Study Labs as a Practical Means of Enhancing Freshman Engineering Courses

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Abstract

One of the biggest shocks for new engineering students is meeting the academic challenges of freshman math, science, and engineering courses. To assist students in meeting those challenges successfully, the West Virginia University (WVU) College of Engineering and Mineral Resources (CEMR) offers free tutoring to freshmen students. Tutoring is offered in all freshmen level math, chemistry, physics, and engineering courses through five nightly two-hour study labs. All freshmen within the College of Engineering and Mineral Resources are required to participate in these study labs at least one time per week.

In addition, the freshman engineering program redesigned the second course (ENGR 102) in the two-course sequence designed for all freshmen engineering students as part of the common freshman engineering experience. Previously, the two course sequence consisted of a “problem-solving and design” course, followed by a “programming” course. The two-course sequence has been redesigned to carry the unifying concept of the problem-solving and design process throughout both semesters. MATLAB\textsuperscript{®} is taught by presenting students with problems that would require the use of a mathematical programming tool to reach a solution. In this scenario, students, working in teams, are motivated to learn the syntax and structure of the language by the need to solve problems, and therefore, view the software as a problem-solving tool. Evidence of content mastery is assessed, primarily, through evaluation of the quality of student projects.

This paper describes the role of study labs in the teaching of ENGR 102 and the effect of study lab participation on student achievement and instructor performance in this programming-intensive, project-focused freshman engineering course.
Introduction

Engineering majors in the College of Engineering and Mineral Resources (CEMR) at West Virginia University (WVU) take three engineering courses as part of a common freshman year experience. A one-credit hour engineering orientation course plus a two-credit hour engineering problem-solving course are taken in the first semester and a second, three-credit hour, engineering problem solving course is taken during the second semester. The one-credit engineering orientation course provides an introduction to college life and engineering disciplines and careers, as well as an opportunity for the development of study skills and time management practices. The other two freshman engineering courses form a two-course sequence with a problem-solving emphasis. Both courses use individual assignments and team projects to teach fundamental engineering topics, basic professional skills, and ethics, and the use of a variety of computer tools. The second semester engineering course is the result of a recent redesign of a traditional programming course to a hands-on, problem-centered and project based technical problem-solving course which uses software as a problem-solving tool. The new course, taught for the first time in Spring 2006, is the result of identifying desired learning outcomes, examining the WVU freshman program and its role in a multi-department curriculum program, as well as the first year engineering programs of other institutions, and reviewing educational literature, ABET guidelines, and “best practice” articles.

One aspect of the freshman engineering program is the requirement that all first year students attend and participate in weekly “study labs.” Study labs offer tutoring by upper-class engineering students in all math, chemistry, physics and engineering courses typically taken by freshmen students. These two-hour tutoring sessions are offered 5 nights per week, Sundays through Thursdays. Upon arrival, students sign-in and begin working on homework assignments. As they have questions, they can ask one of the student-tutors for assistance. Students must stay the entire two hours and sign-out when they leave to receive credit for attending that week. Student study lab attendance is tracked by the Freshman Engineering Office and reported to each of that student’s freshman engineering instructors. Study lab attendance is part of the course grade in all three freshman engineering courses.

During the spring of 2006, Graduate Teaching Assistants (GTAs) who taught ENGR 102 replaced traditional office hours by tutoring in one of these E102 study labs. They noticed an increase in study lab attendance and spent more time helping students than they did in previous semesters when they held traditional office hours. The focus of this paper is to describe the role of study labs in student achievement a programming-intensive, project-focused second semester freshman engineering course.

Study labs in the literature

Reports and studies have shown a number of advantages achieved by applying study labs in different undergraduate programs, especially in scientific majors. A recent paper describes the “I-Help” computer system, reported to effectively offer cognitive, peer-assistance to students, depending on factors including each students’ level of competence for the subject under consideration².

Study labs have also been reported to be a valuable means of pre-exam preparation¹, reducing exam and general course stress and anxiety³, reducing instructor expenses per student⁹,
encouraging a higher student enrollment\(^8\), generally enhancing the learning experience\(^{11}\), and (most prominently) enhancing academic performance among under-achieving students\(^4\).

Martin Goodson conducted a series of objective-based diagnostic tests, evaluating the general importance of help sessions for undergraduate science course achievement, as well as conducting help sessions with different assistance levels. After comparing results of such tests to those from control groups (not having administered the help sessions), he concluded that academic achievement was significantly improved\(^5,6,7\). Another study by Randy Moore\(^10\), also considered ways of conducting help sessions and other means of improving performance for introductory science courses at the undergraduate level.

It must be noted, however, for the literature cited above, that such help sessions were preliminarily directed at offering assistance to subject material covered in science classes (e.g. math, physics, biology, etc.). Engineering study labs at WVU, however, take that “extra mile”, providing not only assistance with problem-solving and homework, but additionally helping engineering students to envision and develop the skills necessary for problem-solving and programming, which are demonstrated in the following section. No literature has been found describing the implementation of such a technique into the freshman engineering curriculum.

**Freshman engineering study labs at WVU**

Beginning four years ago, study labs were initially offered to freshmen engineering students during the fall semester as voluntary tutoring support for all freshmen level math and science courses. Since several students indicated the tutoring was valuable in helping them succeed in their freshmen courses, the concept was expanded and modified. For the past two years, study labs have been mandatory for students. While students are required to attend one study lab per week, the student may select the subject area in which to receive assistance. As an incentive to motivate excellent student performance, students can earn exemptions by earning A’s on their first math and science exams in each semester. In addition, during the second semester, students with a 3.5 GPA or above are exempt from study labs until their first “round” of exams. If they earn A’s on both their math and science exams, they keep their exemption for the rest of the semester; if they do not, they must begin attending study labs.

Beginning in spring 2006, the Graduate Teaching Assistants (GTAs) who served as the instructors for the ENGR 102 course worked in at least one study lab session per week as a replacement for the traditional office hours, since students rarely sought assistance during the instructor’s office hours. During the study labs, instructors were able to answer questions, both individually and for groups. If several students asked similar questions, the instructor could review the concept with the entire group in the study lab, and again in the next class.

Instructors also provide encouragement and appropriate prodding as students, working in groups, struggle through several problem-solving exercises and in writing the necessary programs. Occasional, impromptu mini-lectures on specific programming concepts or on points of clarification of various problems are very helpful in keeping students focused and working productively toward their goals. The informal nature of the evening study labs provides an environment conducive to exploratory and collaborative learning.
Study labs offer a balance to the formality and often impersonal environment of the classroom. The informal interaction between instructors and students, as well as among the students themselves, provides an appropriate environment for the development of strong student-instructor and student-student bonds. Since students are encouraged to work together, they learn how to form study and homework groups, and begin to form solid working relationships with other students. In addition, instructors become more “approachable” to students, hence, students don’t hesitate to ask questions in class and to seek help outside of class on concepts they don’t understand. Students begin to engage their instructors outside of the class and study labs. Because of these relationships, students begin to feel a part of the college and begin to develop study skills and cohort relationships that will help them succeed throughout their university experience.

Instructors also benefit by the increased interaction with the students, since they can use class time more efficiently, addressing issues that may be a cause for confusion for several students at once. The usual stress imposed by class time constraints is relieved, somewhat, by the knowledge that exercises can be finished by the students outside of class, as needed, and the students have opportunities to get assistance, as needed. In addition, as instructors get to know their students and are engaged by them, the entire classroom environment is significantly enhanced.

**Discussion and Conclusions**

A preliminary analysis (Table 1) of student performance data indicates an increase in student achievement, as measured by the average ENGR 102 GPA, between the academic year (AY) 2004-05 and AY 2005-06.

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The data shows a 0.09 point (2.8%) decrease in the fall ENGR 101 grades and a 0.35 point (11.7%) increase in spring ENGR 102 grades. While the fall grades for ENGR 101 remained relatively constant, and were even slightly lower in AY 2005-06, academic performance in the second freshman course, ENGR 102, increased.

Anecdotally, instructor feedback indicates students demonstrated better understanding of problem-solving and programming skills by their classroom performance. Their observations seem to be supported by the data. Instructors also indicated that their participation in study labs gave them insight into specific areas of student difficulty, so they could respond to these issues in class.

In addition, student comments, both informally to their advisors and formally in their Student Evaluation of Instruction (SEI) forms, indicate that students believed the instructors were more accessible for assistance.
Spring 2006 was the first semester that ENGR 102 instructors were directly involved in study labs. Anecdotally, instructors reported crowded classrooms filled with students working together and getting help in problem-solving and programming assignments. Since the study lab classroom holds 72 students, the spring 2006 attendance was higher than expected and higher than the attendance of previous semesters in which no instructor participated. Interestingly, instructors noted that students did not attend only the lab in which their own instructor worked. Since projects were coordinated throughout all sections of the course, instructors were able to work effectively with students from all course sections.

Based on this anecdotal evidence, the involvement of ENGR 102 instructors in the nightly study labs may be a contributing factor in student success.

Two items must be noted. First, other changes were implemented in the ENGR 102 curriculum for the first time in spring 2006. Before spring 2006, ENGR 101 was considered to be the “problem-solving and design” course and ENGR 102 was the “programming” course. Several curricular changes were implemented in spring 2006 to transform the traditional “programming course” into a course that continued the problem-solving and technical communication emphases of ENGR 101 while introducing the use of a computer tool for solving technical problems. The earlier ENGR 102 course focused on learning to program in C++ and briefly introduced MATLAB® toward the end of the semester, while the new ENGR 102 course only uses the MATLAB® problem-solving tool. It was the change to the problem-solving emphasis that led the freshman engineering program to implement instructor participation in the ENGR 102 study labs. That environment enabled the instructors to have more direct interaction with students and more time in which to guide students as they struggled in their application of the engineering problem-solving approach while dealing with the challenges of the MATLAB® software tool. Second, while students were required to attend study labs, they chose the subject in which they received help. Not all ENGR 102 students attended the ENGR 102 study labs; they could choose to receive help in Math, Chemistry, or Physics. Study lab records indicate high attendance in physics and math study labs as well. Data on student performance in these subject areas indicate that student grades have increased in calculus 1 and physics 1. Further discussion of these data is beyond the scope of this paper.

Future research should investigate the following questions: (1) Do the students who attend ENGR 102 study labs perform better in the ENGR 102 class, measured by course grades, than those who do not attend the ENGR 102 study labs? (2) Does it make a difference if the study lab is instructor-led or student-led? Currently, most study lab sessions are student-led.

Several changes to the both the course and the study lab implementation make it difficult to isolate one cause for student improvement; however, the study lab requirement is a contributing factor. While further analysis is needed, it appears that requiring students to attend study labs and offering significant tutoring for a problem-focused second freshman engineering course contributes positively to student performance in that course.
References


Biography

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