

AC 2007-485: UNDERGRADUATE RESEARCH EXPERIENCES THAT PROMOTE RECRUITMENT INTO THE FIELD OF ENVIRONMENTAL ENGINEERING

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Undergraduate Research Experiences that Promote Recruitment into the Field of Environmental Engineering

Abstract

There is a tremendous and rapidly growing demand for mid- and entry-level Environmental Engineers at consulting/engineering firms and utilities in many regions of the United States, and what seems to be a considerable increase in starting salaries offered by engineering consulting firms in the last two to three years is apparent. Furthermore, a Masters degree has become almost a necessity for entry-level engineers practicing in the areas of water and wastewater treatment and industrial waste management, particularly as more complex systems are evaluated and designed. The Environmental Engineering field seems to be moving to a point where a Masters degree is required to be proficient in the workforce, and the Ph.D. is the defining degree for technical work. At the undergraduate level, the objective should be to integrate realistic, useful, and externally-funded research experiences into undergraduate engineering education in a well-equipped laboratory, while at the same time providing a valuable service to regional industries, utilities, and consulting firms. These experiences bolster interest among students in the technical and scientific aspects of Environmental Engineering, thereby enticing and better preparing students to pursue these topics in graduate school and in future careers. These projects also expose undergraduates to both the environmental engineering profession (collaboration with practicing engineers) and larger research universities.

1. Introduction

1.1 Motivation - Shortfall In The Environmental Engineering Pipeline

A joint survey conducted by the Water Environment Federation (WEF) and the American Water Works Association (AWWA) and presented at the 2003 AWWA/WEF Joint Management Conference determined that within the next 10 years almost 80% of the professional workforce associated with public water and wastewater utilities (somewhat vaguely defined) will be eligible to retire. This statistic is readily apparent by observation of the attendees at national and state-level technical conferences hosted by these professional societies. As shown in Figure 1, the age distribution of U.S. Environmental Protection Agency (EPA) employees is likely representative of the profession as a whole. In the March 21, 2005 issue of *Fortune* magazine, an article entitled "Hot Careers for the Next 10 Years" suggested that there will be a 54.3% increase in the number of environmental engineering jobs over the next 10 years, the highest of all the listed professions and well above that predicted for careers such as network systems and datacom analysts, software engineers, and biomedical engineers. Other publications have indicated similar trends.

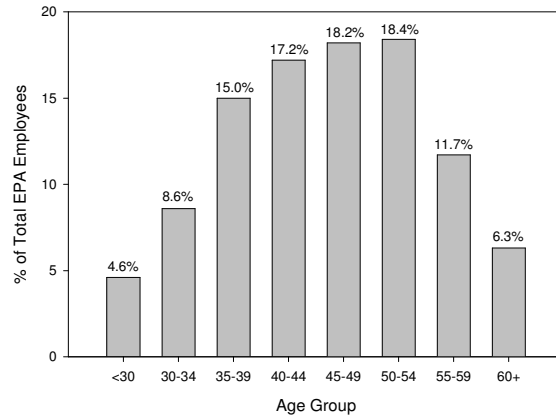


Figure 1. Age Distribution of EPA Employees (EPA Human Resources data as of 3/23/02).

The 2005 and 2006 national conferences of WEF (WEFTEC) and the American Water Works Association (AWWA) also highlight this issue, with several workshops and technical sessions dedicated to the changing workforce, succession planning/management, retirement of the baby boom generation, etc. It is becoming clear that the retirement of the baby boom generation will have a dramatic impact on the environmental engineering profession, perhaps more so than other engineering fields. This is likely due to the significant recruitment of baby boomers into the environmental engineering field in the 1970's at the time when major federal environmental laws and regulations were promulgated. With the commonly reported saturation of the environmental engineering field in the 1980's and 1990's and the emergence of the information technology boom, it seems that the baby boom generation represented the backbone of the professional environmental engineering workforce during this time, with proportionally much less recruitment into the field as compared to other engineering disciplines. Although some of these predictions for the environmental engineering profession are quite speculative, the trend is apparent – there will be a significant demand for technically qualified Environmental Engineers over the next 10 to 20 years.

Though similar activity is occurring in other parts of the US, in our region as an example, this trend is now coupled with a recent emphasis on reducing nutrient load from point sources into the Chesapeake Bay watershed. The Virginia Department of Environmental Quality has set a 2010 deadline for compliance with water quality-based nutrient limitations that approach the limit of technology (LOT) for all significant municipal and industrial dischargers (currently defined as TN = 3 mg/L and TP = 0.1 mg/L). In addition, technology-based nutrient limitations at the LOT are also being considered with the expansion of any of these treatment plants beyond the current design capacity. As discharge permits are renewed, utilities and industries are being required to submit preliminary engineering reports within one year of the permit renewal date to meet these very stringent nutrient discharge limits. Based on the activity this is now generating in Virginia, it is becoming clear that the 2010 deadline will be very difficult to meet simply as a result of the demands placed on the environmental engineering community, not to mention construction requirements. There have been reports that there are not nearly enough qualified engineers in the region to complete this work by 2010, even if all of those available did nothing but this type of project work. Similar activity is occurring in other regions of the US.

Mid- and entry-level Environmental Engineers with a sound technical base are in short supply, and what seems to be a considerable increase in starting salaries offered by engineering consulting firms in the last two to three years is apparent. There is currently a tremendous demand for entry-level Environmental Engineers, although most are actively seeking employees that have obtained a Masters degree in this field. The American Society of Civil Engineers is actively debating its proposed “Body of Knowledge” concept that would guide engineering education for future engineers to obtain licenses and to practice professionally¹. At this stage, it seems likely that a Masters degree will eventually be required for engineering licensure. Based on my experience as a consulting engineer, a Masters degree has become almost a necessity for entry-level environmental engineers practicing in the areas of water and wastewater treatment and industrial waste management, particularly as more complex systems are evaluated and designed (e.g. for LOT nutrient removal). The environmental engineering field seems to be moving to a point where a Masters degree is required to be proficient in the workforce, and the Ph.D. is the defining degree for technical work.

1.2 Hypothesis

At the undergraduate level, the faculty should endeavor to integrate realistic, useful, and externally-funded research experiences into undergraduate engineering education in a well-equipped laboratory or with quality field equipment (e.g. a mobile pilot treatment system), while at the same time providing a valuable service to regional industries, utilities, and consulting firms. In fact, these experiences might even be characterized as consulting projects with an applied experimental emphasis, as opposed to basic research. An example could be an industrial wastewater treatability study that supports a consulting firm and their client, whereby this represents a service that the consulting firm was not prepared to or did not want to provide. These experiences bolster interest among students in the technical and scientific aspects of Environmental Engineering, thereby enticing and better preparing students to pursue these topics in graduate school and in future careers. These projects also expose undergraduates to both the environmental engineering profession (collaboration with practicing engineers) and larger research universities.

1.3 Objectives

The objectives of this paper are to:

- Describe the implementation of an externally-funded research program at an undergraduate-only engineering college.
- Explain the organization of the research program in terms of contracting and effective utilization of undergraduates (with information related to the demand for and the solicitation of these contracts).
- Describe how this program has focused on water and wastewater treatability studies (applied research) through small-scope contracts with local utilities, industries, and consultants that provide a valuable service to the funding organization and are well-suited for undergraduate research experiences in Environmental Engineering.
- Demonstrate through an imperfect survey of undergraduate engineering majors that those who participated in these projects are recruited into the field of Environmental Engineering and into graduate school.

2. Undergraduate Research

2.1 Background

Ph.D. granting universities have long expected their faculty to conduct an active research program, however in the past two decades an increasing emphasis has been reported in the amount of emphasis undergraduate-only engineering schools are placing on their faculty to build research programs². While some studies have questioned whether this has a negative impact upon the teaching experience, especially of technical subjects^{3,4,5}, it will likely continue to increase as administrators seek to improve faculty productivity and university income⁶, and states enact measures to encourage this⁷. The past two decades have also seen a concomitant increase in the desire from university administration through federal granting agencies for engineering faculty members to develop active learning strategies to teach undergraduates, a practice recommended by numerous recent studies^{8,9,10}. Given a limited amount of time and pressure to actively involve undergraduates and conduct research, it is commonly assumed that new faculty intuitively understand the need to combine the teaching and research domains.

While that is true, it is certainly not obvious how to do this effectively, especially at an undergraduate engineering college. Most of this paper is a summary of experiences concerning what seems to work and what does not. It is very difficult to objectively quantify any of the trends or recommendations presented below. When conversing with colleagues from other schools, the author often must explain this seemingly unique position in academia and the approach taken in developing a research program and balancing that with a very heavy teaching load. One trend that became very clear as a Ph.D. student was that involving undergraduates in research projects clearly resulted in those students moving onto graduate school and into a career in Environmental Engineering. The author also found that the student was much more likely to be recruited into the field if they had a good undergraduate research experience; the student clearly understood the details and ramifications of the project (which typically required a more applied research topic), the student recognized that their work had significant implications for the project outcome, and the project scope was small enough so that the student could see the benefit of the work that was done. Clearly, most undergraduates major in engineering because they want to solve problems in society, not in textbooks. They therefore respond better when involved in engineering research, especially in the context of applied and relevant projects (as do the advisors).

2.2 Research with Undergraduates

The challenges of developing a research program that uses only undergraduate students are significant:

- The most obvious problem is that since undergraduates have less academic training, they require more supervision than graduate students. Although it might be expected they have less motivation than graduate students since only a class grade rather than their entire degree is dependent on the quality of the work, the author has found the process of self-selection for this optional research activity results in a very self-motivated student group.
- A less obvious problem is with the new professor rather than the student (author included): Most new professors have either no experience being undergraduate research advisors, or

little if they advised some as a graduate student. This can lead to inappropriate expectations. Graduate students are usually more independent and thus require less management experience on the part of the advisor.

- The high turnover rate from graduation means continuous loss of “institutional knowledge” with undergraduates. Professors typically have at most a maximum 5 semesters of work from undergraduates starting in their first sophomore semester, and the first semester is usually spent substantially in training. In some cases, this time is substantially reduced if classes taught during the junior year are necessary to inform the student prior to commencing a project. It is therefore imperative to establish a steady pipeline of undergraduates in which the more senior ones train the newest members to minimize the time the professor must spend teaching young undergraduates basic research skills (including laboratory, writing, and administrative skills).
- It can be very difficult to identify undergraduates with an aptitude for research and who will thrive in the unstructured environment of independent research. The author has routinely found that the highest GPA may not produce the best results. Traits that should be targeted include exactly the same characteristics that make good graduate students.
- The lack of large blocks of uninterrupted time with students makes it very difficult to accomplish research tasks. Undergraduate engineering students tend to be heavily loaded with classes which leave them much less time to work on research projects than a typical graduate student. Summer research time must be used effectively and completely (often conflicting with summer travel and vacation plans).
- Clearly, the heavy teaching loads characteristic of predominant undergraduate engineering universities causes significant time and resource limitations. The author continues to struggle with this issue, but several suggestions are provided below.

However, based on the shortfalls in the environmental engineering pipeline and the likely success associated with undergraduate research projects (that have the characteristics discussed below), faculty at undergraduate engineering universities should promote research that encourages interest in the technical aspects of Environmental Engineering, that fully prepares students for graduate study, that incorporates modern laboratory and active learning programs, and most importantly, that exposes undergraduates to the profession by collaboration with practicing professionals. Based on experience both at the author’s institution and at other universities, undergraduate research experiences seem to lead to a much more pronounced interest in the field and an increased likelihood of pursuing advanced degrees. Furthermore, the applied nature of the research serves a beneficial role for local industries and municipalities, providing useful technical guidance at minimal cost. Therefore it has been the author’s objective to do the following:

- to conduct projects that offer true technical value for the utilities and industries being supported (that may otherwise not have been able to conduct applied research of this nature)
- to increase the number of students participating in this work
- to promote dissemination of the results through publication and presentation
- to promote interaction of undergraduates with the profession through collaboration with regional utilities, industries, and consulting engineers
- to promote the involvement of undergraduates in environmental engineering professional societies

- to promote collaboration with and exposure to larger research universities (the eventual beneficiary in terms of graduate school applicants)
- to conduct technology transfer from research universities to local utilities and industries
- to provide education of utility and industry staff and awareness of more sophisticated technology and research

To ensure that undergraduate students are recruited into the field of Environmental Engineering and are technically qualified to meet the demands of contemporary projects, it is especially critical for colleges and universities, which specifically focus on undergraduate engineering education, to promote the value of subsequent graduate-level education. To ensure recruitment into the field, undergraduate research projects must generate excitement in the technical aspects of Environmental Engineering. To do this, the following guidelines for approaching research projects with undergraduates are provided:

- Provide projects that are small enough in scope and content that the work can be completed during a summer and academic year (e.g. initiated the summer before the senior year, continuing through the fall and spring semesters of the senior year). This might be a specific phase of a much larger project, but regardless, the student must be exposed to the full scope of his or her own project.
- Ensure that students are exposed to the profession through applied projects, the importance of which can easily be demonstrated by the value provided to the utility or industry.
- Pay the undergraduate a nominal stipend for both summer and semester work to enhance the perceived value of their work and to build confidence, interest, and ownership on the part of the student. The amount of pay is not important – even a negligible amount gets a good response. Tell the student their pay is coming from an outside source, and share the financial and project management details of the contract. Let them meet the specific people who are paying them to do this work and have them give some small presentation to them at an early time: the students will quickly learn that they must take full personal responsibility for the quality of their work.
- Provide summer research credit towards graduation requirements (3 to 6 credit hours).
- Ensure that projects emphasizing laboratory experimentation are combined with field trips, onsite meetings with utility/industry representatives, and/or field sampling exercises.
- Use groups of no more than 2 students for any given project task.
- Ensure that each project leads to at least one publishable paper (conference or journal) and a 20-30 minute presentation. Ensure that each student presents his/her work in at least one state-level or national meeting of a professional engineering organization.

2.3 Targeting Appropriate Research Projects

If at all possible, the research should be externally funded, though it might be more likely that the funding agency is an industry, consulting firm, or utility (rather than federal government agencies). It is clear that some sponsors/contracts/grants are more appropriate than others for undergraduate research projects. Sponsors should have an appreciation and understanding that the work will be completed by undergraduate students, they should value the educational component of the work, and they should have expectations fully in accordance with that of the research advisor. Contracts should have a duration of approximately one year or less and should result in publishable data.

Contacts can be quite difficult to make and develop to a point where a research contract follows. The author concluded that it is much easier when the faculty member has already established contacts as a result of prior employment in a consulting or industry position. In the Environmental Engineering field, the types of experimental work often being conducted by the author's group are that which the consulting firm or industry would likely have done themselves in-house 10-20 years ago, but have since decided that outsourcing this work would be more effective or have simply decided not to maintain this capability. Several suggestions to develop and maintain contacts involve:

- Attend conferences and technical meetings and serve on professional committees where potential contacts are likely to be present.
- Present yourself as someone who understands the applied nature of the problems experienced by potential sponsors.
- The most important thing to “market” is the ability to do experimental or modeling-based investigations for a fraction of the cost compared to the private sector. However, it is critical to be as upfront as possible about the compromises that come with using undergraduates to conduct the project. It is important not to directly compete with the private sector, but rather to find niche work that cannot be easily or effectively completed by the private sector. Attempt to get involved in a larger project where you provide a service that cannot easily be offered by the private sector.
- Present and publish work that has an immediate interest and application for potential contacts.
- Do a really good job on the first contract to establish a good first impression and a good reputation. Deliver more than promised and more quickly than expected in the first contract. While this may not be critical for federal agency grants, it is absolutely essential for contracts sponsored by industry, consulting firms, utilities, etc.

2.4 Developing Appropriate Contracts

Project success is not company critical. There needs to be an understanding on the part of the sponsor of the value provided to the project by the professor being involved and the low-to-zero cost of accompanying student time. The sponsor should be interested in not only the accomplishment and outcome of project, but they should also recognize and value the educational component. Sponsors may be able to favorably publicize their funding of an undergraduate project that encompasses the education of new engineers. The project should be in the advisor's area of competency with minimal requirements for new tools and instrumentation. The project might be one where the advisor could do all of the work (not including long-term experimentation or data collection) him/herself over a long weekend.

Proposals to conduct research should not be submitted blindly. In general, the scope of a project should be well defined through telephone and email correspondence such that the final proposal or scope of work is somewhat perfunctory in nature. Costs, financial and other administrative matters, and schedule should be addressed well ahead of the final proposal.

2.5 Publication and Intellectual Property

Each project should lead to at least one publishable paper (conference or journal) and a 20-30 minute presentation. The student should present his/her work at a state-level or national meeting of a professional engineering organization or other comparable venue. Limitations to publication include project confidentiality or intellectual property concerns, commonly associated with industry contracts. The project advisor should start very early in the project to discuss publication and the value for the student to present their work in a professional venue. Often though discussion, it is possible extract from the sponsor exactly what portions of the project should remain confidential and what parts could be published or presented. Again, the student's involvement in and understanding of contract confidentiality requirements provides an important lesson for future employment and graduate school. In some cases, the sponsor may be interested in publicizing that they have funded an undergraduate research project. At this level, it is also important to recognize that conference papers with podium presentations or posters may better benefit the student than a journal publication. Furthermore, visibility of the undergraduate research program at conferences may enhance the potential for future work with other industrial sponsors.

2.6 Administrative Issues

In most cases, a good approach is for the advisor to act as a project manager leading a team of project engineers. The students should be paid a nominal stipend from the project so that their perceived contribution to the project is valued. Students should be exposed to the financial and contracting issues associated with the project, because this experience is probably just as valuable as the technical aspects. Other administrative issues include:

- **Indirect Costs:** Most university offices of sponsored programs (OSP) require payment of indirect costs. In some cases, the potential project sponsors who would be funding these types of projects are not willing to pay the high rates now commonplace. The sponsor may be willing to pay indirect costs towards the Principal Investigator's stipend but not student stipends and other direct costs. The authors have found that the best solution is for the sponsor to contact the OSP, and specifically state that they will not fund the project unless the indirect cost rate is reduced to some value (email correspondence is sufficient). In most cases, the OSP at an undergraduate college is willing to accept the sponsor's terms versus declining the grant. The objective of the faculty member should be to discretely help the project sponsor to send this notice.
- **Student Credit and Stipends:** In some cases, there is hesitation at predominant undergraduate engineering colleges associated with providing students both a stipend and academic credit towards graduation requirements. The author's opinion on this matter is that the nominal stipend demonstrates to the student their value to the project, while the academic credit recognizes their achievements with respect to enhancing engineering capability and skills. In the VMI Civil and Environmental Engineering Department, the policy is that only 3 credits of independent research can count towards required technical electives for graduation requirements. Any additional credit can influence student GPA, but it does not count towards other mandatory technical electives and courses. The principal investigator must also decide whether lump sum or hourly student payments are appropriate. The author has found that some colleagues routinely provide hourly labor payment, while others prefers lump sum stipends. Lump sum amounts paid are approximately \$750-\$1,500 for a semester and \$3,000-\$4,000 for summer work.

- **Supplies and Travel:** The contract should include sufficient budget for supplies and travel costs. The author has found that this cost is often significantly underestimated during the budgeting process.
- **Professional Liability:** In cases where the project has immediate engineering design implications, the professional liability of the principal investigator can be a significant concern for the sponsoring organization, the university, the OSP, and the professor. In most cases, the OSP holds general liability insurance, but there is no professional liability and no Errors and Omissions insurance. In some cases, it may necessary to forgo the project due to liability concerns. Otherwise, one mechanism is for the professor and OSP to indicate that they accept no professional liability, and the indemnification for the project as a result of negligence, errors, and omissions is limited to the value of the contract. This may or may not be acceptable to the sponsoring agency.

2.7 Suggestions for Getting Help

Given the heavy teaching load typical of undergraduate engineering universities and the time required to advise a group of undergraduate students, there is a need for both administrative and technical support. Often, these schools do not have the administrative structure in place to fully support research contracts, and the faculty member is required to perform significant administrative duties in the execution of the contract. Several suggestions are provided:

- Hire existing college support staff using research funds to work on the side to manage and administer contracts
- Use laboratory technicians as much as possible to advise and guide undergraduate students
- Use senior level students to train incoming researchers

The author is employed by an undergraduate-only college with no graduate program. As a result, the research program to date has been staffed exclusively by undergraduate students. Combined with a heavy teaching load, the author has had as many as 7 undergraduate researchers working on applied and externally-funded research projects at one time. This work has focused primarily on industrial wastewater treatability studies and applied experimental work that directly supports local water and wastewater utilities. In order to grow the program and incorporate more students, assistance is required to mentor these students and to help manage their projects. Clearly, a Ph.D. student that is interested in this type of position at an undergraduate engineering college would be a great candidate.

With this idea in mind, the author recently worked with Virginia Tech to develop a collaborative program whereby alumni from VMI will attend graduate school at Virginia Tech, but conduct their research projects with author, supervised and externally-funded by the author. One critical role of these graduate students will be to mentor current our current undergraduate students on their respective projects, thereby providing additional resources that would allow more students to participate in undergraduate research. This program would also allow student to teach an undergraduate level course in our program under the mentorship of the Civil and Environmental Engineering Department Head and the author.

3. Experiences and Examples

The research projects that the author has emphasized directly support regional utilities and industries with a broad range of environmental issues. These projects tend to result in applied research that dramatically boosts student interest in this field and that enhance environmental engineering education through active learning. The following discussion provides a description of several recent externally-funded research projects. Since VMI encourages engineering faculty to pursue consulting activities, the author has also engaged in a number of municipal wastewater treatment and industrial waste management consulting projects. Very often, this consulting and independent research work leads to experimental laboratory and field research projects that involve students and are consistent with that discussed above – and at the least, establish good points of contact to solicit for potential undergraduate research opportunities.

3.1 Example Projects

A selection of recent projects is described below:

1. Assessing the impact of zinc ortho-phosphate added to the potable water distribution system for corrosion control on the inhibition of nitrification and BNR at a local wastewater treatment plant
 - Two students were involved in this project over a period of approximately one year.
 - An important aspect of this project was coordinating and negotiating a partnership between USEPA and the treatment plant so that this research could be effectively supported by both agencies.
 - Most of the experimental work was performed at the plant. Students worked at the plant for most of summer 2005, and the author spent on average 2 days per week with them at the plant.
2. Assessment of biological phosphorus removal in an oxidation ditch process
 - One student was involved in this project over approximately 6 months.
 - Research grant funded by the equipment vendor for the biological process installed at a local wastewater treatment plant.
3. Industrial wastewater treatability studies in support of remediation activities at a local Superfund site
 - Six students have works on various phases of this project over 3 years.
 - Project has included laboratory bench-scale testing, field pilot testing, and field process sampling.
4. Improvement of an established acid mine drainage treatment technology - controlled evaluation of vertical flow reactor performance and longevity using a passive dosing siphon.
 - One student was involved in this project over approximately one year.
 - The objective of this project is to evaluate the use of and design criteria for an automatic dosing siphon to minimize the accumulation of iron and aluminum solids in a passive acid mine drainage treatment process known as a vertical flow reactor, also known as successive or reducing alkalinity producing system.

5. Phosphorus removal by iron precipitation at a local wastewater utility.
 - One student was involved in this project over approximately 6 months.
 - This project involved a mechanistic evaluation of phosphorus precipitation kinetics and mixing effects by ferric iron.

3.6 Examples of Good and Bad Projects

Good: An industrial sponsor funded a project to evaluate the potential for a biological wastewater treatment process that they market to accomplish a new objective (i.e. biological phosphorus removal). In this case, the experimental work required to do this evaluation could not be accomplished by the sponsor themselves, and there was really no way to accomplish the project objectives by contracting to the private sector. In addition, the treatment plant of interest was located within 45 minutes, and sampling time was a critical factor. The industrial sponsor was also looking for an independent third party to perform the evaluation and to publish the results to increase the value of their future marketing claims about their process. The scope of work was negotiated by the sponsor and the author, and the final proposal was submitted without significant problems or delays. The experimental work was conducted during the summer, and a final report was submitted that was somewhat beyond the expectations of the sponsor. Abstracts were also quickly submitted for conference publications. For the specific treatment plant investigated, the experimental data were somewhat ambiguous as a result of factors beyond our control, but the sponsor asked us to continue our work with evaluations at other similar sites on the east coast (which required travel to those respective plants).

Bad: A project with which the author was involved during previous employment as a consulting engineer had changed hands and was currently being managed by a different consulting firm and a completely different group of engineers. On request from the client, the author was given a lump sum contract by the consulting firm to assist with the project because of his involvement over the last few years. It was clear the budget would not be spent, because the new firm was not involving the author in ongoing work associated with the project. As a result, the author proposed three beneficial tasks that could be completed with the help of undergraduate students and would result in the expenditure of the full contract amount. Through negotiation of the scope of work, one of the more research-oriented tasks that would have been quite appropriate for undergraduate student involvement was eliminated. The scope of another appropriate task was modified to be a relatively minor fraction of the project, and the primary project task evolved to become a standard field sampling and laboratory analysis exercise with no significant research question to be answered or controlled by the author and students. The primary project task was negotiated to a point where it could have been completed more effectively by a contract analytical laboratory and the consulting firm itself. The work was completed, but it was clear to all parties that the task was not appropriate for undergraduate student or university involvement. The consulting firm's expectations were not met. Fortunately, the outcome of the relatively minor research-oriented task was relatively successful, and the consulting firm may eventually implement systems based on that work.

4. Survey of Undergraduate Engineering Majors

In an attempt to refute or accept the hypothesis presented above, a simple summary of the fate of the students who have worked or are currently working on undergraduate research projects in Environmental Engineering is provided below. Although not at all scientific and difficult to compile a representative control group of students, the trend suggests some inclination to graduate school attendance and the Environmental Engineering (ENE) profession. However, it is clear that several of these students would have very likely been the ones expected to attend graduate school even if they did not complete an undergraduate research project.

Out of 17 students (ENE = Environmental Engineering),

- Two direct employment in ENE.
- One direct employment in ENE, followed by likely Masters in ENE
- Two Masters in ENE, and soon starting Ph.D. in ENE.
- One working on Masters in ENE, followed by employment in ENE.
- Three will start Masters in ENE, followed by likely employment in ENE
- One will start direct undergrad to Ph.D. in ENE
- One directly employed in Geoenvironmental Engineering, and now in graduate school part-time in that field.
- One completed Masters in Construction Management, and employed in that field.
- One directly employed in Transportation Engineering.
- One starting employment in Structural Engineering
- One serving as an active duty military engineer, and likely to attend graduate school in ENE.
- Two active duty military officers, and likely to enter employment as engineers.

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