-class readings covered a lot of foundation knowledge, team-based learning relates to the human dimension, and the independent learning projects correlate to learning how to learn.

The most beneficial activities, in a course, usually involve application of foundation knowledge, and this was certainly the case in this course. The mid-semester project was to design a course for

Rigid Body Mechanics, a sophomore level engineering course. As a team ("Preparing for College-Level Teaching" was taught using team-based learning), we had to create learning goals for the different kinds of learning. Additionally, we had to outline learning activities and feedback and assessment procedures for the course. Personally, I found the application of the principles to be difficult, but rewarding, because it added depth to my understanding of some of the key topics in the course.

As I move forward in my development as an educator, there are a number of ways in which this course will help me. Along with all of the foundational knowledge and practice applying concepts, I also have a better sense of the strong correlation between how well you design a course and the level of student learning that occurs. Additionally, I am aware of the connection between performance as a teacher and assessment of your teaching, including self- and outside observer assessment, video and audio tapes, and student evaluations, feedback, and performance. Each of the mechanisms has strengths and limitations, but by integrating them, you can develop a significant assessment strategy.

As a result of the course, I am definitely more confident about my ability to be a productive teacher now than before. I also realize that I do not have to know everything about a given subject. Rather in teaching, it is most important to know how to facilitate student learning. I do not have to stand at the front of a classroom and lecture three hours each and every week, although I can if I think it is the best way to promote student learning in a given situation. My independent learning project for the course focused on problem- and project-based learning, which I think would be very effective formats for upper level undergraduate and graduate engineering courses.

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8. Biographies.

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Dr. Kolar is Associate Professor in CEES at OU and Associate Director of the Environmental and Groundwater Institute. B.S. degrees in CE and Math are from the U. of Idaho; Ph.D. is from the U. of Notre Dame (GAANN Fellowship). Research centers on computational hydraulics; educational interests include bringing "real world" engineering into the classroom via the Sooner City project. In 2000, he received the ASEE Dow Outstanding New Faculty Award.

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Dr. Dresback is a Research Associate in CEES at OU. Undergraduate and graduate degrees in civil engineering are from the University of Oklahoma and her Ph.D. is from the University of Oklahoma. Her dissertation work was funded from GAANN and through two grants from the DOD and NSF. Research centers on computational hydraulics. In 2005, her dissertation received an Honorable Mention from the Universities Council on Water Resources.

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Evan Tromble is a graduate student in CEES at OU, funded by a GAANN Fellowship. His undergraduate degree in engineering (civil specialty) is from the Colorado School of Mines; his graduate research is in the computational hydraulics.