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EXPERIENCES IN UNDERGRADUATE RESEARCH EXPOSING CIVIL ENGINEERING STUDENTS TO RESEARCH AT AN INSTITUTION WITH NO ENGINEERING GRADUATE PROGRAMS

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Abstract

The Engineering Programs at the University of the District of Columbia (UDC) solicited support from the Xerox Corporation to initiate a research experience for undergraduate students similar to Graduate Research Fellowships (GRF). For over 20 years now Xerox Corporation has helped to fund what is called "The Xerox Fellows Program" (so named in recognition of their sustained support). This program provides a small stipend for the student and one for a faculty mentor. The mentor and student agree upon an appropriate research topic. A school committee reviews and ranks the proposals; the Dean then ranks the fellowships. The fellows' experience has been very beneficial to both students and mentors who have participated in the program. This paper is a brief overview of the Fellows Program, including selected examples of student research projects.

Introduction

One of the most beneficial aspects of graduate studies is the opportunity for students to work as graduate assistants in either teaching or research activities. For the graduate student this has two primary benefits:

1. It provides income to assist the student to pursue graduate studies
2. It enhances the student's KSA's (Knowledge, Skills, and Attitudes) necessary for mastering the students' chosen discipline.

In the early 70s the authors felt that a similar experience would be equally beneficial to undergraduate students, and that it would enhance their ability to pursue graduate studies. This interest is particularly relevant to the University of the District of Columbia, since it is a relatively new urban institution of higher education, having only undergraduate studies in engineering and technology. From the authors' efforts to provide a research experience for undergraduates and from the generosity of the Xerox Corporation arose the "Xerox Fellows Program." The Xerox Corporation provides a small stipend for the student and his or her faculty mentor and the student experiences the challenge and excitement of the research experience through the mentorship of a faculty member.

This paper describes the evolution of this program and presents a few of the student research projects with highlights of some of the interesting aspects of undergraduate research.

Concepts and early development

At the very beginning of this program, a small stipend of $1,000 was provided for each Xerox fellow. Faculty received only personal and professional satisfaction for their participation. Student fellows and faculty mentors were selected on an ad hoc basis. As the program developed it became obvious that more structure in the selection of students was necessary. Also, while faculty mentors were not compensated for their effort, it became apparent that the scope of activities in which fellows and mentors could engage was restricted unless some funds could be made available for the mentor to purchase materials and supplies to support a research project. Toward this end, $500 was allocated from the Fellowship grant for the mentor to purchase supplies and materials. As the merit and benefits of the Xerox Fellows Program were realized, more faculty and students desired to participate in the program. To assure a fair and objective basis for the selection of fellows and mentors, procedures were initiated for mentors to request a Xerox Fellowship and for students to apply.

The current application forms and procedure are included in Appendix-1. Today the $500 given to the mentor may be used at his/her discretion.

Sample student Xerox Fellow projects

Project-1

Three years ago, a senior engineering student Gezahegn K. Asnake had an interest in a project in transportation. The transportation faculty member from the Civil Engineering program, Philip L. Brach, had just purchased state-of-the-art traffic counting equipment and software for processing traffic count data. Since the equipment and software had not previously been used, the faculty member required assistance in troubleshooting and experimenting with this new equipment. The student also mastered the use of the software that came with the equipment for analyzing traffic count data. The fellowship project consisted of the student assembling and using the traffic counting equipment.

An integral part of each fellowship activity is the preparation of a written report and the presentation of an oral report to an assembly of the department's students and faculty. For this particular project, the report was especially beneficial for the mentor and the engineering department because it explained the use of the new equipment and software. To test the equipment and software the student designed and implemented a field exercise to count the vehicular flow in and out of the university's parking garage. This process involved 24 hour-7 day counts of traffic in and out of the garage. This information would also prove to be useful to the university's facilities management.

An example of one of the learning experiences, possible only through such an exercise, was the realization by the student that technical instrumentation requires calibration and verification. On the first application of the traffic counting instrument, and the analysis of the resulting data, the student discovered that fewer vehicles exited the garage than entered. We were accumulating 30%-40% of the capacity of the garage at the end of each day. Obviously this was impossible (unless the cars were being disassembled in the garage and carried out!).

This proved to be an extremely useful learning experience for the student. He had to explore what was the cause of this anomaly. This meant he had to physically count the vehicles to validate the instrument's count. Through this process he discovered that the speed at which vehicles crossed over the counting mechanism influenced the count. This further led to the observation that because cars had to stop at the garage entry booth for an entry pass or to make payment, they crossed over the measuring tube at a very low speed. Upon exiting the garage, there was no need to stop and therefore they passed at a higher speed. From his search for the reason for the anomaly, the student discovered calibration of the measuring device depended on the speed of vehicles. As a result he was able to properly calibrate the instrument and obtain accurate data.

In his final report the student showed the demand for space in the university's parking garage warranted keeping the payment booth open until 8:00 pm at night. Previously the booth was closed at 6:00 pm and the gate left open so that students arriving for classes after that time could park for free. This study showed the cost of operating the booth for an additional 2 hours each week day would be cost effective. Thus, both essential engineering and economic principles were learned.

Project-2

A junior civil engineering student, Koji Harada, in collaboration with professor Brach, designed a Fellows project to confirm that the new digital surveying instruments are equally precise when read automatically using a digitally coded rod as when read traditionally by an instrument person. A procedure was designed to determine the difference of elevation of two points both by traditional human optical readings and with automatic digital readings. The accuracy of level reading when obtained traditionally is significantly influenced by the length of sight (distance from the instrument to the rod). The experiment included determining the difference in elevation by both methods for varying lengths of sight.

Selected results are displayed in Appendix-2. The results of this project provided evidence that the new automatic digital level was as good as or better than the traditional way of determining the differences in elevation. Appendix-2 shows excerpted sections of Koji's report indicating that for longer sights the digital readings were more consistent than the traditional human readings. This was expected because we know the longer the sight the more difficult it is for the human eye to discriminate the rod reading. To actually experience this was a valuable learning opportunity for the student. This project also provided the opportunity for the student to apply basic statistics to an engineering problem. See Appendix-3 for a sample of the student's results.

Project-3

In the spring of 2003, we worked with our architectural program to investigate the indoor air quality (IAQ) in buildings. Our architectural program is involved in the renovation and restoration of older buildings. One of the significant problems in these buildings (and some new buildings as well) is the quality of the indoor air as a result of contamination of the air by mold, chemicals leaching out of building materials, and from the use of cleaning agents. When exploring this problem we realized it would be beneficial for both engineering and architecture students to understand the problems associated with air quality in buildings, so we decided to develop a learning exercise related to these ideas.

A proposal was prepared and submitted to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) requesting funding to purchase the equipment necessary to monitor air quality. We were fortunate to receive a grant to initiate this research. See Appendix-4 for a copy of the proposal.

Drs. Brach and Zeytinci in collaboration with a nationally known expert in HVAC systems, Donald Carter, and a senior mechanical engineering student, Adrian Mirt, have initiated a laboratory fellow experience which is to begin in the spring of 2004. An anticipated benefit of this fellowship is the development of field experiments for monitoring building indoor air quality that will become part of our engineering and architectural curriculum.

Observations and Recommendation

The opportunity for undergraduate engineering students to experience the benefits of the research experience is "priceless." In this paper the authors presented just a few of the many beneficial aspects of exposing undergraduate students to the research process. Working with a mentor permitted the students the freedom to explore a topic on their own volition and discover by trial and error the struggles and elation that come with "original" work. True, the material was not new for the mentors but it was for the students.

In addition to the traditional value of the research experience, there were a number of ancillary benefits for our undergraduate students. We are a diverse urban institution of higher education, with a significant number of international students. The Fellowship program provided students for whom English is not their mother tongue another opportunity to improve their command of English. While not to the level desired, it is improved.

For all students the Xerox Fellowship program proved to be a maturing experience both professionally and personally. The authors found the extra effort required on their part as a mentor to be well worth the investment.

For those so inclined, we recommend the undergraduate research experience as an option for all undergraduate students.

Appendix-1 Xerox Fellows Application

UNIVERISTY OF THE DISTRICT OF COLUMBIA
SCHOOL OF ENGINEERING AND APPLIED SCIENCES

LABORATORY FELLOWS PROGRAM

The SEAS Laboratory Fellows Program **is an honors program for majors in the School of Engineering and Applied Sciences. It is a program to bring faculty and students together in a collegial relationship. This relationship is intended to enhance the professional careers of both the faculty and the students. The faculty member will benefit from the assistance of the Fellow in the laboratory. The Laboratory Fellow will benefit from the personal, collegial relationship with a professor as mentor.**

A Laboratory Fellow will work closely with a faculty member in a specific laboratory activity. The Fellow is obligated to spend approximately ½ day per week for a semester engaged in professional activity related to a specific laboratory activity (i.e., research/contract work).

Selection as a Laboratory Fellow requires a serious commitment on the part of both the student and the mentor (faculty member). For the semester of the fellowship, the Fellow will receive a stipend of approximately $1,500.00. The stipend will be awarded at the time of the presentation of the required paper specified below. A Laboratory Fellow will also receive a certificate and membership in the SEAS Laboratory Fellows Group (LFG). The LFG will be a special group at UDC. It will be an organization of the very best students from the programs in the School.

The following are the prerequisites for a student to be considered for selection as a Laboratory Fellow:

- **The student must be an upper division student (i.e., have completed the first 30 credits for the associate degree or the first 60 credits for the baccalaureate degree).**

- **The student must be in the top 1/3 of his/her major class (as determined by cumulative grade point average).**

- **The student must have an overall cumulative grade point average of at least 2.5 and a cumulative grade point average in major courses of at least 3.0.**

Upon completion of the fellowship, the Laboratory Fellow must present a short paper on the activity he/she was engaged in during the fellowship. The paper will be presented at an appropriate seminar to be scheduled by the Dean's Office in conjunction with the department and mentor.

Appendix-1 Xerox Fellows Application (continued)

The following are the guidelines and procedures for requesting and selecting Laboratory Fellows:

- **Faculty shall request the association of a Laboratory Fellow using a standard form (copy attached).**
- **The student selected by the faculty member to be a Laboratory Fellow must complete an Application for Fellowship form (copy attached) to be submitted with the faculty request.**
- **The forms are submitted through the appropriate department chairperson who must provide a brief endorsement of the request.**

The Dean will make the awards. The number of awards will depend upon funding.

UNIVERSITY OF THE DISTRICT OF COLUMBIA
SCHOOL OF ENGINEERING AND APPLIED SCIENCES

LABORATORY FELLOWS PROGRAM

Faculty Request For Laboratory Fellow

Faculty Member: ____
Department: ____

I would like to participate in the Laboratory Fellows Program. The following are the specifications for my laboratory activity:

Laboratory: Title________________________**Building**________**Room**_______

The Fellow is requested for the ________________**semester of 2**____________

The student selected for the Fellowship is:
Name __________________________**Social Security Number** ____________

The activities the Laboratory Fellow will participate in are:

____
____
____

The following are special requirements the Laboratory Fellow must meet in addition to the minimum criteria for Laboratory Fellows (e.g., specific course(s) completed, special skills(s), etc.).

____
____

Appendix-1 Xerox Fellows Application (continued)

I understand the special learning experience(s) the Laboratory Fellows Program provides, particularly the required report of the Fellow and I accept the responsibility for overseeing the Fellow's preparation of the formal report.

Mentor's Signature: ____ Date: ______________________

This request must be submitted through the Department Chairperson to the Dean's Office by the last day of class in the semester preceding the semester requested.

Endorsement of Department Chairperson:

____

____

______________________________ ____________________

Department Chairperson's Signature **Date**

UNIVERSITY OF THE DISTRICT OF COLUMBIA
SCHOOL OF ENGINEERING AND APPLIED SCIENCES

LABORATORY FELLOWS PROGRAM

STUDENT APPLICATION FOR FELLOWSHIP

Student's Name:

____

Department:

____Major:__________________________

Mentor (Major Professor):

____

Number of Credits completed: _______ Cumulative GPA: _______ Cumulative GPA in Major:

____

Endorsements:

Mentor:

____

____

____

Department Chairperson:

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____

____

The mentor and/or Department Chairperson shall verify that the minimum requirements to be a Laboratory Fellow have been met. A copy of a working transcript must be submitted with the application.

Appendix-1 Xerox Fellows Application (continued)

Recommendation of Review Committee:

A Laboratory Fellow will [ ] be granted, will not [ ] be granted for the following reason(s):

______________________ ________________

Review Committee Chairperson **Date**

Action: Award [ ] granted, [ ] not granted for the following reason(s):

____

____

____

____

_____________________ ______________________

Dean's Signature **Date**

The applicant must complete the following statement in no more than 200 words.

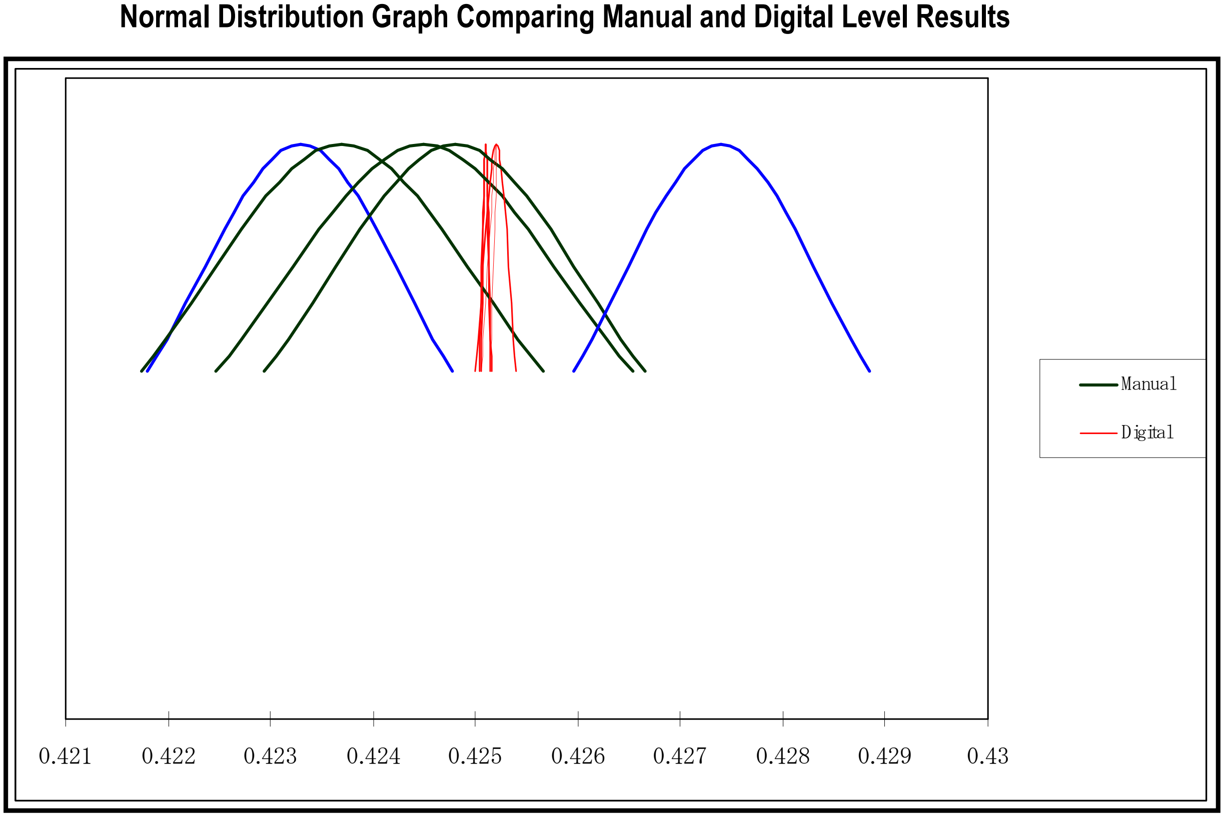
As a Laboratory Fellow, I expect to benefit in the following ways:

I understand that at or near the end of the term of the Fellowship I must prepare and present before an appropriate forum, a report on my activities as a Laboratory Fellow and that the stipend for the Laboratory Fellow is usually made at the presentation.

____ ____________________________

Student Applicant's Signature **Date**

Appendix-2 Selected Results of Digital Level Research



From this graph you see the more precise nature of the automatic digital readings and the more consistent (accuracy) nature of the readings with varying lengths of sight. The manual readings are much less precise. The chart illustrates that the longer sight distance (135 ft.) is significantly different from the shorter sight distances. (The manual curve for the 135 ft. sight distance is the one to the extreme right.)

Appendix-2 Selected Results of Digital Level Research (Continued)

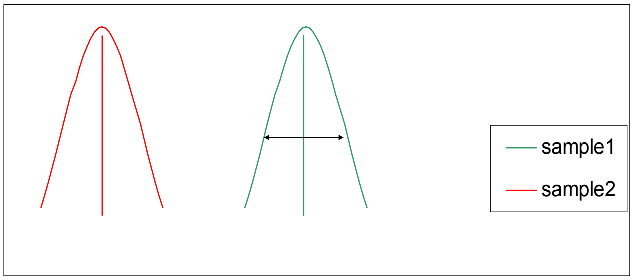
Conclusions

Based on my experiments and analysis, digital leveling is more consistent (precise) than manual level. When the sight distances increase the variation in the manual results will be greater. This is due to the inherent difficulty in reading the rod at longer distances. While there were statistically significant differences in the two procedures, at both shorter and longer sights, the absolute difference in the results from either method were of no practical significance. Finally, due to the greater precision and speed of operation, the digital level will most likely replace manual leveling in the near future.

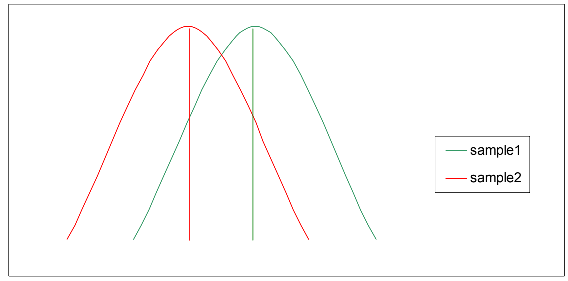
The above paragraph is the conclusion from Mr. Harada's Power Point Presentation.

Appendix-3 Sample of Statistical work of Student

Significance test



Graph 1 (Manual Readings)



Graph 2 (Digital Readings)

A Significance Test is performed to determine if the mean value of the samples are statistically different at the 95% confidence level. Graph 1 is significantly different at 95% level. Graph 2 is not significantly different at 95% confidence level. The smaller the standard deviation, the more precise the observations. Therefore, observations represented in Graph 2 are more consistent than those of Graph 1.

A page from Mr. Koji Harada's presentation illustrating the statistical difference in the test results for one aspect of his research.

Appendix-4 Proposal to ASHRAE

Project Description:

I- **Introduction**

An essential aspect of renovation and restoration of existing buildings is the upgrading of the HVAC systems. Newer systems are more efficient resulting in energy savings and are less intrusive on the beneficial occupancy of the building (usually lower space requirements for system components, ductwork and lower noise levels.)

A major concern when working on older systems (and some more modern systems) is the necessity to address mold and related Interior Air Quality (IAQ)

II- **Overview**

Essential to the design of HVAC systems in existing buildings is the analysis of the current air quality. We believe that students will have a better grasp of the overall aspects of the design of the systems if they are exposed to the actual collection, monitoring and analysis of air quality samples from "real" buildings.

Currently through its Architectural Research Institute (ARI) the University is a major player in the District of Columbia Homestead Act (restoration of properties, auctioned through a lottery to low income families). University students are actively engaged in this work.

III- **Grant Proposal**

Our request is for funds to purchase test equipment to collect field data and software necessary for the analysis of this data for eventual use in the design of HVAC systems. It is also expected that this equipment will be beneficial in the investigation of Indoor Air Quality (IAQ) problems. In older buildings the existence of mold is frequently a problem. Here in Washington we are frequently involved with the restoration of historical buildings. This presents unique challenges and opportunities. Test equipment to establish objective data is essential to quality solutions to problems in this area. The primary objective of this Grant Proposal is to establish a "real world" learning environment for students to be able to experience the problems and their solutions related to Interior Air Quality.

One of the major problems confronting the architect and the engineer is that of mildew and mold in HVAC systems and building in general. The equipment we wish to purchase and student exercises we will develop will enhance the students' understanding and capability for designing systems to assure the quality of air inside the building envelope.

IV- Budget

1- Airflow meter (capable of measuring velocity, volume, temperature, humidity, humidity, dew point, and wet bulb) ($1,850)
2- Leak Detector ($135)
3- Remote temperature sensor ($125)
4- Air pump (for collecting air samples) ($800)
5- Collection Filters ($220)
6- Moisture meter ($250)
7- Software ($550)
8- Training : $750
9- Miscellaneous (Manuals, postage, etc.) $150

Total: $4,830