The Role of Computing in Civil Engineering Education

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ABSTRACT

The rapid advances occurring in computer software and hardware have provided the engineer with a powerful means of processing, storing, retrieving, and displaying data. This has made computer science a growing and essential part of nearly every engineering discipline. Applications of fundamental computing technologies are spreading and are giving engineers a sophisticated means of rapid access to a wide variety of information, solutions to complex problems, and ways to model complicated engineering systems. More advanced computer science technologies in such areas as data management, artificial intelligence, concurrent processing applications, and interactive computer graphics have also prominently emerged in engineering.

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 current computing curriculum in civil engineering education and to assess the computing needs in the civil engineering profession. The 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 in-house 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.

The role of computing is increasing in nearly every engineering discipline. One of the dilemmas in engineering education today is how future engineers can best assimilate the advanced, yet fundamental, knowledge of computing technologies appropriate for their professional engineering career [Comfort81, Rasdorf84, Rasdorf87, Rehak83]. This paper suggests that the role of the academic community must be to prepare engineering students to use computer methods and applications as a part of their fundamental civil engineering education. It is the responsibility of universities to incorporate contemporary computing fundamentals into their academic curriculum to improve the professional qualifications of their engineering graduates, since it has been well recognized that the traditional introductory programming courses are no longer sufficient for enabling students to become familiar with current computing technologies.

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 sent it to both academicians and practitioners to solicit responses. The responses to the survey have been accumulated and analyzed. This paper presents and discusses the results of the survey.

The paper is organized as follows: section two provides the background on 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 conclusions and commentary on the results; and, section five provides a summary. Appendix A provides a list of general comments that were accumulated from both surveys.

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 about computing resources in civil engineering departments and 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 extra computing courses beyond the first programming language course. The faculty responding to the survey strongly agreed that 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 on the use of 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. 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 computer 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 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 a survey to academicians that are teaching computing courses in civil engineering departments across the nation;
2. Assessing the computing needs of the civil engineering profession by sending out surveys to civil engineering practitioners in both the public and private sectors 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, accumulated the results that are presented in this paper. The effort spanned a period of one year starting in March, 1988 and ending in January, 1989.

3 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 out of the total number of responses (given in the table header) selected the item shown. Also, the percentages represent the ratio of
the number of responses for each item 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 actual subject areas displayed in Figure 1. Figure 2 is a bar chart of the number of computing courses (beyond the first course in computer programming) offered at the universities represented by the 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 actual 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 actual application areas displayed in Figure 4.

The comments provided by the participants of both surveys are summarized in Appendix A. These comments will be used as a basis for developing the recommendations and suggested guidelines for a modified civil engineering computing curriculum.

Referred to Appendix A, one can conclude that there is a general consensus among academicians and practitioners with respect to the need for an increased emphasis on computing in existing civil engineering courses. This remark is based on a 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; practitioners believe that it is more important to emphasize the use of personal computer based software packages that relate to civil engineering as well as teaching students how to judge and evaluate computer outputs.

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 to use computers and when to use other capabilities.

4 Conclusions and Commentary

This section discusses the results of both surveys, list the conclusions, and suggests guidelines 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 academicians and practitioners believed to be the most important to the civil engineering profession:
1. Spreadsheets,
2. CADD (Computer Aided Design and Drafting),
3. Programming,
4. Graphics, and
5. Databases.

From the above list one concludes that both academicians and practitioners realize the need for adopting computing concepts and technologies and integrating them with the civil engineering education. It was encouraging to note that both surveys were in almost total agreement on the prioritization of the above list which indicates 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 are starting to 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 (beyond the first course in computer programming) and an additional 6% are planning to offer one in the near future.

From Table 4 and Figure 4 one can conclude that practitioners 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 what existing courses should receive the most attention relative to computing.

The following guidelines are based on the comments provided in Appendix A as well as the conclusion drawn in this section. These guidelines are not intended to be complete or exhaustive but represent somewhat of a consensus distillation of the survey results. Universities should:

1. Emphasize computing in existing civil engineering courses by requiring the use of computers in more and more courses at the junior and senior levels.
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 use.
5. Teach students how to use computing concepts effectively and how to judge and evaluate computer outputs. The best way to accomplish this is to design homework problems that require students to interact with the computer and not use it as a black box.
5 Summary

This paper presented the results of a survey that was conducted by the ASCE Education Task Committee 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 for conveying 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 have been very helpful in completing this study.

References


Appendix A: Summary of the Comments from Both Surveys

**Academic Survey Comments:** Out of the 85 participants in the academic survey 69 provided written comments. Out of the 86 participants in the professional survey 65 provided written comments. The following compilation summarizes the most frequent comments provided by the participants and indicates their frequency.

<table>
<thead>
<tr>
<th>Comment</th>
<th>Academic Responses (out of 69)</th>
<th>Professional Responses (out of 65)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Put more emphasis on computing in civil engineering courses.</td>
<td>29</td>
<td>18</td>
</tr>
<tr>
<td>2. Acquire and maintain good software and hardware.</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>3. Maintain a balanced computing education curriculum that does not overemphasize computing and does not sacrifice underlying civil engineering principles and engineering judgment.</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>4. Educate faculty members on computing and on the need to start realizing that computers are useful tools.</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>5. More support is needed to acquire good software from both state and federal agencies.</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>6. There is a need for good educational software.</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>7. Require students to own computer systems.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>8. Put more emphasis on PC use and less emphasis on mainframe use.</td>
<td></td>
<td></td>
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<tr>
<td>9. Teach students to judge and evaluate computer output.</td>
<td></td>
<td></td>
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<tr>
<td>10. Teach students when to use computers and when to use other capabilities.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Put less emphasis on programming and more emphasis on available tools.</td>
<td></td>
<td>4</td>
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