

# **Undergraduate Research: The Lafayette Experience**

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## **Introduction**

Lafayette College is an undergraduate institution with approximately 2200 students. On average, approximately 80 of those students are civil engineering majors; the Department of Civil and Environmental Engineering graduates anywhere from 12-25 students per class. The opportunity for students to conduct one-on-one research with a faculty member is a strength of the Lafayette College environment. Lafayette encourages undergraduate research in all disciplines through a variety of programs, including independent studies, honors theses, and paid research assistantships (called the EXCEL Scholars program). The Department of Civil and Environmental Engineering has been highly successful in involving students in research experiences through independent studies and as EXCEL scholars, and moderately successful at graduating students with honors theses. On average, approximately one quarter of the students in the department are involved in research with faculty in any given semester, and a higher percentage participate at some time during their Lafayette careers.

There are many possible ways to define what constitutes a “successful” undergraduate research experience. As an institution, Lafayette College does not aim to send students specifically to industry or to graduate school; rather, the goal is to provide students with experiences that will enable them to make informed decisions about their future. We consider the experience of a student who discovers that he or she does not enjoy research to be as much a success as the student whose experience spurs an application to graduate school.

A successful research experience also must satisfy faculty needs. Lafayette’s tenure and promotion requirements include scholarly work. With no graduate research assistants, faculty members often must rely on undergraduate researchers for assistance. Research products, such as papers and presentations, are quantifiable measures of research productivity, and these products can result from student research experiences. A research product not only helps faculty members, it gives students a specific goal and a sense of accomplishment, and it provides a distinguishing characteristic for the student’s resume or graduate school applications.

The objective of this paper is to examine the undergraduate research experience in our department at our institution. We first describe in detail the types of experiences that are available to our students. We then summarize the last five years of student research projects conducted in the department. Based on this information and discussions with department faculty, we summarize the lessons we have gleaned from this study. Finally, we outline our plans both for increasing student involvement and for increasing the quality of the experiences.

## **Types of Research Experiences Available to Lafayette Students**

Lafayette College facilitates three different mechanisms for student research, as described in the following paragraphs.

### ***Independent Study***

A student takes an independent study during a semester for course credit (for a Civil Engineering major, this course typically counts as a civil engineering elective). Any student may request to work with a faculty member on an independent study project, and the project may take a variety of forms, including but not limited to laboratory research, case studies, and tutorials on advanced topics. If a faculty member is willing to supervise the student project, the student must prepare a proposal for the project and submit the proposal to the department head. The independent study proposal should include a statement of the problem to be addressed or topic to be investigated in the independent study, an overview of the proposed research plan or a syllabus, any deliverables, and a timeline for the project. All students who take an independent study are required to present a seminar to faculty and students and prepare a final paper on the results of their work. A copy of all final papers is kept by the department.

### ***Honors***

Lafayette College specifies that, “Departmental Honors are awarded for outstanding performance in writing a Senior Thesis or in conducting Senior Research.” The College also specifies that candidates for Departmental Honors must:

- Maintain a GPA of 3.0 overall and 3.2 in the honors department;
- Register for the appropriate course in the honors department during the fall semester of the senior year and arrange for a faculty member to supervise the project; and
- Submit a thesis or research report to the research supervisor; the report is evaluated by a committee composed of the research supervisor, at least one other member of the department, and at least one person from outside the department or College. The committee must give unanimous approval for honors to be awarded.

Students receive course credit for honors research, and courses are graded based on the quality of student work. If the student’s work during the first semester is “of high quality,” the advisor may nominate the student for honors, and the student is permitted to register for a second semester of research. Otherwise, the student receives an appropriate grade and is not allowed to register for honors research during the second semester.

In addition to the College requirements for Departmental Honors, the Department of Civil and Environmental Engineering requires that an honors candidate submit a thesis proposal to the research supervisor and the department head by the end of the first week of the fall semester. This proposal includes a statement of the objectives of the honors project, a sufficient summary of the literature to justify the value of the proposed project, a detailed plan for meeting the objectives of the project, and a list of the members of the honors committee. The student also is required to give a presentation to the honors committee, department faculty, and students on the progress of his/her work during the last week of classes of the fall semester, and copies of a written progress report are due to members of the honors committee and to the department head no later than the last day of final exams of the fall semester. In addition to submitting a final

report, as required by the College, students are required to give a presentation to the honors committee, department faculty, and students on the results of their work no later than the last week of classes during the spring semester.

### ***EXCEL Scholars Program***

According to the Lafayette College Catalog, the EXCEL Scholars Program “enables students to participate in academically meaningful experiences outside the classroom. Students selected for this program engage in collaborative research projects with Lafayette faculty, enhancing their academic skills as well as developing other skills that will be useful in post-graduate education and careers.” It is stated explicitly in the Lafayette College Faculty Research Manual that the work of EXCEL students must be research-oriented and not be clerical in its primary emphasis. Participating students are paid \$8-\$10 per hour and receive no academic credit<sup>1</sup>. During the academic year, students can work up to 8-10 hours per week; during the interim and summer sessions, students may work full-time. In addition, during the interim and summer sessions, the College provides the students with free housing. To qualify for the program, students must maintain a GPA of at least 3.25 both overall and in their major.

### ***Additional comments***

Students conducting research with Civil and Environmental Engineering faculty members through any of the mechanisms described above typically are accorded privileges not available to their peers. For example, the students receive keys to the laboratories and computing facilities in which they work so that they can have after-hours access. They may also be given desks or other workspace as well as areas to keep their books and other materials.

### **Summary of Departmental Student Research Experiences**

The Department of Civil and Environmental Engineering has made an effort to involve students in research. Faculty members publicize their research needs in a variety of ways, most commonly in the classroom, but also in other forums, such as meetings of student organizations. While the majority of students working on research with Civil and Environmental Engineering faculty are Civil Engineering majors, this is not a requirement. Civil and Environmental Engineering faculty members have worked with students from a variety of majors, including Chemical Engineering, Mechanical Engineering, Bachelor of Arts in Engineering, and Geology. In addition, during the period summarized in this paper, all Civil and Environmental Engineering faculty members who were doing research had students working with them.

Table 1 summarizes the number of civil engineering majors involved in research in the department for the last five academic years (a total of 43 students). An additional 18 non- Civil Engineering majors worked with Civil and Environmental Engineering faculty members during

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<sup>1</sup> Lafayette College funds the EXCEL Scholar program from a variety of sources including all money obtained from overhead charged to externally funded research grants (e.g., National Science Foundation grants). In addition, if a faculty member has undergraduate research funding written into a grant, the faculty member can apply for the students who participate in the grant to be part of the EXCEL program so the students receive the distinction and associated benefits.

this period. Their work is not summarized in the tables given in this paper. The shaded lines in the table (and all other tables in this paper) represent years for which data is not yet complete.

Table 1. Department of Civil and Environmental Engineering Research Students by Year

<b>Academic Year<sup>2</sup></b>	<b>Number of Students Involved<sup>3</sup></b>	<b>Independent Study</b>	<b>Honors</b>	<b>EXCEL Scholars</b>
1998-1999	9	3	1	5
1999-2000	9	0	0	9
2000-2001	11	2	1	8
2001-2002	11	2	1	9
2002-2003	15	6	3	7
2003-2004 <sup>4</sup>	10	5	1	5
Total	65	18	7	43
Average	10.8	3	1.2	7.2

It is clear from Table 1 that the EXCEL Scholars program is the most common mechanism for Civil and Environmental Engineering faculty members to involve students in research, followed by independent studies, and then honors. There is some concern among faculty members that the structure of our curriculum may inadvertently discourage students from completing honors projects.

Table 2 summarizes the number of Civil Engineering majors involved in research in the department by class, beginning with the class of 1999. The number of students in each graduating class who are involved in research appears to be increasing, a trend that was not clear in the data presented in Table 1.

<sup>2</sup> Academic year starts in fall semester and concludes at end of following summer.

<sup>3</sup> Students may be involved in more than one type of research experience.

<sup>4</sup> Does not include complete information for spring 2004 semester or summer 2004.

Table 2. Department of Civil and Environmental Engineering Research Students by Class

<b>Class</b>	<b>Number of Students Involved<sup>5</sup></b>	<b>% of Class</b>	<b>Independent Study</b>	<b>Honors</b>	<b>EXCEL</b>
1999	5	24	2	1	2
2000	5	33	1	0	4
2001	7	33	1	1	7
2002	4	25	2	1	3
2003	9	64	3	3	7
2004	9	64	6	1	3
2005 <sup>6</sup>	4	17			4
2006 <sup>6</sup>	1	4			1

Table 3 summarizes the products of Civil Engineering majors' research by class. Conference papers and presentations listed in the table are for conferences held by national professional engineering or science organizations. Journal publications are papers in refereed publications. The National Conference on Undergraduate Research (NCUR<sup>7</sup>) papers are papers written and presented by the students at an annual conference for undergraduate research. (Lafayette College covers the travel costs for all students whose papers are accepted for this conference. Unfortunately, the conference dates typically coincide with the dates of the Fundamentals of Engineering Examination. This limits the number of student participants from our department.) "No Product/Other" includes all students who had either no product or whose product, while contributing to the overall research goals of the faculty advisor, does not fall under the categories listed in the table (e.g., contributions to project reports for sponsoring organizations). As noted previously, all independent study and honors students are required to write a final report and present their work on campus. These reports are not included in the table.

Table 3 indicates that while many students have "No Product/Other," of the students who do have a product, the publication or presentation of results at conferences is the most common mechanism. Since refereed journal publications involve more time and commitment and typically have no firm deadlines, this result is not unexpected.

<sup>5</sup> Students may be involved in more than one type of research experience and may have more than one research product.

<sup>6</sup> The number of students involved is expected to increase as this class approaches graduation.

<sup>7</sup> For more information see [www.ncur.org](http://www.ncur.org)

Table 3. Products of Student Research by Class

<b>Class</b>	<b>Number of Students Involved<sup>8</sup></b>	<b>% of Class</b>	<b>Conference Paper or Presentation</b>	<b>Journal Publication</b>	<b>NCUR Paper</b>	<b>No Product/Other</b>	<b>Unknown</b>
1999	5	24	3	1	1	2	0
2000	5	33	1	1	1	0	3
2001	7	38	2	1	1	4	0
2002	4	25	2	1	0	2	0
2003	9	57	5	1	2	2	0
2004	9	64	1	0	1	8	0
2005 <sup>9</sup>	4	17	3	1	1	0	0
2006 <sup>9</sup>	1	4	0	0	0	0	0

Table 4 provides information on the products of student research as a function of the type of research conducted. Table 4 shows that independent study projects typically do not lead to products that would assist a faculty member with tenure and/or promotion. However, it should be noted that as described above, not all independent study projects involve what is traditionally considered to be research. In addition, anecdotally we know that independent study projects occasionally lead to honors projects, but this factor was not tracked in our study. Given the low number of honors projects, this benefit of independent study projects is probably not significant. It should be noted again that students who start out in an honors project, if they do not make sufficient progress during their first semester, are given credit only for an independent study. The percentage of independent study projects that resulted from an unsuccessful honors project was not tracked in the study.

Table 4. Products of Student Research by Research Type

<b>Research Type</b>	<b>% of Students</b>			
	<b>Conference Paper or Presentation</b>	<b>Journal Publication</b>	<b>NCUR Paper</b>	<b>No Product/Other</b>
Independent Study	0	7	0	93
Honors	56	33	11	0
EXCEL	33	9	18	40
All Types	30	11	12	47

<sup>8</sup> Students may be involved in more than one type of research experience and may have more than one research product

<sup>9</sup> The number of students involved is expected to increase as this class approaches graduation.

Table 5 summarizes the results from a survey of students and faculty involved in research experiences over the last five years. Each student and faculty member was asked to evaluate whether the experience was “very good”, “good”, “fair”, “poor”, or “very poor”. Thirty of the 43 students involved responded to the survey and seven of the ten faculty responded.

Table 5. Summary of Student and Faculty Opinions of Research Experience

	Very Good	Good	Fair	Poor	Very Poor
<b>Student Responses</b>					
Independent Study	3	3	1		
EXCEL	15	3	1		
Honors	4				
<b>Faculty Responses</b>					
Independent Study	1	4	1	5	1
EXCEL	19	3	2		
Honors	4		1		

In the survey, students and faculty were also asked to give a brief explanation for their ratings of the experience. Student explanations for rating an experience as “very good” included learning new material, being involved in an interesting project, acquiring valuable research experience, developing good communication skills, preparing for graduate school, interacting one-on-one with faculty, and the having the opportunity to travel. Students who rated their experience as “good” had similar comments as those who rated it as “very good” but added that their projects seemed to lack clear objectives or that the guidance provided was less than they would have liked. One student who rated the experience as “fair” commented that the data necessary to complete the project was not available.

Faculty explanations for their ratings of the research experiences for projects rated “very good” included comments that the students were hardworking, reliable, independent, motivated, and very capable of completing the tasks required. The faculty also noted that these experiences typically were associated with products. For projects rated as “good”, the positive comments were similar to those for those rated “very good” but negative comments could be divided into those associated with the students (student not dependable, lacked independence) and comments associated with the project (project scope not fully developed, project too difficult). For projects rated as “fair” or worse, faculty comments associated with the students included lacked initiative, lacked independence, not careful enough in testing, too much supervision required, lacked aptitude, and lacked motivation. Comments of “fair” or worse associated with the projects themselves noted that too much was attempted or the project scope was poorly defined.

### What Have We Learned?

As we began our analysis, it quickly became clear that individual faculty members in the department document student involvement in their own research (student involvement is valued during tenure and promotion reviews), but the department has not kept records on overall student participation. While we evaluate courses regularly, the individual nature of the research

mechanisms has led to a gap in our evaluation of the experiences of students who conduct research.

From Tables 1-4, we conclude that:

- The percentage of students involved in research is increasing.
- The EXCEL Scholars program is very beneficial to student participation in research. The majority of student conducting research with faculty members do so as paid research assistants through the EXCEL Scholars program.
- The student working on an independent study is unlikely to produce a significant research product (i.e. journal publication or conference paper or presentation).
- The student pursuing an honors project is also the most likely to produce a significant research product.

From Table 5 and student and faculty comments, we conclude that:

- Both students and faculty are most satisfied with Honors and Excel research experiences.
- Faculty members are least satisfied with Independent Study research experiences.
- Faculty members should be careful both with selecting projects and selecting students.

### **Where Are We Heading?**

Our analysis of student research in the Department of Civil and Environmental Engineering has generated a number of new questions and has identified significant gaps in our knowledge about successful undergraduate research experiences. In writing this paper, we discovered how little information we had about satisfaction with and success of student research. As a result, we conducted the surveys of the department faculty and students summarized in Table 5. Beginning this year, our senior exit surveys will request feedback on research experiences in addition to other aspects of the undergraduate experience.

We are concerned about the small numbers of products resulting from independent studies. As a result, we intend to review the departmental guidelines and make students more aware of the issues identified in this study that affect the success of a research experience. For example, we will talk with students explicitly about the importance of motivation, organization, and independence in completing research. In addition, we will be asking the department to consider requiring students working on any type of research to attend a series of one-hour seminars. Each semester, all new research students would be required to attend a one-hour seminar that reviews procedures, potential products, and other research issues that faculty members often take for granted. We would also hold one or more seminars per semester on a range of topics related to research (e.g. networking and presenting at a conference, writing a journal article, preparing an effective poster, etc.).

We have noted that the percentage of students involved in research seems to be increasing. As a department, we need to discuss what an “appropriate” number of students working on research would be. While we could say that, ideally, every student ought to have a research experience before graduation, several obstacles exist. For example, not every student is a good candidate for research, and it could be detrimental to both the student and the faculty supervisor if student research was required. In addition, faculty members have limited time available, and increasing



the number of students involved could both decrease the quality of the experience and detract from other faculty efforts.

While we may not want to require student research for graduation, the numbers we have presented in this paper suggest that we could continue to increase the number of students productively involved in research. Some initial ideas on how we might do this include:

- Increase the pay for EXCEL Scholars,
- Increase the prestige associated with performing research,
- Provide office space for all researchers,
- Hold weekly/monthly seminars for researchers, and
- Hold/participate in regional Civil Engineering undergraduate research conferences.

Student research increasingly is being recognized as an important component of undergraduate education. We believe the information we have learned from this study will improve research experiences at our institution. We encourage others to undertake similar efforts and to share their results.

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