Integration of Computer Applications in the Practice of Architecture

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Computer Applications in Architecture is emerging as an important aspect of our profession. The field, which is often referred to as Computer-Aided Architectural Design (CAAD) has had a notable impact on the profession and academia in recent years. A few professionals have predicted that as slide rules were replaced by calculators, in the coming years drafting boards and parallel bars will be replaced by computers. On the other hand, many architects do not anticipate such a drastic change in the coming decade as present CAD systems are supporting only a few integral aspects of architectural design. However, all agree that architecture curricula should be modified to integrate CAAD education.

In 1992-93, in the Department of Architecture of the School of Architecture and Interior Design at the University of Cincinnati, a curriculum committee was formed to review and modify the entire architecture curriculum. Since our profession and academia relate directly to each other, the author felt that while revising the curriculum, the committee should have factual information about CAD usage in the industry. Three ways to obtain such information were thought of, namely: (1) conducting person to person or telephone interviews with the practitioners (2) requesting firms to give open-ended feed back and (3) surveying firms by sending a questionnaire. Of these three, the most effective, efficient and suitable method to obtain such information was an organized survey through a questionnaire. In mid December 1992, a survey was organized which was sponsored by the School of Architecture and Interior Design, the Center for the Study of the Practice of Architecture (CSPA) and the University Division of Professional Practice, all from the University of Cincinnati.

This chapter focuses on the results of this survey. A brief description of the survey design is also given. In the next section a few surveys organized in recent years are listed. In the third section the design of this survey is presented. The survey questions and their responses are given in the fourth section. The last section presents the conclusions and brief recommendations regarding computer curriculum in architecture.

Previous Surveys

There have been a few surveys in the area of computer applications in architecture in recent years. Information about the following surveys is available through published articles, actual survey results or brochures:

- “CADD Activities Survey” by ACADIA [ACADIA, 1986].
- “The Integration of Computing into Architectural Education Through Computer Literate Faculty”, a survey by Pamela Bancroft [Bancroft, 1999].
- “The AIA’s Firm Survey” [AIA, 1989].

Of these, the last four are the surveys of practitioners and firms and are thus relevant in the context of this survey. The survey by Practice Management Associates which is done annually, concentrates on the cost factor of the hardware and software in the industry. The MicroCAD News Survey and the AIA Firm Survey addressed issues of hardware and software utilization in architectural firms. The survey by Kalisperis and Groninger was designed to “explore the integration of CADD into the architectural design process by examining the utilization of CADD by architects based on design...
philosophy and their approach to the making of architecture” [Kalisperis and Groninger, 1992]. This survey is referred to as the Design Philosophy Survey in this chapter. While presenting the survey results in the next section, the data are compared with those obtained from the previous firm surveys whenever applicable. This is done to help determine the reliability of this survey.

Survey Design

Most of the surveys previously undertaken have typically addressed quantitative variables such as firm size, number and type of systems used, number of people involved in CAD area, etc. A typical curriculum committee in a school would need additional information such as whether CAD is utilized in the design process in the industry, what professionals expect of computer education in schools, and whether the professionals give importance to CAD proficiency while hiring interns and fresh graduates. Although the cost of systems is an important factor in determining computer usage, the goals of the research undertaken by the author did not include this factor. Thus, the goals of this survey, which was titled A Survey of Computer Applications in Practice of Architecture, were as follows:

1. To determine the hardware and software usage in the area of Computer Applications in Architecture among firms.

This included current usage as well as the predicted usage in the near future. The focus was on broad criteria such as the type of computers and applications used. Information about details such as screen resolution, graphics cards, and various releases of the software used (e.g. AutoCAD release 10/11 or 12) was not important at this stage of the research.

2. To determine whether preference was given to candidates having experience in computer applications while hiring interns or fresh graduates.

3. To understand the expectations of firms from our school in terms of the computer elements of our curriculum.

The survey questionnaire was grouped into three parts. The first part included identification information which was not used in the analysis. The second part was designed to get general information such as the type of firm (Architecture, Architecture/Engineering, Construction, etc.), number of employees and the number of co-operative/intern students with the firm. This section also included questions to determine if, while hiring student employees, preference was given to those who had experience in computer applications and if so, what kind of applications. The third section was to collect information about how CAD was used in architectural design. This section also contained questions regarding practitioners’ opinions about our school curriculum.

We wanted to distribute the questionnaire among a cross-section of firms that would be representative of a broad range of architectural employers. At the same time, due to economic reasons we had to restrict the sample size to about a hundred firms and in the end 110 firms were contacted. These firms, which are AIA members, are participants in the co-operative program of the University of Cincinnati. The “contact” persons for many of these chosen firms are in touch with co-op students and thus with the school and its curriculum. The firm size varied from single employee offices to firms employing more than a hundred persons. The selected firms were geographically located all across the country. The questionnaires were mailed to the firms on December 8, 1992 with a request to return them in two weeks (i.e. by December 24, 1992).

The Results

Seventy seven out of the selected 110 firms returned the questionnaire by the deadline. That is a response of about 70%. The Design Philosophy Survey had received a 28.7% response and other recent surveys have received an even lower response [Kalisperis and Groninger, 1992]. Thus, compared to these surveys, the 70% return can be considered as an overwhelming response.

The questions and their significant responses are as follows:
1. Please check the designation that best describes your firm:

About forty percent of the firms that returned the questionnaire were architectural firms. Architecture/Interior Design firms accounted for about twenty-four percent. Nearly twenty-three percent were Architecture/Engineering firms. Only one firm (i.e. 1.3%) was solely an "engineering" firm. The rest came under "other category" such as firms specializing in code development and planning/ architecture.

2. How many employees (including principals) are in your firm?

About a third of the responding firms had 10 to 19 employees. About twenty percent had more than 100 employees, an equal proportion of the firms had employees between 5 to 9, and another equal proportion of the firms had 20 to 49 employees. Nearly twelve percent of the firms had 50 to 100 employees. A small percentage of the firms had less than 4 employees.

When the firm types were compared with the firm sizes, in the case of the architectural firms it was found that a majority of them (about 43%) had 10 to 19 employees. About fourteen percent had 20 to 49 employees whereas only ten percent of the architecture firms had more than 100 employees.

The answers to this question showed that the firm sizes varied from small firms to large firms, and thus the data received was more random and thus more reliable.

3. How many co-op/intern students do you have at present and how many of them are from the University of Cincinnati?

About a third of the responding firms had one and another third had two co-op students. About twelve percent had three co-op students. A small percentage had five or more student employees.

A few of these firms responded that they hire students from our school. At present, about thirty-seven percent of the respondents have one co-op student from our school, about one third have two students from our school whereas about one fourth of the firms do not have interns from our school at all.

4. While hiring student employees do you give preference to students who have experience in CAD applications?

This question was important as we wanted to know whether practitioners give consideration to experience in CAD while hiring co-op students. Nearly thirty percent of the respondents do give preference to students who have such experience. About thirty-four percent of the respondents give such preference but take into account other considerations such as design ability, drafting skills and prior work experience. About twenty-seven percent of the firms do not give any such preference. Some of these respondents mentioned that they do not give such preference because they train the student employees anyway. See Figure 1.

![Preference given to students with experience in CAD](image)

Figure 1: Preference given to students with experience in CAD

5. If your answer to question number 4 is "yes", in which of the following packages do you expect co-op students to have experience prior to joining your firm? (Please rank in order of importance: 1: most important, 2: the next important)

This, along with the following question was asked to determine whether the firms expected a specific type of experience in computer applications and systems of students while hiring. A majority two-third of the respondents ranked AutoCAD as the most important package that co-op...
students should have prior experience in before joining their firms. Nearly eight percentage of the firms felt that the co-op employees should have prior experience in Intergraph and an equal proportion of the firms thought that the interns should have experience in other packages such as Arris, WordPerfect, Lotus 1-2-3, etc. A very small percentage (2.63%) checked IBM/SOM’s AES system and nearly the same percentage selected DataCAD. None ranked Macintosh based packages such as Architron, Form Z or animation packages such as 3D-Studio as the most important packages for students to have experience in. See Figure 2.

6. In which computer system do you expect co-op employees to have hands-on experience, prior to joining your firm?

A notable majority of the firms (71%) expected their co-op employees to have experience in IBM 386/486 (DOS based) or compatibles systems. Only one firm expected prior experience in Macintosches and one other had selected the category of “experience in Unix based work stations”. The rest did not check any choice.

This shows that a majority of practitioners expect students to have prior experience in DOS based machines and applications much more than any other system and applications.

7. Are you using computers in your firm for applications other than word processing?

It is believed that almost everyone uses computers for word processing in the industry. We wanted to know about the usage of other relevant computer applications. Nearly all of the respondents (99%) indicated that they used computers for applications other than word processing. This is an impressive figure considering that only a decade ago a very small percent of firms were using computers.

According to the MicroCAD News Survey approximately 47.6% of the firms were using CAD applications in 1989 and 56% of the firms were planning to use CAD in the near future [MicroCAD, 1989]. In the Design Philosophy Survey, 47.3% of the responding firms reported that they used CAAD in their firms [Kalisperis and Groninger, 1992].

At this stage, an instruction was given to those who were not using computer applications other than word processing. They were instructed to answer the remaining questions only if they had plans for such usage in the next two years. In that case, they were asked to complete the survey based on their plans. However, since 99% of the respondents answered affirmatively, the instruction proved to be superfluous.

8. Approximately what percentage of your projects are done using computer applications at some stage?

About fifty five percent of the respondents indicated that they carried out 75 to 100 percent of their projects on computers at some stage. About twenty two percent of the respondents used computers for 50 to 75 percent of the projects. A small percentage (5%) did not use computer applications at any stage. See Figure 3.

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Figure 2: Packages ranked "most important" for students to have experience in.

Figure 3: Percentage of work done using computers

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When compared with the type of firms, we found that a significant number of firms which were solely architectural (i.e. 50% of architectural firms) used computer applications in 75 to 100 percent of their projects at some stage.

9. During which of these phases are you regularly using computers?

The phases and the responses were as follows:

- Programming: 54 percent
- Schematic Design: 70 percent
- Design Development: 80 percent
- Construction Drawings: 87 percent
- Specifications: 84 percent

The above responses give some idea about whether computer applications are being used in the industry during the different stages of a project. They show that computer applications are being used heavily in all stages. However, in this question, we had neither defined these stages nor had we specified what we meant by the term using computers. A user may be making sketches on paper during the schematic design stage and then transferring them into the computer system. Can this be called a use of computers as a design tool? Probably not. However, the goal of this survey was not to get such detailed information on the use of computers as a design tool, but to get an overall idea. To investigate such detailed data, a separate focus survey needs to be conducted.

10. What CAD software packages do you use in your firm?

Like in many other previously published surveys, in this survey too, AutoCAD was found to be the most popular package. The MicroCAD News Survey and the Design Philosophy Survey found that 46% and 42.7% of the firms surveyed were using AutoCAD, respectively. According to this survey, three fourth (74%) of the firms are using AutoCAD, and about seven percent of the firms are using Intergraph. One firm is using DataCAD and two other firms are using IBM/SOM's AES system. None of the respondents are using Macintosh based CAD applications such as Architron or Form Z. These responses suggest that DOS based software packages are popular among the firms. (Figure 4)

11. Do you use any of the following animation packages? (The packages listed included 3D-Studio and WaveFront.)

About twenty six percent of the respondents are using 3D-Studio for animation work. About 15% answered that they were using other animation packages which were not listed. A majority (59%) left this question unanswered, giving an impression that at present, animation packages are not widely used in practice. According to the MicroCAD News Survey, animation tools were used by 13% of the respondents.

12. Which computer applications other than CAD are you currently using?

Like the previous question, this question was also skipped by a majority (58%) of the respondents. About sixteen percent of the responding firms are using energy analyses packages, four percent of the firms are using structural analyses packages whereas only 1.32% (one firm) of the respondents are using lighting applications. Nearly twenty percent of all the firms are using other types of applications such as HVAC and specification programs, database programs and spreadsheets. This is illustrated in Figure 5.
13. Which computers do you have in your firm?  
   Also specify number of computers of each type.  
   Please exclude machines used exclusively for word-processing.

Almost seventy four percent of the respondents have IBM 386/486 (DOS based) or compatibles. About eight percent of the firms have Macintoshes. However, some of the Macintosh users indicated that they were using these machines for word processing. Nearly twelve percent of the firms indicated that they had Unix based work stations. See Figure 6.

14. Which systems do you use for CAD applications?

An impressive number (75%) of the firms are using IBM PC (386/486) or compatibles. Only one firm is using Macintoshes for CAD applications. A notable number (11%) of the respondents are using Unix-based work stations which included Sun Sparcs.

Again, half of the firms that are using IBM PC (386 or 486) compatible systems for CAD applications are doing 75 to 100 percent of the projects using computers at some stage.

15. Do you have networking capabilities?

This question was asked to see whether firms have started networking their machines. About fifty percent of the firms do not have such facilities and that is understandable given the fact that more than half of them have fewer than 10 machines. Nearly fourteen percent have Novell and eighteen percent have other networks such as Shiva, Local-talk, etc.

When compared with question # 13, it was found that thirty six percent of the firms that have networking facilities are using IBM 386/486 or compatibles. Almost all firms having Unix based workstations have networked their computers.

16. Are you currently using computers as a design tool? (If "yes", what packages are you using for this purpose?)

This question was asked to get a general feeling about the use of computers as a design tool.

A significant number of the firms (80%) answered affirmatively to this question. Thirty six percent of them noted that they were using AutoCAD for design work. Seven percent of the firms were using Intergraph, and five percent were using Arris for designing. About one third of the respondents did not specify the names of the CAD systems they were using for designing. (Figure 7)
17. If you are not currently using the computer as a design tool, do you anticipate doing so within the next two years?

About twenty-six percent of the responding firms said that they would likely use computers in the near future for design. About seventy-four percent of the firms left this question blank. When compared with the previous question, there is an anomaly of 6% since based on the previous question a maximum of 20% of the firms should answer this question affirmatively. From this the author concludes that approximately 74% of the respondents are using computer as a design tool.

18. We have been thinking of introducing the following topics in our classes. Please rank them in order of importance from your viewpoint.

The topics listed were: philosophical and theoretical aspects of computing, programming, specific packages, and integration of computers in studios, environmental technology, structures and construction. About half of the respondents gave the highest priority to the integration of computers in studios whereas about twenty percent felt that introduction of topics such as "specifications" is the most important area.

About 18% selected integration of computers in environmental technology as the next important issue. About twenty-one percent of the respondents gave the third highest priority to the integration of computers in structure classes and an equal number of firms felt that integration of computers in construction classes was the fourth important area. These results are illustrated in Figure 8.
Education and Practice: THE CRITICAL INTERFACE

19. The field of computer applications is rapidly changing. Please comment on the computer education we should be providing for our students.

In the previous question topics in the area of computer applications in architectural education were provided. In this question, the participants were asked to express their views freely.

On the whole the respondents felt that the field is extremely important and that we should integrate all possible aspects of computer education in our curriculum. Some felt that courses in basic 2D/3D CAD and “computer as an information tool” are enough. AutoCAD was listed by many as the most important package which should be taught/used in schools. A respondent commented, “At this time we would probably not be interested in hiring a co-op that could not use AutoCAD”. Some asserted that the theoretical aspects of computing is good but should not be over emphasized and stress should be on the learning/using of packages. Understanding of systems such as DOS and Unix, as well as exposure to database packages was also thought to be important by practitioners. A few felt that along with the knowledge of CAD packages, students should be able to maintain stand-alone or networked systems. One practitioner summed it as, “Firms like ours look to universities to provide students who have been exposed to cutting edge technologies.”

Conclusions

This survey provided a good picture of computer usage in the industry. The high response and the representative selection of firms across size and geographical location make the survey results reliable.

In the category of systems and applications used, DOS based machines have a commendable lead and AutoCAD is seen as a winner. More and more faculty in the Department of Architecture at the University of Cincinnati, however, are using only Macintoshes and are somewhat against the idea of using AutoCAD, DOS or Unix machines in the classes. Our students however, are eager to know all types of systems. A student survey done prior to this survey showed that students do not have any mental block against using DOS or Unix machines, as opposed to having a strong preference for Macintoshes like faculty. As a matter of fact a majority of our students (75%) indicated that they would like to learn AutoCAD and DOS based machines. A few of these students also indicated that it would be better if AutoDesk modified the package to make it more of a 3D designing tool.

It is clear that a growing number of firms are expecting students to have prior experience in computer applications before joining their firms. Firms have slowly started using other applications such as evaluation programs, specification and animation packages. It will not be surprising if they expect students to have a conceptual understanding of these applications in the near future. A few firms have networked their computers, however, a majority of them are still not taking advantage of this powerful technology.

Most of the respondents of this survey felt that the school should integrate computers into the studio environment and start using them in teaching design. They also felt that we should use computer applications in non-studio classes such as environmental technology, landscape architecture, specification, construction and structures. A very small number of the respondents thought that we should offer classes in languages such as Pascal, C or C++. Probably, that is considered to be a job of the Computer Science Department or is probably not considered as an important topic at all. However, it may be argued that by not introducing programming classes in our curriculum we are making architecture students only users of the systems.

In the Department of Architecture at the University of Cincinnati, at present only one computer course offered is mandatory. The basic format of this course, which is offered at the sophomore level includes two lectures/week followed by a four hour computer lab. The major goals of this class cover computer literacy, general knowledge of how computers can be used in the design process both as a drafting and an intelligent tool, basic knowledge of DOS and Unix, basic 2D/3D skills in AutoCAD, demonstration of how relatively unknown but user-friendly Mac-CAD programs can be used in the design process. A seminar class (three lecture hours/week) is offered as an elective for upper level students. Each year different topics are covered in this class including introduction to C, introduction to IBM/SOM's AES system and expert systems in architecture.

The author believes that this present computer curriculum needs fundamental changes to meet the
growing demands in this rapidly changing field. The exposure to computers can be done by integrating computers in non-studio settings (i.e. lectures, seminars and labs) and in studios.

Based on this survey, it can be concluded that the following topics need to be introduced in-depth in an architecture curriculum today:

- Computer literacy, introduction of 2D/3D CAD.
- Advanced features of 3D CAD.
- Rendering and animation.
- Use of computer applications in the areas of lighting, HVAC, construction, energy analysis, structural analysis and specifications.
- Introduction to graphic and object oriented programming in high level languages.

The question of how to introduce/use this knowledge bases in individual programs is dependent on the structure of the curriculum, the overall program, hardware and software availability, and the faculty expertise.

In summary, the survey undertaken was successful. We got what we were expecting from this survey. We may need to carry out a focus survey of computer usage in design, if necessary, in the future.

References


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