

AC 2008-1586: CAMP CONCRETE – GROWTH OF A GRADUATE PROGRAM

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Camp Concrete – Growth of a Graduate Program

Abstract

Students at The University of Oklahoma are offered an opportunity to participate in a locally funded undergrad research program, "Camp Concrete", which is loosely based on the National Science Foundations, Research Experience for Undergrad (REU) program. Forty seven students have been involved in this program during the last four summers. The research foci include structural, and civil engineering materials. This successful summer research program involves large numbers of undergraduates in cutting edge, "pure" research.

The organization and management of the undergrad research program is discussed. Challenges for the faculty and staff include; locating funding support, quick implementation of the research, high volume testing, encouraging active learning while making the work fun and exciting, and expanding the student's horizons beyond the immediate research focus of their team. As the summer progresses, the students take over day-to-day management of the projects. To ensure that all the students are engaged in the research and understand its goals and challenges, weekly meetings are held to discuss progress, difficulties and preliminary results. Helping to make the work fun and exciting, while granting the students control of the research process, encourages the students to pursue graduate study.

Each of the projects that are used to fund this program addresses an immediate need identified by the individual project sponsor. The project sponsors are not aware that their research program is funding this undergraduate research program and are only interested in solutions to their research problem. Assessment methods for the undergraduate research include the standard methods used for graduate level research. This includes evaluation of the projects outcome by the sponsors, presentation and discussion at national conventions & peer reviewed journal articles. The program is analyzed and the students experience and its possible impact on their personal and professional life is discussed and evaluated in this paper. These aspects of the program are assessed through the use of a survey.

Overview

To summarize Ramseyer¹, Camp Concrete developed in response to the unique constraints and opportunities experienced by the structural engineering group at the University of Oklahoma (OU), Department of Civil Engineering and Environmental Science (CEES). These constraints started with the loss of all structural engineering faculty between mid 1999 and late 2000. As new faculty members were hired, there was a period of time during which very little research was conducted at OU's Fears Structural Engineering Laboratory. While the undergraduate program in structural engineering had been relatively unaffected, the graduate program was virtually non-existent. Opportunities included nearly unlimited access to Fears Structural Engineering Laboratory, a fairly large undergraduate student body wanting to focus on structural engineering, and a very understanding administration.

As Camp Concrete developed it rapidly became apparent that the research experience, developed out of necessity, was beneficial as an undergraduate research experience and has become a key

tool for recruiting students to our graduate program. It has also proved to be an effective method for increasing the amount of high-quality research completed in our laboratory.

Background

Camp Concrete, the undergraduate research program at The University of Oklahoma which is the focus of this paper, is a sole investigator program, totally administrated by the investigator. It is loosely based on the National Science Foundations, Research Experience for Undergrad (REU) program. The primary reason this program is "loosely based" on the REU program is that the principle investigator was not selected for involvement in the NSF – REU program. This problem was compounded by program challenges such as a moribund graduate program, and very limited funds. For each of the past four years Camp Concrete has been funded by an assortment of projects at any one time. Each funded project covers the discrete costs for its share of the program. Primarily due to the nature of the research performed during Camp Concrete the projects and funds are supplied by the Oklahoma Department of Transportation (ODOT), the Oklahoma Transportation Center (OTC) and private industry such as LaFarge North America Inc., CTS Cement Manufacturing Corp, Franks Casing Crew and Star Building Systems. In general Camp Concrete requires approximately \$150,000 overall. This cost is has never been supported between less then three funded projects each summer.

The undergraduate research program is similar to a NSF – REU in the following ways:

- Undergraduate students are given an opportunity to gain an excellent research experience.
- This is often the students' first experience conducting research.
- Undergraduates work directly with a principal investigator on leading edge research.
- The experience is an excellent method for students to prepare for graduate school.
- The students experience "immersion" through quick implementation of the research and very few competing distractions.
- The experience includes social activities that help build long term friendships and build a sense of community.

But the program differs in the following ways:

- A NSF – REU is generally an eight week in length. The Undergrad research program at The University of Oklahoma is twelve weeks in length.
- At the end of the NSF – REU the student generally has very little continuing collaboration or association with the research. The Undergrad research program "Camp Concrete" at The University of Oklahoma allows the team leader to use the data collected over the summer as the foundation of their M.S. thesis. Additionally, the research teams often continue to work on the projects during the school year as undergrad research assistants. In general students participating in "Camp Concrete" enter graduate school with all or their research completed.
- Camp Concrete is only available to students enrolled at OU. This program does not provide the student with the travel experience that a NSF –REU would.
- A NSF – REU is funded by the federal government and the funding has no relationship to the research project, in essence the REU student is "free" labor for the project. The Undergrad research program at The University of Oklahoma is funded by the research sponsor, who's sole focus is on the results of the research.
- Free housing is not provided.

- Food and travel allowances are not provided.
- The stipend is not quite as generous.

Challenges for the faculty and staff include; locating funding support, quick implementation of the research, high volume testing, encouraging active learning while making the work fun and exciting, and expanding the student's horizons beyond the immediate research focus of their team. As the summer progresses, the students take over day-to-day management of the projects. To ensure that all the students are engaged in the research and understand its goals and challenges, weekly meetings are held to discuss progress, difficulties and preliminary results. Helping to make the work fun and exciting, while granting the students control of the research process, encourages the students to pursue graduate study. These challenges and the development of the undergrad research program at The University of Oklahoma are discussed in depth in a prior work by the author¹.

Learning Skills Emphasized

At any university, the undergraduate student can be considered the primary product. With this in mind, any institution's long term success or failure will be gauged by the students they graduate. After studying the impact of departmental research and teaching climates on undergraduate growth, Volkwein and Carbone at SUNY-Albany have concluded that "students in exclusively research-oriented departments report more growth than those in exclusively teaching-oriented departments," but that departments which exhibit "...a combination of strong research and strong teaching..." make the most "...significant contributions to undergraduate intellectual growth."² The undergraduate research program provides a research oriented component for our undergraduates that is generally missing from most undergraduate experiences.

Schoenfeld and Magnan³ conclude that a typical "pure" research standard includes:

- To conduct research with appropriate methodological techniques and vigor;
- To conceptualize and theorize in an original way, with logical and mathematical formulation as appropriate;
- To synthesize, criticize, and clarify extant knowledge and research;
- To innovate in the collection or analysis of empirical data;
- To relate research to the solution of practical problems of individuals, groups, organizations, or societies.

The undergraduate research program involves all five points of "pure" research as defined above.

Implementation:

Due to the time constraints involved, the research topics and the specific objectives are developed before the students are hired. There was a strong need to avoid wasted time at the beginning of the summer. Any delay at the beginning of the summer could translate into a perception on the research assistants' part that either time was not critical or that a failure to complete the work by summer's end could be blamed on a lack of preparation by the principle investigator. Neither of these outcomes is considered appropriate. All materials and testing equipment required for the first eight weeks are available on the first day of Camp Concrete.

To further instill a sense of mission and urgency, each day of the first week is pre-planned with group meetings and work. The meeting topics included an orientation to the summer's goals, introduction to the research topics and instruction on completing literature reviews, creating a test matrix, planning work, keeping records of the research in a lab book and writing a research report. The work sessions included initial cleaning and organization of their work area and rebuilding several pieces of equipment. Having the students clean and improve their work space before starting helps them to take ownership of the area and encourages them to maintain the area in an acceptable manner. The students, in general do an excellent job of maintaining the space and monitoring each others behavior. The lab management has not had to hold a special "lab cleaning day" during the last four summers. Prior to Camp Concrete these events occurred at least twice during the summer.

During orientation on the first day of Camp Concrete, the summer research assistants learn what research topics are available. Each of them are given copies of the research proposals and asked to list their preferences. By the third day of Camp Concrete, the students are divided into teams with specific goals. Each team has a leader and one or more team members. None of the teams is large enough to be self sufficient. They all need to trade labor between each other to complete the more physically challenging portions of the research.

By the end of the first week, the work area is typically ready and each team has developed a test matrix, which the principle investigator reviewed. By the beginning of the second week, research is in progress. Each member is required to bring in copies of two research papers relevant their research weekly for the first eight weeks. By the middle of the summer, each team's notebook typically includes between 25 and 40 journal articles. In this manner the students quickly became familiar with the latest research on their topics.

Due to the nature of the research, a rigid work schedule is not usually possible or desirable. The teams share a limited work space. In the first summer four of the teams were working on concrete material studies and needed to batch concrete, but Fears Lab only has one small batch mixer. For most of the summer, batching began at six in the morning and extended until mid-afternoon. Specimen testing often ran into the evening, and material preparation often went on until after midnight. No single student was in the lab during the entire 20 hour work day, but at any given time several students could be found working. The students created a work schedule that would have seemed draconian if the principle investigator had suggested it. This freedom to control the schedule was ceded to the research assistants during the first summer and has never been changed. In general this system has worked very well. It frees the principle investigator from being a clock watcher or micro manager and allows the research assistants further control over their destiny. This system allows the students to also take an intersession or summer session class during part of the summer, coordinating their working hours around time spent in class and studying.

During the first four weeks of the summer, the teams require a lot of help and direction. The principle investigator is careful to suggest courses of action but does not dictate a work regime. This allows the research assistants to rapidly gain control of the day to day operation of their research. At end of the summer each team gives a presentation of their work and turns in a completed research report.

Lessons Learned:

- In general, the student teams are extremely productive. The research material on hand at the start of the first Camp Concrete did not last eight weeks as expected. By week four, the principle investigator was scrambling to find more material. These surprises have not occurred during subsequent years due to a simple inventory management system.
- Not all teams integrate well. On several occasions the principle investigator has had to quickly shift team members to solve a personality clash. While worrisome, these corrections do not seem to have long term impact on the students or the work.
- On occasion teams have trouble starting their research. In general this is due to: 1) lacking a sense of urgency to complete the work during the summer or 2) not wanting to start any research until they fully understand the expected outcome. In this case the students were not used to a problem with multiple possible solutions. Several meetings with the principle investigator are generally required to help these students understand that a "failed" test was acceptable so that they could move forward.
- Students want ownership of their work. By allowing the students to determine their own work schedule and to create their own test matrices, the students achieve much more than anticipated. The students far exceed the principle investigator's expectations for both breadth and depth of study. Several of the groups initiated investigations into possible solutions that were not in the initial proposals or test matrices. These initial pilot studies have led to additional research funding.
- Failure is not to be avoided, and the principle investigator must resist the temptation to micro-manage undergraduate students out of fear that they are incapable. One of the most productive teams discovered at mid-summer that all of their previous work was flawed. They identified the flaw and the action required to address it with only minimal guidance. They decided on their own to redo all of their previous work. Within four weeks, they had recovered and were back on their schedule.
- Community building is extremely important. The Friday lunches provided by the principle investigator were a much needed social event every week. After the first week, this is the only time all of the students are present at one time. In addition to community building the lunches have also become an excellent avenue for the principle investigator to assess the progress of the teams without creating any undue pressure. It is also a good method for the research assistants to address issues with one another and the principle investigator.
- Undergraduate students are capable of both performing laboratory research and reporting it. The teams write the final project reports, which were submitted to sponsors with only minor editing by the P.I.
- Be prepared for administrative difficulties. One of the most difficult roadblocks to making Camp Concrete a success is hiring undergraduate research assistants for the summer. We are not able to appoint them to a position for the summer. Hiring them requires extra time, effort and paperwork.
- Large scale testing is problematic in this format. Smaller projects with repetitive tests tend to fit the Camp Concrete format best. These allow the students time to learn the tests and time to repair mistakes. Large scale testing generally takes so long to set up the under graduates become less interested in discovery, instead they get worn out building the test.

Administrative Support:

Typically pre-tenure metrics of faculty performance often involve items such as nationally funded research dollars and graduate students being mentored. The University of Oklahoma follows a similar approach but because of their strong belief in under-graduate education the pre-tenure metrics of faculty performance also include state funded research dollars and under-graduate students being mentored. This approach to tenure system metrics allows a program such as "Camp Concrete" to be recognized as a significant portion of the faculty members' annual evaluation without needing to modify or adjust the metrics system.

Analysis of the Program

In total there have been forty seven students involved in Camp Concrete. Analysis of the program was performed using two methods. These included review of data established by our department and the use of an anonymous student survey. While the departmental diversity information was available for all participants, not every student answered all of the survey questions.

Figure 1 presents a graph of the total number of students involved for each of the last four summers in this project while Figure 2 presents a break down of the students involved by gender. The percentages in Figure 2 are for the given summer. In the last four summers, twelve or 25.5%, of the students involved in the undergraduate research program "Camp Concrete" have been female while Thirty Five or 74.4% have been male. The diversity of the total current graduate masters student population is presently 36.4% female and 63.6% male but within the Structural Engineering Sub-Group the student population is not quite as diverse and is presently 16.7% female and 83.3% male. The result is that the four year average for the structural engineering sub-group's graduate student diversity is not as great as the departments graduate student diversity. But Camp Concrete's gender diversity is actually better then the structural engineering sub-group's graduate student diversity. This would suggest that barriers to involvement in Camp Concrete do not exist based on gender when compared to graduate students.

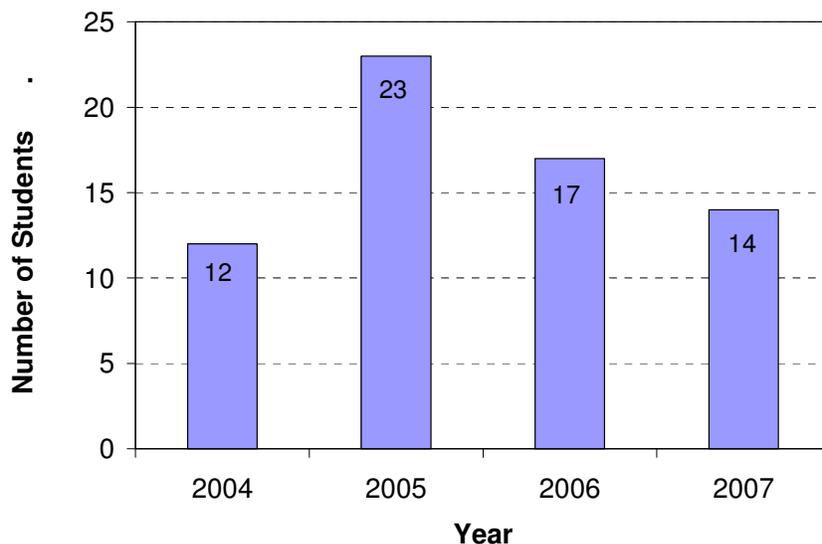


Figure 1 – Number of students in "Camp Concrete"

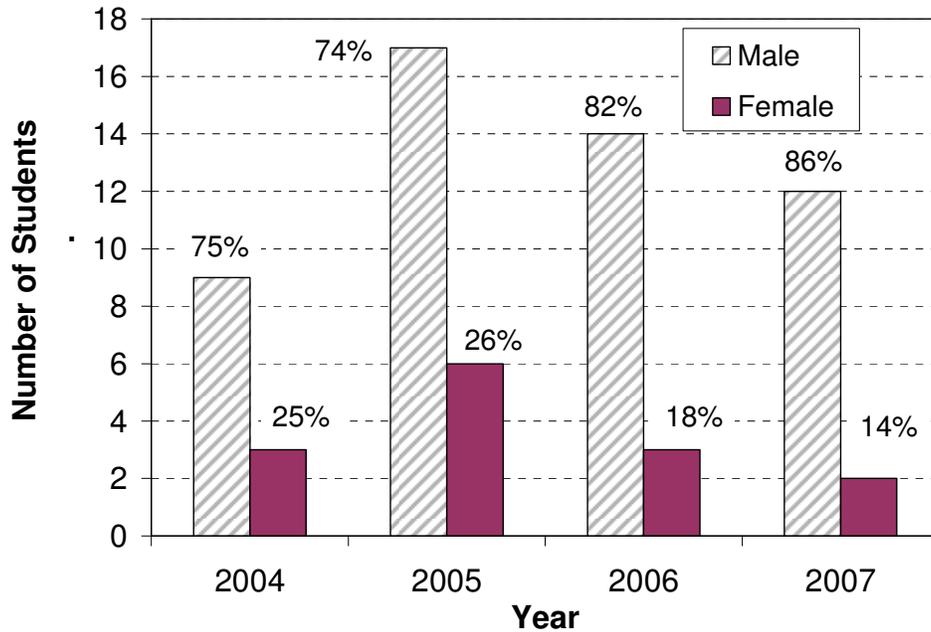


Figure 2 – Number of students in "Camp Concrete" by gender

Figure 3 presents the total fall enrollment of civil engineering undergraduates at OU for the last nine years. The fall enrollment ranges in a fairly tight band between 119 and 140 students. Figure 4 breaks this information down by gender. For the nine year period, on average 18.9% of the civil engineering undergraduates enrolled in the fall are female. Between 2004 and 2006 the average dropped slightly to 17.7%. In comparison, during the same period Camp Concrete averaged 23.0% females. This would suggest that barriers to involvement in the undergraduate research program do not exist based on undergraduate gender and are not influenced by variations in civil engineering student body population over time.

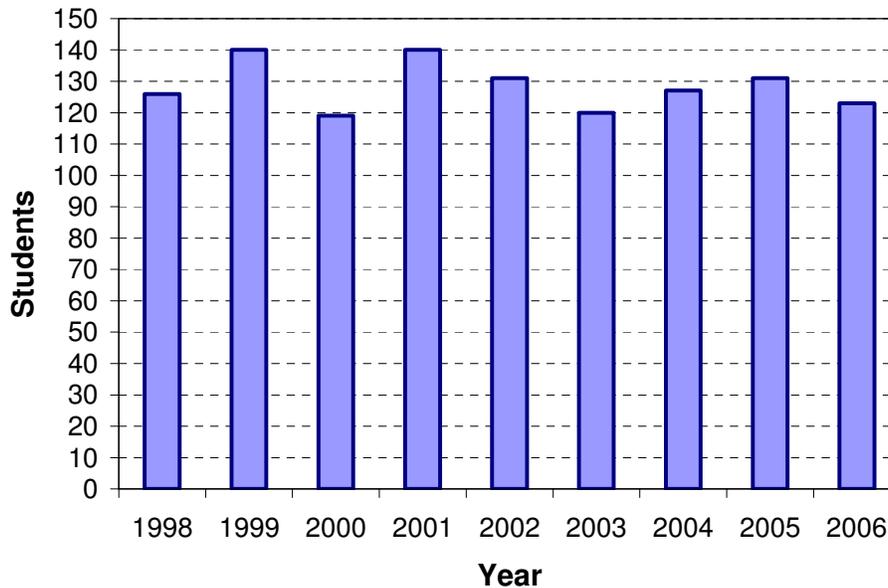


Figure 3 – Annual fall enrollment of C.E. undergraduates

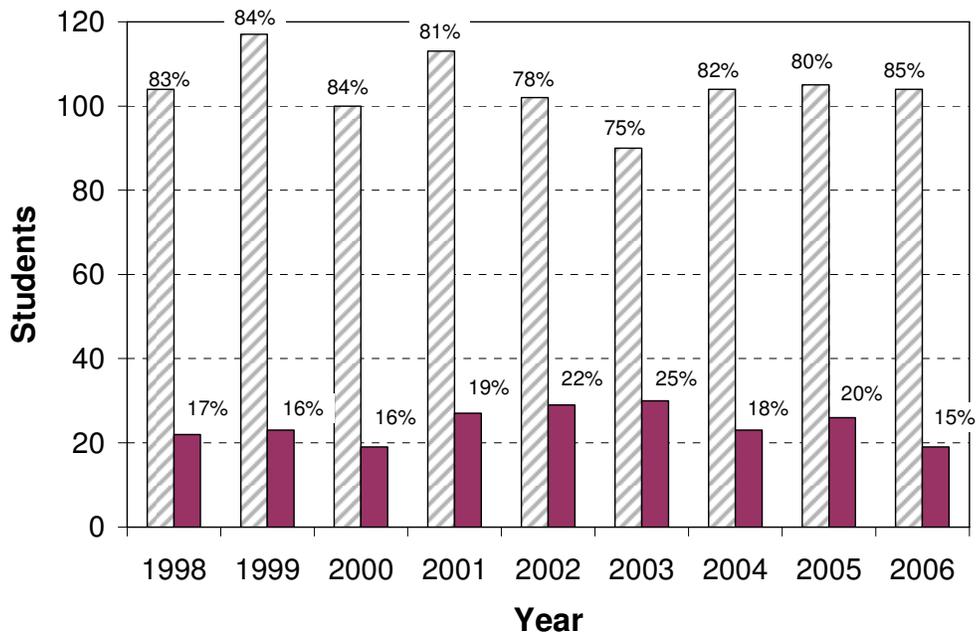


Figure 4 – Annual fall enrollment of C.E. undergraduates by gender

While additional diversity information such as ethnicity is available for Camp Concrete similar information is not available for the CEES department. Without this information for comparison, the value of this diversity data is questionable and is not presented at this time.

Figure 5 presents fourteen years of fall semester enrollment of students in the M.S. program with the structural engineering sub-group at The University of Oklahoma including the number of students that received their B.S. at The University of Oklahoma. This graph points out how the structural engineering graduate program nearly ended in 2001. This is the point at which all structural engineering faculty left the school and a single adjunct was hired to fill the gap. The steady increase in enrollment of students with a B.S. from 2001 till now is an indication there has been a steady increase in recruitment of M.S. graduate students from within the department.

Figure 6 presents six years of annual graduation data for students in the M.S. program with the structural engineering sub-group at The University of Oklahoma and the number of graduates that had been involved in Camp Concrete. This is direct evidence that students from Camp Concrete are making a positive impact on the number of M.S. graduated each year from the structural engineering sub-group. The steadily increasing number of students from Camp Concrete graduating with an M.S. also suggests that the increasing enrollment shown in Figure 5, is positively impacted by Camp Concrete.

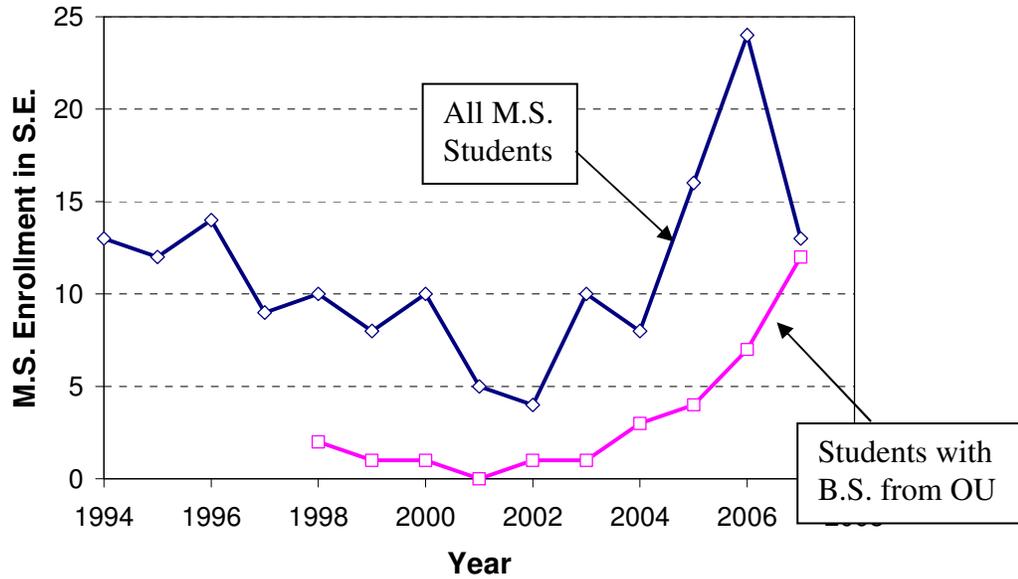


Figure 5 – M.S. Annual Fall Enrollments for Structural Engineering Sub-Group

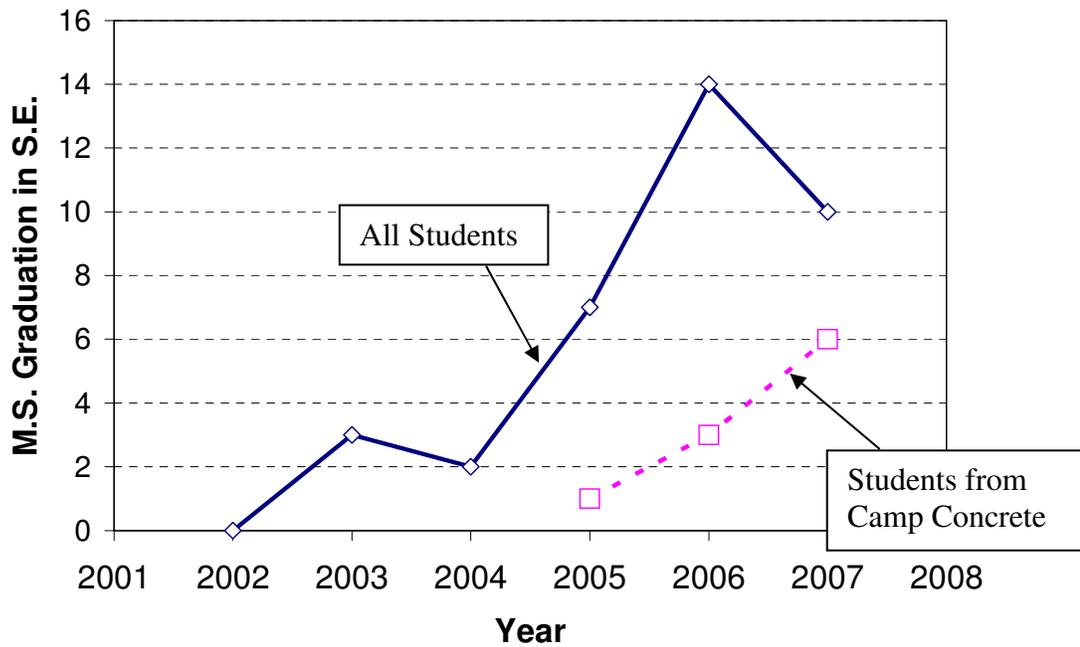


Figure 6 – MS Annual Graduations for Structural Engineering Sub-Group

Aspects of the program have been assessed through the use of a survey. This survey evaluates components of the undergrad research program with the hope of facilitating improvements in the future and to better understand the dynamics of the program. Please note that while there have been forty seven students involved in Camp Concrete, not every student answered every survey question. The following is a summary of the responses:

1. What is your present status?
7 Undergraduate 14 Grad student (list school) 26 Working
2. If you are working did you attend grad school? 10 yes 16 no
3. If you have not been to grad school do you plan to go to attend? 4 yes 17 no
4. What size of project were you involved in?
35 2-3 team members 12 more than 3 team members
5. Was the project substantially completed during the summer in which you participated in the undergrad research program? 32 yes 15 no
6. Were you a project leader? 19 yes 28 no
7. If you were a project leader, have you or do you plan to use the project as your Masters of Science Thesis? 18 yes 1 no
8. Would you consider undergrad research program a good introduction to conducting laboratory research? 35 yes 3 no
9. Would you consider undergrad research program a good introduction to types of research being done at University of Oklahoma ** Lab? 42 yes 2 no
10. Did participation in undergrad research program improve your skills in research report writing? 38 yes 5 no
11. Did participation in undergrad research program improve your skills in making presentations? 40 yes 3 no
12. Did participation in undergrad research program improve your skills in conducting a literature review/library research? 44 yes 0 no
13. Did you feel that attending the large group meetings & lunches was a beneficial use of your time? 44 yes 0 no
14. Was the faculty advisor accessible? 38 yes 6 no
15. Would you consider undergrad research program a good introduction to University of Oklahoma *** Lab?
40 yes 0 no 7 not applicable – already knew about research at University of Oklahoma ***

16. Did the experience you received during the undergrad research program help you with your decision with regard to grad school?

30 yes _____no (4 already planned 9 never planned to attend grad school)

17. Would you recommend the undergrad research program to other CEES students?

45 yes 2 no

18. Have you recommended undergrad research program to other CEES students?

30 yes 17 no

19. Did you have fun being involved in undergrad research program?

45 yes 2 no

Conclusions

From question one and two, 24 or 51% Camp Concrete participants graduated with an M.S. or are in Graduate school pursuing an M.S.. An additional 8.5% (question three) plan to attend Graduate school but have yet to complete their B.S.

Reviewing the results of question 7 suggests that group leaders almost always (94.7%) complete or plan on completing a M.S. Four of the participants in Camp Concrete, who had not been group leaders came back a second summer to participate as a group leader. This supports the premise that the undergrad research program is helping recruitment of students into the M.S. graduate program.

Most respondents felt:

1. felt the program was a fair introduction to experimental research (questions 8, 9 & 15).
2. believed that they learned from the program (questions 10, 11 & 12)
3. they enjoyed the program (questions 17 & 18)
4. the program helped them decide on grad school (question 16)

Camp Concrete has shown it self to be an excellent retention and recruitment tool for graduate school. Additionally this program is beneficial to diversity or at the very least that barriers to involvement in Camp Concrete do not exist based on gender and are not influenced by variations in civil engineering student body population over time.

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