DOCUMENT RESUME

ED 369 313 HE 027 351

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TITLE An Integrated, Cooperative Learning Oriented Freshman Civil Engineering Course: Computer Analysis in Civil Engineering.
PUB DATE Feb 94
NOTE 11p.; Paper presented at the Freshman Year Experience Conference (13th, Columbia, SC, February 18-22, 1994).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Civil Engineering; College Freshmen; *Computers; *Cooperative Learning; *Course Content; Critical Thinking; Curriculum Development; *Group Dynamics; Group Experience; Higher Education; Interpersonal Competence; Problem Solving; *Required Courses; Skill Development; Technical Institutes
IDENTIFIERS *Worcester Polytechnic Institute MA

ABSTRACT

Worcester Polytechnic Institute (Massachusetts) has developed a new freshman course titled "Computer Analysis in Civil Engineering" as part of a curriculum revision project which emphasizes critical thinking, cooperative group learning and problem solving, the integration of knowledge through projects, and student responsibility for learning. The three objectives of the course are fundamentals of civil engineering, computer skills, and working in a group environment. The course incorporates computer application skills, the development of oral and professional presentation skills, team teaching, small group cooperative learning, Graduate Teaching Assistants, and the use of undergraduate students as Peer Learning Assistants. The course utilizes a hands-on approach that involves the learner in the building of bridges between facts and concepts and between disciplines and subdisciplines. Student groups range from informal gatherings (e.g., three to four students organized into teams during lecture periods) to formal groups (e.g., laboratory teams in which each student is given a role assignment and the team is asked to conduct an experiment or solve a problem and then submit a formal report). A rationale for the curriculum revision process is offered, and course evaluation plans are outlined. (JDD)

AN INTEGRATED, COOPERATIVE LEARNING ORIENTED FRESHMAN CIVIL ENGINEERING COURSE: COMPUTER ANALYSIS IN CIVIL ENGINEERING

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ABSTRACT

Worcester Polytechnic Institute (WPI), through a grant from the Davis Educational Foundation, has initiated a curriculum revision project which focuses on improving the teaching quality and faculty and student productivity in introductory level mathematics, science, computer science, and engineering courses.

The objective of this project is to re-emphasize the commitment of the undergraduate program to critical thinking, cooperative group learning and problem solving, the integration of knowledge through projects, and student responsibility for learning. This objective strives to build upon the foundation set over twenty years ago with the creation of the WPI Plan and its emphasis on project-based learning in the upper level undergraduate curriculum.

One example of this project, a new freshman course in Civil Engineering, is described in detail. This course, Fundamentals of Civil Engineering and Computers, incorporates computer application skills, the development of oral and professional presentation skills, team teaching, small group cooperative learning, Graduate Teaching Assistants, and the use of undergraduate students as Peer Learning Assistants. Preliminary assessment results are reported on the course's impact on student and faculty satisfaction and indices of academic performance.

INTRODUCTION

As the United States attempts to retain (or regain) its leadership position in science and technology, renewed attention has been focused on the state and process of engineering education in the nation's colleges and universities. Exemplifying this attention are the recent efforts of the National Science Foundation to establish a number of coalitions of universities to enhance the education of freshman engineering students and other independent efforts by institutions such as Worcester Polytechnic Institute (WPI). A major grant from the Davis Educational Foundation has supported a two-and-one-half-year curriculum revision process at WPI which focuses on improving the quality and productivity of freshman year mathematics, science, and engineering courses.

Before presenting a detailed description of one example of the outcome of WPI's freshman year curricular revision efforts, a brief rational for such efforts will be stated. Critics say that science and engineering, as it is currently taught, tends to be overly reliant on passive teaching approaches. The goals too often are the accumulation of facts and vocabulary that requires memorization over comprehension and reasoning. Scientific and technological education has become static and teacher oriented rather than dynamic and learner focused and controlled. Engineering education is stuck in the "transmission" mode where professors lecture andstudents absorb. This traditional passive mode of instruction does not engage students in the process of making meaning, or participating in the process of constructing knowledge. A process that comtempory educational psychologists say is the key to effective learning, retention, and future application of knowledge.

The project based, team oriented approach being developed in freshman level instruction at WPI emphasizes a hands-on approach that involves the learner in the building of bridges between facts, concepts, and disciplines and sub-disciplines. At the same time, it provides "real time" instruction and experience in learning interpersonal relations and group dynamics skills. These skills are not only essential for success in the upper level undergraduate courses that students will take at WPI, they are critical for success when our students enter the real world of work. The practice of engineering and science is done in integrated project teams where the team member's ability to work together, solve technical and personal problems, communicate effectively, and manage work tasks and interpersonal conflict will greatly affect immediate and long term professional outcomes.

A recent survey of employers of entry level engineers conducted by the National Society of Professional Engineers (NSPE, 1992) presents findings that support the need for the development of higher level interpersonal skills. Eighty percent of respondents in this survey placed a high value on the importance of team-work in engineering while only one in four felt that new graduates were adequately prepared in this area. In addition, when asked to prioritize the need for further instruction in seven key areas (communications, practice, basic science, engineering design, self/social management, specialty engineering, and ethics/humanities), over 60% of employers--the highest individual ranking--identified communication skills as the curricular element needing increased emphasis. Employers of entry level engineers are clear about the value of, and need for better undergraduate instruction in team-work and communication skills.

As part of WPI's efforts to restructure undergraduate instruction the Department of Civil Engineering developed a new freshman level course supported by an internal mini-grant from the Davis Educational Foundation project. The course was offered for the first time in the Fall of 1992. Entitled "Computer Analysis in Civil Engineering", this course is required of all Civil Engineering students and provides the foundation for future academic coursework for all majors. There are three principal objectives of this course. First, as the title implies, is the introduction of the fundamental use of computers for solving basic civil engineering problems. This objective, in-of-itself, represents a significant change in introductory civil engineering education. Second, students are exposed to the basic areas and sub-disciplines of civil engineering. This exposure comes at the very beginning of their professional education and enables students to make more reasoned career decisions and course choices. It also constructs a more integrated picture of civil engineering where by students see the interconnectedness of skills and ideas comprising the entire discipline. This perspective is seen by WPI to be a critical element in professional success.

Both the structure and method of teaching this course also represent major educational innovations. Cooperative learning is integrated throughout the course with students organized into project teams where they must work together and where they are evaluated based on individual and group contributions. These student work groups are supported by a network of teaching supports consisting of an undergraduate Peer Learning Assistant, who provides assistance with group process issues and technical support for computer applications, and a Graduate Teaching Assistant who monitors and supervises computer activities. Teaching this course has also involved seven different Civil Engineering faculty in instructional activities and a text specifically designed for this unique teaching/learning approach has been written.

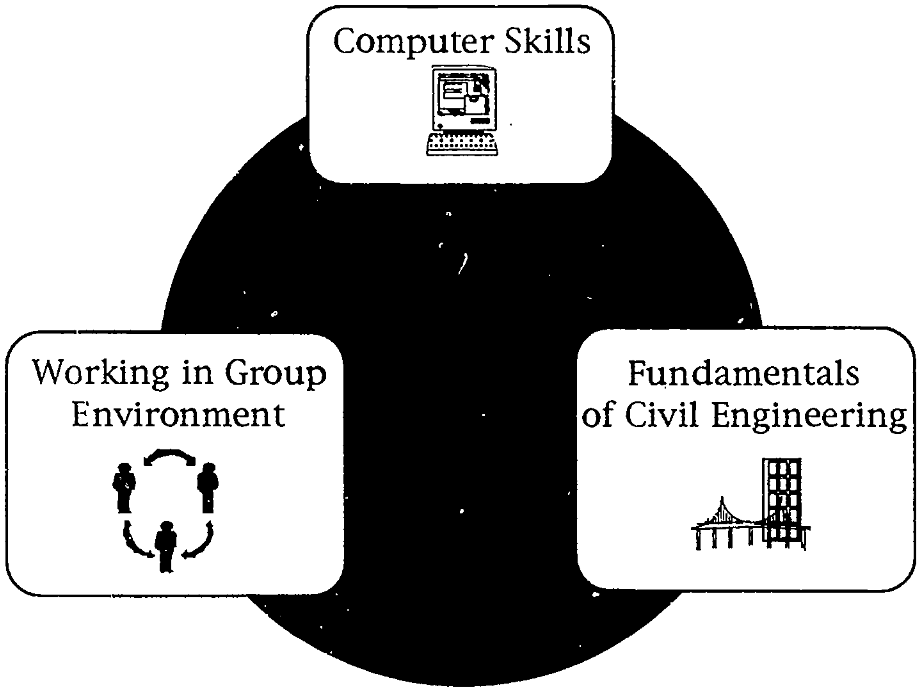

Figure 1 Course Goals

COURSE OBJECTIVE

As shown by Figure 1, this course was designed to meet three objectives. Further elaboration on these objectives are presented below.

Working in Groups

The style of teaching this course, and consequently the course structure incorporates a method of learning called "cooperative learning". Descriptions of this educational technique can be found in numerous publications. Simply stated, cooperative learning stresses participation through student group activities. Student groups may range from informal gatherings (e.g. 3-to-4 students organized into teams during lecture periods) to formal groups (e.g. laboratory teams asked to conduct an experiment or solve a problem and then submit a formal report). This shift from the traditional lecture classroom to active student group participation is being made to place learning responsibility closer to where it will be most effective (i.e. the students). Instead of simply passing information from the teacher to the students and then asking the students to parrot this information back, the cooperative learning approach asks students to work together to build from information that has been made available to them. In addition, group interaction experiences willhelp prepare students to function more successfully in their future professional work environments, which will certainly involve group activities.

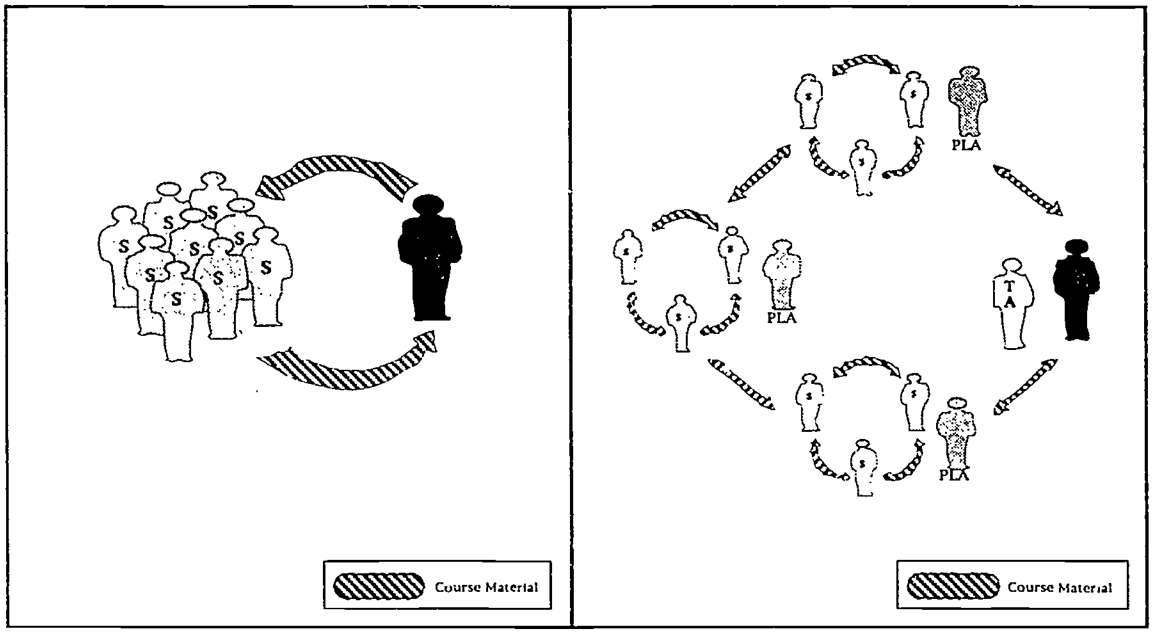

Figure 2 Traditional Teaching Style vs. Collaborative Teaching Style

It is important to recognize that a student group is not simply a gathering of three to four students thrown together to solve a problem. Group dynamics are carefully monitored and encouraged by the faculty member and his/her teaching aids (TA & PLA's). A more thorough discussion of group dynamics can be found in the literature. Two types of student groups are used in this course: (1) the informal group, and (2) the formal group. Informal groups are formed for short classroom problems while formal group activities are formed for the laboratory periods and the final presentation period.

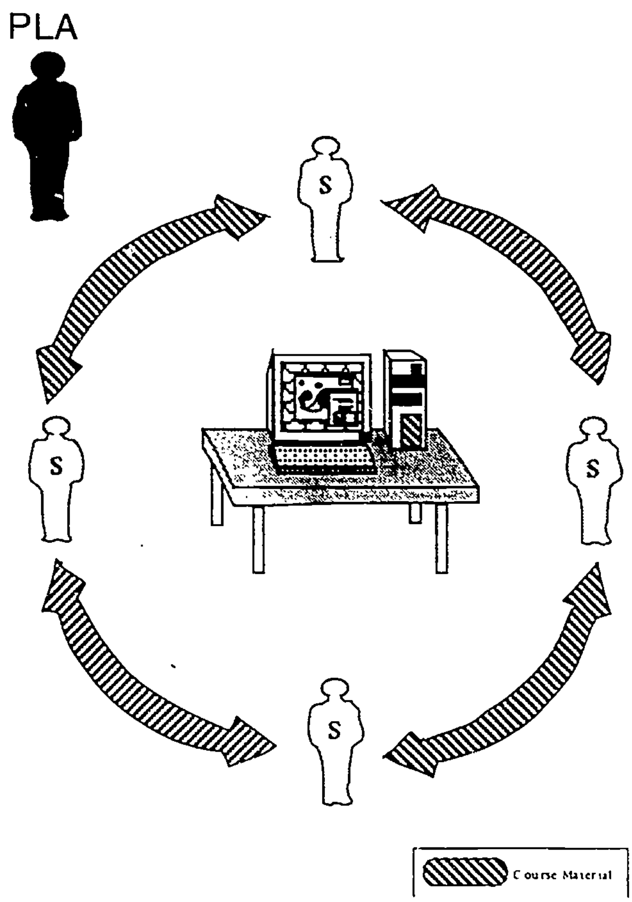

Figure 3 Student Group

Team members of a student group are assigned titles with specifically stated roles. This approach of formal role assignments is mainly used to help initiate group activities. It is not expected that these roles and titles will be carried throughout the course as students will eventually adopt their own approach towards organizing themselves. To help deliver the message that this type of teamwork parallels a typical engineering group, their titles may be adjusted to resemble professional roles:

- Project Manager (reader - assures that all group members understand the problem and have a clear understanding of their function in solving the problem).

- Chief Engineer (encourager - makes sure that all members of the group get their work done).

- Engineer (checker - oversees the analysis and certifies that the work is accurate).
- Client Representative (summarizer - presents the final summary).

BASICS OF CE PROFESSION

Each of the six sub-disciplines of civil engineering covered in this course relies on unique fundamental concepts. For example, environmental engineers use concepts of energy conservation when evaluating fluid mechanic problems, reaction kinetic concepts when evaluating unit process problems, and conservation of mass concepts when evaluating a host of water and wastewater treatment operations.

The intent of this course is to introduce students to the bridge between these types of theories and their relevant applications at an early stage of their educational development (even before theories or applications have been covered). With this understanding presented to them, they will be able to make the link between theory and application in later courses when they are concentrating on either of these areas.

Students will also become familiar with the many sub-disciplines of civil engineering. This is accomplished by the course content, which consists of topics in the following areas of civil engineering: Statics and Structures, Environmental Engineering, Materials Engineering, Geotechnical Engineering, Surveying, and Construction Engineering & Cost Estimating.

Computer Skills

All engineering topics presented in this course require students to acquire computer use skills through practice and example. These skills include: Spread Sheets, Word Processors and Drawing Graphics.

Spreadsheet packages (primarily Excel, and Cricket Graph) will be used for data manipulation, graphical representation, and simple statistical analysis. These skills are often considered essential to a student's success in later courses and in the profession. For example, students may be given cause and effect data (e.g. loading vs. deflection) and will be asked to apply this relationship to a simple application (e.g. size a beam). Data manipulation and graphical representation may then be used to identify various relationships needed to arrive at a successful design (such as stress vs. strain). The spreadsheet package, therefore, will be used as a tool for systematically investigating observations and subsequently arriving at usable engineering relationships. As the course progresses, more advanced uses of the spreadsheet (such as use of functions, table lookups, graphics and macros) are presented.

COURSE DESCRIPTION

Because this course introduces civil engineering basics (structural engineering, environmental engineering, hydraulic engineering, geotechnical engineering .... etc) , expertise from a variety of civil engineering fields are required. To meet this need, a faculty team teaching approach is used with a different faculty member assigned to each weekly topic. A week is scheduled as follows:

Monday:	Lecture 1 (basic fundamentals)
Tuesday:	Laboratory 1 (basic fundamentals)
Wednesday:	Lecture 2 (engineering problems)
Thursday:	Laboratory 2 (engineering problems)
Friday:	Group oral presentations
------	(weekend group work)
Monday:	Written group report due

The intensive nature of this course is purposely adopted to stress the importance of group interaction and organizational skills. As can be seen, student groups are expected to give a professional level presentation (complete with slides or other visual aids) two days after assigned a laboratory problem. In addition they must submit a written report (with graphics, diagrams, ...etc) on the following Monday.

Classroom Periods

Lecture periods are structured to include informal group participation. This method of lecture presentation (sometimes referred to as a book-end style of lecturing) layers lecture sessions (about 15 minutes) with informal student group sessions (about 5 minutes). These student groups (referred to as informal groups) are given a problem to solve by the professor. At the end of their allotted five minute period they may be asked to present their results or participate in a class wide discussion. This method of lecturing is designed to keep the students attentive and to encourage active learning during lecture periods (rather than simply absorbing information).

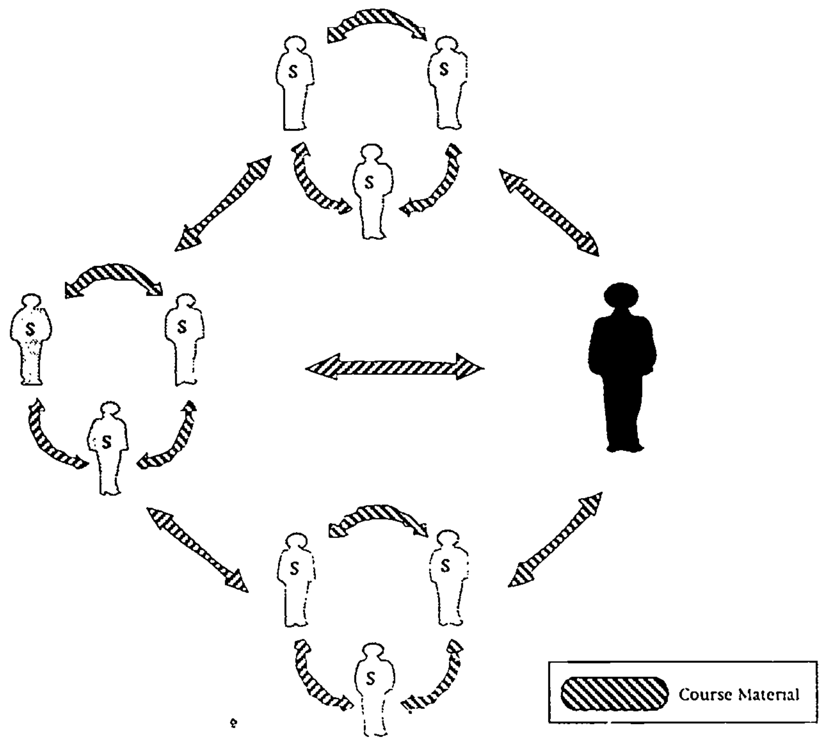

Figure 4 The Collaborative Lecture Style

Laboratory Periods

At the conclusion of each lecture period, laboratory problems are given to the students for the next day's session. These laboratory sessions are designed for formal groups. Each group (consisting of four students) is assisted by a PLA. Although the faculty member is not present during these periods, he/she is accessible for consultation by the TA or a PLA if problems develop.

Although a computer laboratory is used for this course, student groups must begin each laboratory period in a meeting room. During this planning session, team member roles (to be discussed later) and project tasks are identified. Once a student group develops a plan, and each team member has a clear understanding of what he/she will be doing, they are free to enter the computer laboratory.

Presentation Periods

The oral presentation involves a high degree of organization and preparation. Formal group presentations are required, with each individual assigned specific tasks. High quality overheads or computer projected slides are used for these presentations. Because of time constraints, these presentations are limited to about ten minutes. A typical oral presentation may be divided into the following parts:

1. Title of Presentation: Names and titles of all group members are introduced here.
2. Problem Statement: This portion of the presentation normally includes a diagram illustrating the problem along with a diagram illustrating all important variables.
3. Identify Objectives: A bullet listing of problem objectives, and a discussion of methods used are presented here.
4. Presentation of Results: Graphical and/or tabular results are presented here.
5. Conclusions: A summary of conclusions supported by a bullet listing is presented here.

COURSE ASSESSMENT

An ongoing assessment process was initiated at the beginning of the first term of instruction and will continue throughout the Spring semester. In addition to demographic and student outcome and performance information, data is being collected concerning student opinions about the subject matter and teaching methods, present and future student expectations and aspirations, and problem solving preferences.

Specially modified versions of a pre- and post-course survey are being used to collect student data. This survey has been successfully utilized to measure curricular revision efforts in the departments of Biology and Biotechnology, Mathematics, and Computer Science. In addition to this survey, results on the standard WPI student course evaluation form will be analyzed. Findings will be communicated as they become available. It is also planned to track the students who have enrolled in Computer Analysis in Civil Engineering throughout their academic career at WPI to assess the longitudinal impacts of the course on such variables as: retention in the major, satisfaction, and performance on required academic projects.