The Role of Computing in the Civil Engineering Curriculum

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ABSTRACT

The effective use of computers in engineering processes and applications is recognized by many as the key to increased individual, company, and national productivity. This paper presents the results of a survey that was conducted by the ASCE Task Committee on Computing Education to assess the computing needs in the civil engineering profession and to assess the current computing curriculum in civil engineering education.

The survey results presented in this paper can be used as a guide by educators who wish to enhance the computing aspects of their engineering curricula and by engineering firms that are evaluating the educational profile of new graduates. The goal is to enable students to possess, in addition to their engineering skills, both the ability to evaluate and use production software and the ability to organize and supervise the development of software.

1 Introduction

In the future, an integrated combination of computer-aided analysis and design tools and techniques will be developed for all types of engineering design problems. This will require applying computer science principles and practices to a variety of engineering systems in order to determine their response to external influences. The implications of this requirement for the academic community are clear: we must prepare our students to use computer methods and applications as a part of their fundamental engineering education [Rasdorf84, Rasdorf87, Rehak83].

Considering the above observations, the American Society of Civil Engineers' Education Committee proposed and started a study on computing education requirements for the civil engineering curriculum. One of the tasks in this study was to assess the current teaching practices and course offerings in civil engineering departments of various universities and to assess the educational requirements, relative to computing, of professional engineering firms. The task committee designed a survey and send it to both academicians and practitioners to solicit responses. The responses to the survey have been accumulated and analyzed. This paper presents and discusses those results.

The paper is organized as follows: section two provides a discussion of the history of the ASCE Education Task Committee on Computing Curriculum and on the survey conducted; section three lists the results of the survey in tabular and graphical forms; section four provides a commentary on the results; and, section five provides a summary.

2 Background

Adequate computer resources have been a subject of concern in engineering education. In 1986, the education committee of the Technical Council on Computer Practices conducted a survey to determine the availability of computing resources in civil engineering departments and to determine the attitude of faculty towards computing in civil engineering education. The committee received over 93 responses from the civil engineering departments and 550 responses from faculty across the country.

The survey indicated that while almost all universities require a programming course, most civil engineering departments do not require, nor do they have, any additional computing courses beyond the first programming language course. The faculty responding to the survey strongly agreed that some type of a computing technology course should be a fundamental course within a civil engineering degree granting program. Furthermore, the faculty strongly agreed that the civil engineering curriculum should allocate course time to train students to use computers even if the result is an increase of 3-6 hours in the overall number of courses required to complete the BSCE degree. Three specific areas were identified by the task committee that civil engineering students need to be exposed to:

1. The technology of computers - how they work and how to program them.
2. Computers as problem solving tools - how to use spreadsheets, graphics, CAD, databases, etc. to solve engineering problems.
3. Computers as engineering simulators - how to use software to illustrate and evaluate a variety of solutions or alternatives.

Because there is a lack of consistency in computing education to address these areas, there is clearly a need for a comprehensive review of the computing aspects of the civil engineering curriculum.

The formation of a task committee under the ASCE Education Committee for assessing the status of the civil engineering curriculum with respect to computing was first initiated in 1987. A proposal was written, submitted, and approved by the Technical Council on Computer Practices of ASCE. The proposal called for developing guidelines and recommendations for a computing curriculum in civil engineering education. The activities involved in the effort included:

1. Assessing the current computing curriculum in civil engineering education by sending out surveys to academicians that are teaching computing courses in different schools across the nation;
2. Assessing the computing needs of the civil engineering profession by sending out surveys to practitioners in both the public and private sectors in different civil engineering firms across the nation; and

3. Developing recommendations and suggesting formal guidelines for a modified civil engineering computing curriculum.

The proposal called for completion of these activities in a two-year period. This paper addresses the first two of these three issues.

The task committee members, represented by the authors of this paper, approved two mailing lists: one for the professional candidates and one for the academic candidates; sent the questionnaire to each candidate; collected the responses; and, tabulated and analyzed the results that are presented in this paper.

3 Survey Results

The results of the academic survey are tabulated in Tables 1 and 2. They are also displayed in Figures 1 and 2. The results of the professional survey are tabulated in Tables 3 and 4. They are also displayed in Figures 3 and 4. In the tables, the number of responses shown indicates how many survey responses, out of the total number of responses (given in the table header), selected the item shown. Also, the percentages shown represent the ratio of the number of responses to the total number of responses (given in the table header).

Figure 1 is a bar chart of the prioritization of the different subject areas in civil engineering that were provided by the participants of the academic survey. Table 1 lists the titles of the subject areas displayed in Figure 1. Figure 2 is a bar chart of the number of computing courses offered at the universities represented by the academic survey participants. Table 2 lists the actual number of computing courses displayed in Figure 2. The "no course" percentage (36%) item in Figure 2 and Table 2 includes both those institutions where there is no computing course offering (30%) and those institutions where there are future planned courses (6%).

Figure 3 is a bar chart of the prioritization of the different subject areas in civil engineering that were provided by the participants of the professional survey. Table 3 lists the titles of the subject areas displayed in Figure 3. Figure 4 is a bar chart of the civil engineering computing application areas that were provided by the participants of the professional survey. Table 4 lists the titles of the application areas displayed in Figure 4.

The survey has determined that there is a general consensus among academicians and practioners with respect to the need for an increased emphasis on computing in existing civil engineering courses. This conclusion is based on such an indication from 42% of the responses from the academic survey and 28% of the responses from the professional survey, where these percentages were the highest on both surveys.

The second highest percentage on the academic survey was different than that of the professional survey. While academicians believe that acquiring good software and hardware and maintaining a balanced computing education curriculum that puts equal emphasis on computing and basic understanding of the underlying civil engineering principles; practioners believe that it is more important to emphasize the use of personal computer based software packages that relate to civil engineering as well as to teach students how to judge and evaluate computer program results.

The third highest score on the academic survey emphasized that there is a need for educating faculty members on computing concepts, techniques, and utilization. The third highest score on the professional survey was given to the fact that students must learn when it is appropriate to use computers and when it is appropriate to use other problem solving tools.

4 Survey Commentary

This section discusses the results of both surveys, list the conclusions, and suggests general guideline for schools that intend to develop a new computing course or courses.

From Figures 1 and 3 and Tables 1 and 3 one can observe that the following subjects were the top highest five subjects that both academicians and practioners believed to be the most promising and awarding to the civil engineering profession: spreadsheets, CADD (Computer Aided Design and Drafting), programming, graphics, and databases.

From the above list one may conclude that both academicians and practioners realize the need for adopting computing concepts and technologies and integrating them into the civil engineering educational program. It was encouraging to note that both surveys were in almost total agreement on the prioritization of the above list which may indicate that these subjects are in fact emerging as substantial prerequisites for civil engineering practice and research.

From Figure 2 and Table 2 one can observe that civil engineering departments clearly realize the need for adopting courses to teach computing concepts and techniques. 64% of the schools represented in the survey offered at least one computing course and additional 6% are planning to offer one in the near future.

From Table 4 and Figure 4 one can conclude that practioners overwhelmingly favor (76% of the participants) the design, management, analysis, and drafting application areas to the other areas. This should convey a message to academicians about which existing courses should receive the most attention and provide the largest professional payoff relative to computing.

The following guidelines are based on the comments provided by the survey respondees as well as the observations made in this section. These guidelines are not intended to be complete or exhaustive but they do represent somewhat of a consensus distillation of the survey results. Participants generally suggest that colleges and universities should:

1. Emphasize computing in existing civil engineering courses by requiring the use of computers in junior and senior level courses.
2. Acquire and maintain quality hardware and software.
3. Maintain a balanced computing education curriculum that gives increased emphasis on computing concepts as well as on civil engineering principles.
4. Organize workshops for educating faculty members on computing concepts and computer use.
5. Teach students how to use computing concepts effectively and how to judge and evaluate computer program results. The best way to accomplish this is to design

homework problems that require students to interact with the computer rather than to use it as a black box.

5 Summary

This paper presented the results of a survey that was conducted by the ASCE Task Committee on Computing Education to assess the role of computing in the civil engineering curriculum. The survey sought to determine the depth of course offering in civil engineering departments of various universities, to assess the computing education specifications of educators, and to assess the computing educational requirements, relative to computing, of professional engineering firms. The motivation for the survey and the origins of the ASCE Education Task Committee were described. The results of the survey were provided and discussed. Conclusions were drawn based on the accumulated results and a commentary on the results was provided.

6 Acknowledgment

The authors would like to express their gratitude to everyone who participated in this survey for their cooperation and subjective comments. In addition, ASCE is acknowledged for supporting the task committee in its charge, for providing the resources to conduct the survey, and for providing the forum to convey the results to the civil engineering community. The former task committee on computing resources was chaired by professor Darrell Fontane of Colorado State University, whose encouragement and suggestions were very helpful in completing the study described here.

References

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Table 1: Academic Survey Subject Results (85 Responses).

Rank	Subject	Responses	%
1	Spreadsheet	63	74
2	CADD	57	67
3	Programming	55	64
4	Graphics	46	54
5	Databases	27	32
6	Wordprocessing	23	27
7	Software Packages	22	26
8	Expert Systems	15	18
9	Software Engineering	14	17
10	Geometric Modeling	12	14
11	Numerical Analysis	11	13
12	Operating Systems	11	13
13	Networking	3	4
14	Finite Element Methods	2	2
15	Simulation	2	2

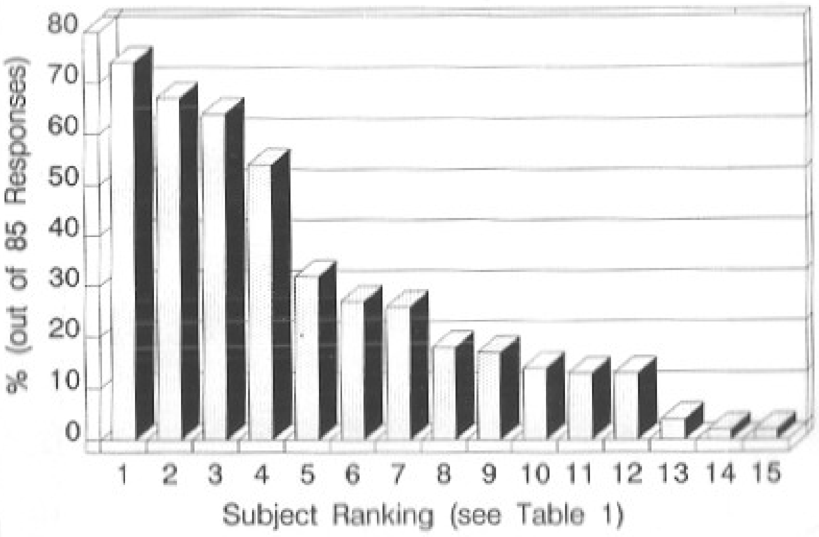

Figure 1: Academic Survey Subject Results.

Table 2: Academic Survey Course Offering Results (85 Responses).

Course Offering	Responses	%
no courses	31	36
1 course	20	24
2 courses	18	21
3 courses	12	14
4 or more	4	5

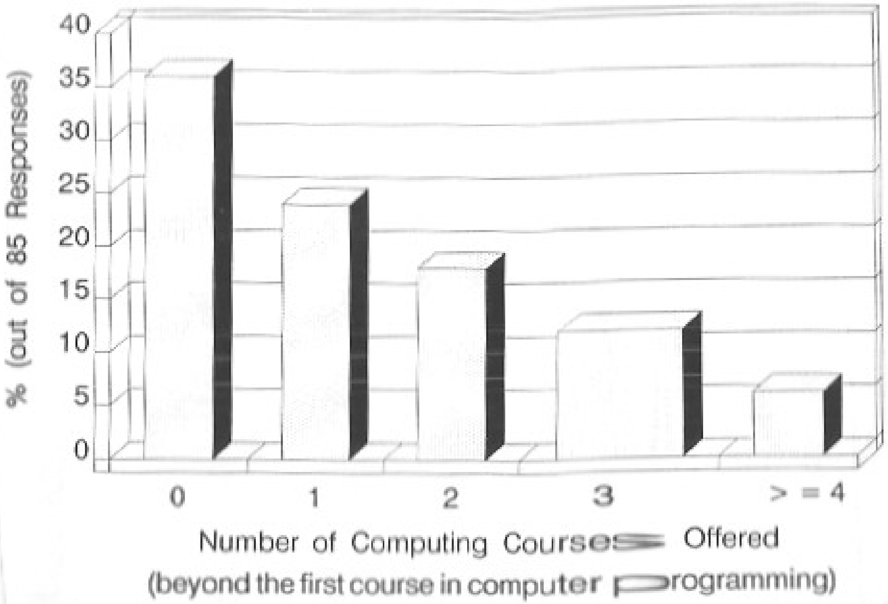

Figure 2: Academic Survey Course Offering Results.