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Changing the paradigm of power in the classroom to teach, promote, and evaluate leadership training within an existing Civil Engineering curriculum

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Abstract:

This project evolved out of three years' worth of data from junior/senior-level engineering majors who completed both pre and post-semester surveys asking them to rate their perceptions of preparation and training in a variety of areas. Not surprisingly, the majority of students reported that they believed they were well prepared in the technical realm, and many also reported that they were becoming more prepared in the area of technical communications. Surprisingly, though, many of the students also indicated that they hoped to acquire leadership/management training experience before graduating.

In response to this student feedback, we took the following actions: first, we extended the survey questions to include students from a second population in order to determine if the perceived deficiency was a local issue or more of a regional issue; next, five engineering educators from two universities collaborated to design opportunities to promote leadership/management activities within the existing curriculum.

Our research reports the details of our findings, presents a series of exercises easily incorporated into existing courses, and also includes a metric for evaluation and assessment of these new strategies.

Introduction:

ABET's "a-k" guidelines present the professional expectations of the accreditation for all undergraduate engineering programs nationwide, and most engineering programs are in the process of incorporating practices to follow these guidelines, but what do students themselves expect from their undergraduate experiences? What can engineering educators do when students report "gaps" in specific areas?

As engineering education continues to shift to a student-centered learning paradigm, student feedback and perceptions provide essential information that engineering educators can use to meet specific needs and to fill specific gaps on a course-by-course basis.

Is it possible to: (1) meet ABET's performance criteria (a-k), (2) obtain and incorporate student feedback in a flexible curriculum design at the course level, and (3) implement an ongoing system of documentation to support (1) and (2)? Can these things be done without sacrificing engineering content within existing engineering courses? Our research presents our attempts at answering these questions based on a specific "gap" area reported consistently by our students: leadership training. This paper presents our data collection methods, the findings, possible pedagogical alternatives, and several different approaches to "just-in-time" gap-filling at the course level. We hope to persuade other engineering educators to experiment with customization of our methods in their own courses.

Background:

This project represents teaching and curricular changes that have been implemented at the course level in two large urban universities based on constituent feedback. In this case, our primary constituents are undergraduate civil engineering students from The University of Memphis and The University of Arkansas, but other applicable constituent groups include program employers and alumni. The project was divided into several discrete tasks:

- Obtain students' self-perceptions of their own areas of strengths and weakness during their junior/senior years as undergraduate students majoring in Engineering
- Implement "Just-in-Time" Teaching Strategies to target identified areas of weakness through curricular and pedagogical modifications in existing engineering courses
- Evaluate and assess these changes and make further recommendations based on these findings.

Why is this important? For example, Ford and Riley (2003) present the idea of "competency gaps" as students leave the classroom and enter the workforce. While there has been a lot of research documenting the importance of communication skills in success as professional engineers, the research also documents that students themselves report they are under-prepared in these areas. (Riley, 2000 study and Ford/Riley, 2003 study)

We believe these findings are quite relevant because they represent the voices of our graduates. When students identify an area of under-preparation and/or request additional information before graduation, engineering educators should take note. In our case, the students' self-perceptions supported our 2002-2003 ABET accreditation review comments, and this strengthens the relevance. Finally, in light of the declining undergraduate enrollments in engineering combined with budget issues, it seems smart to try to consolidate as many concepts as possible in order to prepare our engineering graduates for the realities they will face as professional engineers.

This paper presents a more detailed background along with our methodology, our results, and our generalizations. In addition, we present a series of curricular modifications that can be incorporated into existing courses with examples for three common courses, and we include a metric for evaluation and assessment of these new strategies.

Methodology

All engineering students at The University of Memphis are required to enroll in English 3603, Engineering Communications, as part of the undergraduate degree requirements. Anna Lambert, co-author and instructor of English 3603, collected survey data during the 1999-2003 period that revealed a consistent pattern of strengths and weaknesses as perceived by junior/senior-level interdisciplinary students. During this period, 78 students responded to survey questions asking that they identify what they considered the professional strength and weakness. These students were a mixed population of students from both engineering and engineering technology majors at the University of Memphis. The results of these surveys are presented in Figure 1. In addition to the self-evaluations, the students were asked to identify which skills from the same list they wanted most to develop during their undergraduate programs. The results from this question are presented in Figure 2.

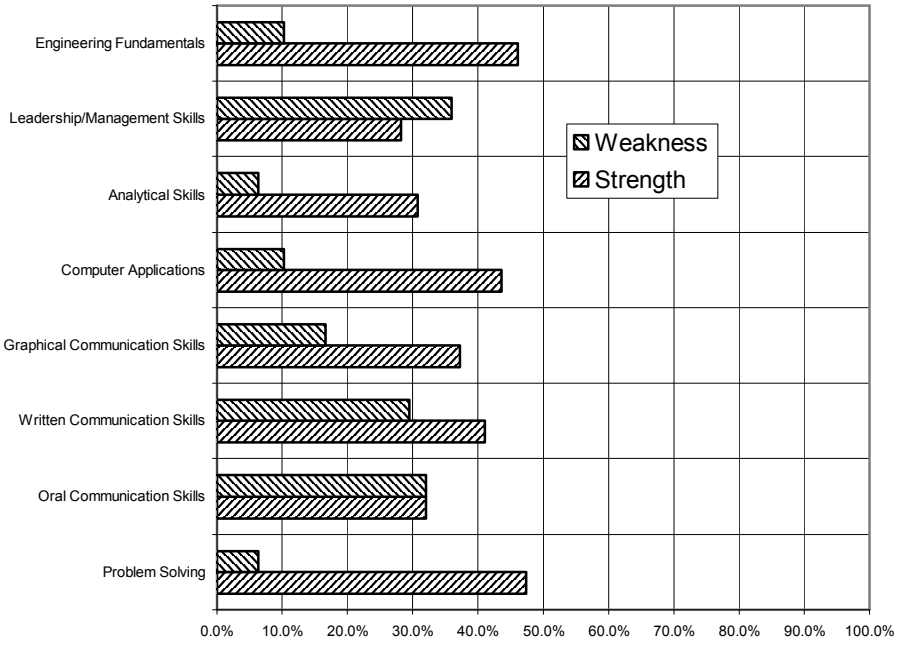

Figure 1: Student Self-Evaluation from the University of Memphis

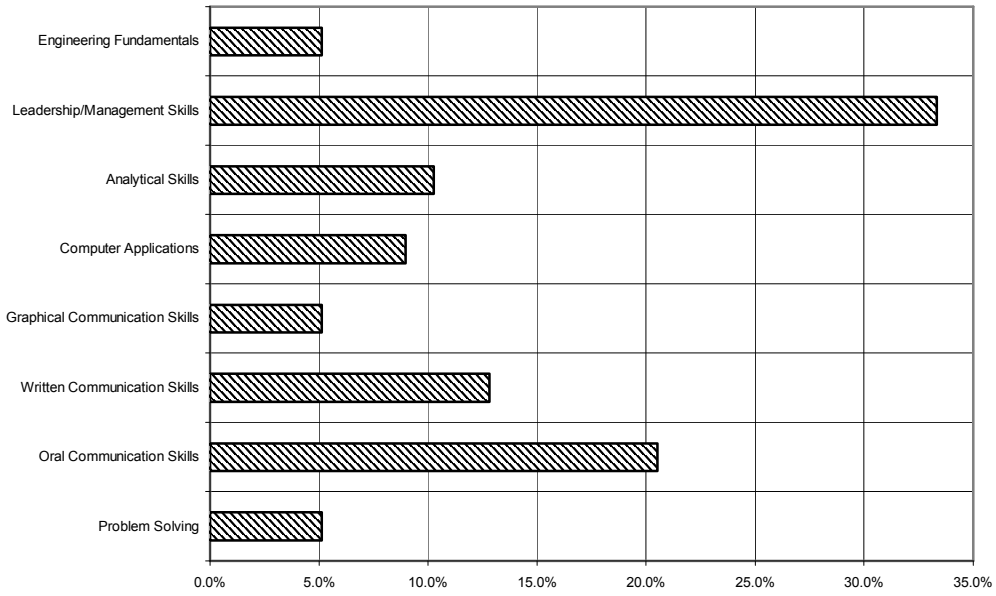

Figure 2: Skills Identified as Most Wanted to Develop before Graduation (University of Memphis data only)

A group of 45 students primarily from the Civil and Industrial programs at the University of Arkansas were given the same initial survey to identify their strengths and weaknesses. The results of their responses are shown in Figure 3.

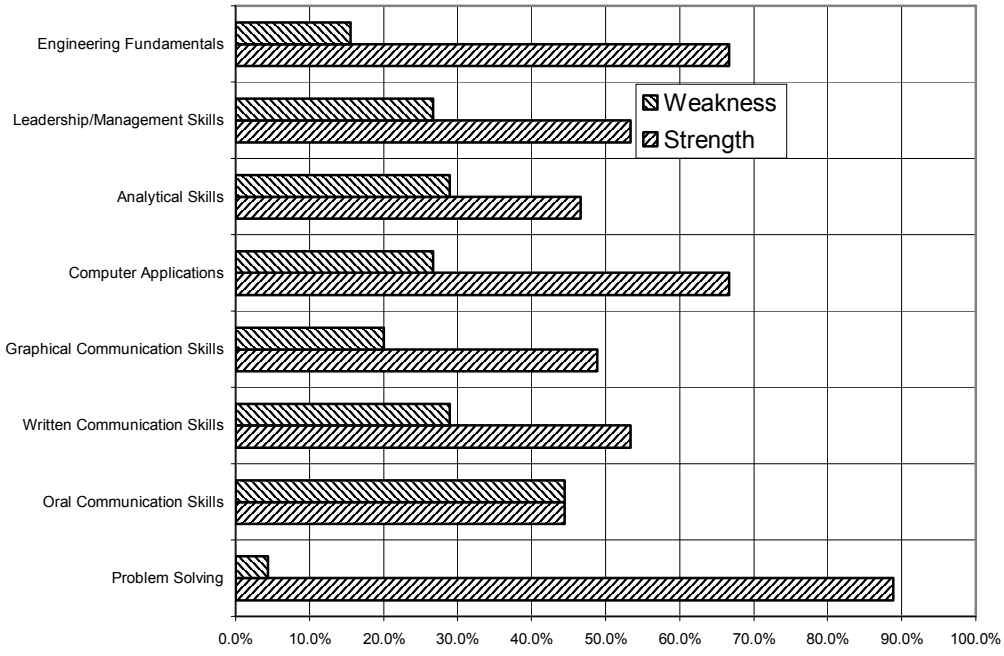

Figure 3: Student Self-Evaluation from the University of Arkansas

Pedagogical Alternatives

Where can leadership/management training occur in an existing engineering program? How does it fit with technical communication?

Felder and Brent (2003) discuss ideas for an "integrated approach" to using teaching strategies designed specifically with ABET's "a-k" criteria and they provide an excellent array of possible assessment instruments at both the program level and course-level, and we believe their article should be required reading for all new engineering educators, but it does not extend to student perceptions and self-reports. Ford and Riley (2003) suggest interdisciplinary and multidisciplinary approaches to solving these problems. Some programs integrate non-engineering faculty members as specialists in non-technical areas. For example: The University of Tennessee now offers a five-course minor in Engineering Communication and Performance through collaboration of 3 departments: Counseling, Education, and Engineering with a focus on collaboration and leadership skills, presentation and communication skills, and psychological/psychosocial communication skills. Ford and Riley (2003) cite the University of Washington as an example of extreme collaboration: The Department of Technical Communications is located within the College of Engineering and offers its own degree programs in conjunction with existing engineering programs.

While it's not feasible to attempt to redesign our curriculum or add additional coursework at a time when most undergraduate engineering programs are trying to lower the overall credit hours required for graduation, we have found that it is possible to address these issues at the course level by incorporating these skills in conjunction with existing topics. The following section describes examples of these pedagogical approaches as applied to an Engineering Communications course, an introductory Foundations sequence in Civil Engineering, two upper-division Construction courses, and a Soil Mechanics course.

Pedagogical Strategies based on results

Clearly, the student perceptions from the students at the University of Arkansas contrast with the findings of the students from The University of Memphis, with the majority of University of Arkansas students reporting high levels of preparation in management/leadership skills. While these findings represent only one group of students compared with multiple groups from The University of Memphis, we believed it was important to investigate how these skills were being taught, and our findings are presented below.

Foundations Engineering - The University of Arkansas

In CVEG-4143, Foundation Engineering, the students are responsible for completing a geotechnical report for a major facility (Medical Center, Office Complex, Convention Center, Multi-story Mall Complex) that starts with a conceptual layout, recommends a subsurface exploration program, reduces the data from that program to get design properties, recommends shallow and deep foundation sizes and types and several retaining wall sizes and types. The project is completed in 4 phases with each phase requiring a written report. The reports consist of a 5-7 page summary of the design process and recommendations followed by an appendix(s) containing all calculations. The initial reports are abysmal, but each successive report gets better as the students incorporate comments and correct deficiencies from previous reports. A final

written report consolidates the 4 interim reports from each phase into a document that would be suitable to send to a client as a final report. These 20 to 150 page reports are very high quality.

Before we cover any technical content in the course, the students are given the general resource requirements statement for the facility, divided into four person teams and given two lectures on teaming skills. We talk a bit about team dynamics, how to break big tasks into smaller subtasks, work flow, document handling, deadlines, etc. The first team assignment is to develop job descriptions for each member of the team, and management structure for the team, a workflow process for the team and to prepare a Gantt chart identifying the tasks (with responsible party) that are necessary to complete the entire project. Gantt charts are a project planning tool that can be used to represent the timing of tasks required to complete a project. The Gantt chart is updated in greater detail for each phase of the design.

Clearly, this pedagogical approach emphasizes management/leadership skills through a mentored, hands-on project that involves the students in managing multiple components of a group project, and further feedback from the students in this course will provide valuable information.

Engineering Communications – The University of Memphis

In response to the student feedback, Anna Lambert incorporated a new assignment into one section of Engineering Communications in the Fall, 2003 semester. This assignment was introduced as Project 9: Captain Content and it involved the synthesis of evaluation and critique processes of current mass-media books on leadership/management/communication topics with a 15-20 minute presentation to the rest of the class regarding the findings and connecting and contrasting those findings to previously discussed principles of technical communication. Pedagogically, this assignment allowed for discussion/information of material from 11 different authors in the leadership/management/communication fields, and it also required that students synthesize the findings, prepare relevant and interesting visual examples and handouts, and present all of this information within a short time period. Fellow students filled out comment/feedback forms, and these forms were shared with the presenters.

While this assignment has been in place only one semester, the overall student feedback regarding the assignment has been positive. While the formal assessment instruments will not be returned to the instructor before publication of this paper, informal classroom assessment strategies have indicated that this assignment is promoting leadership/management knowledge through a combined approach incorporating oral and written communication.

Instructions and criteria for assessment/evaluation of this assignment can be located in the Appendix.

Construction I and II – The University of Memphis

Within these two courses, a series of projects are utilized throughout the semester demonstrating the activities of a project management team in a simulation-type atmosphere. Project activities

include reviewing of plans and specifications for a construction project (ex: medium-size commercial building, warehouse, residential home), developing an estimate, preparing appropriate bid documents, developing a project schedule, updating project schedule, and submitting all necessary documentation for the project throughout the simulation.

Before teams are formed, a lesson is devoted to teambuilding and team management. Emphasis is not only placed on the logistical activities of working in groups, but also concepts of organizational behavior.

The first segment of the simulation requires the newly formed teams to assign roles and responsibilities within the team. Students are required to develop a set of by-laws for the group outlining thee roles, rights, and responsibilities of each group member. Despite the fact that individuals naturally connect better with certain roles in a team than others, students are encouraged to experiment with exchanging roles and responsibilities throughout the semester. The first segment also requires each group to review the plans and specifications and prepare simulated documentation that customarily accompanies the bid (i.e.- necessary bonds and insurance, affidavits, licenses, etc.).

The second segment requires each group to prepare an estimate for their project. Students are aided by Microsoft Excel spreadsheets they prepared in Construction Engineering I (CIVL 4171) for determining quantities required and productivity rates for a variety of construction processes. After the estimate is complete, each group is required to decide on dollar amounts to be included as contingency and profit to complete their bid for the project.

The last segment of the simulation requires each group to prepare a work breakdown structure and CPM schedule for the construction of their project, update the schedule as advised, and handle other project management duties as given.

Finally, each group prepares and presents a summary of their project, including problems that arose, how they were handled, and lessons learned from the experience. As a part of each simulation segment, each group member prepares an evaluation of the performance of each group member (including themselves). Students will assign each group member a score based on his/her performance, with the total number of points available for allotment being determined by the group's score on that segment. Comprehensive evaluations are completed at the end of the simulation, and peer evaluation scores are factored into each student's grade.

This simulation is pedagogically designed to give students the hands-on experience that they continually request, as well as provide an opportunity for leadership experience within a group. Peer assessments are designed to provide real feedback, and force students to adjust their behavior for overall group success.

Civil Engineering Foundation Sequence – The University of Memphis

Within the four-course Civil Engineering Foundation Sequence, students are exposed to leadership experiences as part of the project work in the four classes. Students rotate through different positions such as project manager, lead writer, lead analyst, lead editor, and lead

presentation manager. In each of these positions, they are asked to work as a part of a team and develop an understanding of all the component parts of a successful team. Debriefing sessions include time to evaluate each team member in their role for that project and how they and their other group members could have better accomplished the task by being better at accepting and working at their assigned roles.

The leadership skills are not formally developed but the faculty members are available as resources should group conflicts or other problems of group cohesiveness arise. Typically the faculty members have been able to provide guidance to group leaders and allowed them to resolve problems within the groups.

Discussion/Conclusion

As evidenced by the responses to the student surveys, there is a desire on the part of the engineering students, Civil Engineering students in particular, to developing their leadership and management skills. There is also a strong desire to develop their communication abilities both verbally and orally. At the University of Memphis, there has been a concerted effort to develop and reinforce communication skills through their emphasis in the first two years, the Foundation sequence of courses in Civil Engineering. These students are more comfortable with their communication skills and identify leadership and management skills as a goal about twice as often as they identify enhancement of communication skills. At the University of Arkansas, there is less formal emphasis in the classes the first two years on communication so those students identify communication as a weakness at approximately the same frequency as they identify leadership and management skills.

With the reduction in hours that has become commonplace across most universities, it would be difficult to add a new course emphasizing leadership and management skills into the Civil Engineering curriculum. At the same time, not many programs would be able to make the case to substitute a management/leadership course from the Business/Management school in place of a liberal arts course. This leaves the alternative of trying to integrate leadership/management skills into existing course structures using a model similar to that by which communication skills were added. Three possible ideas which have been successful at both the University of Memphis and the University of Memphis are suggested.

- Involve collateral departments to work within an existing curriculum by integrating multi-disciplinary opportunities like 3603. Since most programs have some form of communications course, probably taught by another department outside engineering, the model for this type cooperation may already be in place.
- Share survey data with other faculty members to encourage greater incorporation of common management/leadership concepts/issues specific to the different disciplines in Civil Engineering.
- Experiment with these techniques in your own courses.

The addition of management/leadership does not mean that the technical content of any course must be reduced. Rather these skills can be modeled on a just in time basis as projects are developed for the course. If the student groups have well identified internal rolls, understand

what it required of each roll, have resources to draw upon if they need help and support working within these rolls, and receive feedback from both their peers and from their teachers, a successful model of leadership can be developed. Some courses will lend themselves more readily to this type of work. Courses where team design work or team problem solving with a deliverable product would appear to be the easiest to incorporate this type of work into.

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Biographical Information

Paul Palazolo is currently a faculty member in the department of Civil Engineering at the University of Memphis and the Assistant Dean of the Herff College of Engineering at the University of Memphis. He is part of a four-member team that developed and teaches the Foundation sequence of courses in the Civil Engineering department.

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Anna Lambert is currently a faculty member in the department of Civil Engineering at the University of Memphis and the direction of the Engineering Communication Center for the Herff College of Engineering at the University of Memphis. She is also a member of the development and teaching team for the Foundation sequence of courses in Civil Engineering. She advises the college on both communication and assessment issues in course development.

Eric Lambert is currently an adjunct faculty member in the department of Civil Engineering at the University of Memphis and an engineer for the Memphis District U.S. Army Corps of Engineers. In addition to his degree in Civil Engineering, he holds a Masters of Business Administration.

Norm Dennis is currently a professor of Civil Engineering at the University of Arkansas with areas of emphasis in transportation, logistics & Infrastructure as well as Materials & Manufacturing. In addition to a doctorate in Civil Engineering, he holds a Masters of Business Administration.