Computer Aids in education of CAAD

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Abstract

This paper focuses on the first years of the CAAD curriculum of Calibre - Computer Application Laboratory in Building Research and Education- at the Eindhoven University of Technology. It describes the use of computer systems as a modern aid to learning and some aspects of the development of the educational program CALinCAD.
Introduction

Teaching CAAD to students means teaching about computer techniques, methods and applications. Generally, this is done by first explaining to the students the functions of a system and the commands, and then through guided practice, they get the necessary experience.

Another approach of teaching could be the use of computersystems in the curriculum as an alternative aid in education. The keyword here is CAL. There are several advantages in using educational programs, not only to the students but also to the teachers. Studies comparing CAL with traditional educational methods have shown that apprenticeship decreases at an average of 30% when CAL is used in the curriculum.

CAL

CAL is an acronym, short for Computer-Aided (or Assisted) Learning. There is another similar term, CAI, or Computer Assisted Instruction. CAL means using the computer to support education. Courseware, this is educational software, involves the presentation of educational material, typically by means of an electronic screen. CAL is not a teaching aid, it is a total teaching system with the computer-driven screen simply as another medium, similar to chalkboard and books.

Some important advantages to using computer systems in education are:

- Students can work at their own place,
- Students can select their own learning-path,
- CAL is good for the students motivation and confidence,
- CAL is time efficient for teachers,
- CAL is time and place independent.

In general, it offers all the advantages of the individual teaching style. CAL releases students from the discipline required in the lecture halls and it offers the possibility of instructions at any time of the day or night and at almost any place as opposed to the strict schedules of the lectures.

There are two major strategies in which computer assisted learning might be used to implement and augment learning and training in CAAD. The first approach involves providing students with appropriate computing resources such as wordprocessors, spreadsheets, paintprograms or CAD-applications. This approach is called Explicit CAL. These resources can be used in various situations within the domain of CAAD. The second approach, Implicit CAL, involves the development of special types of educational software (courseware). Because writing successful courseware is very complex, time consuming and expensive, Explicit CAL is more widely used as an educational tool than implicit CAL. At CALIBRE, both ways of computer aided learning are used although the implicit approach is at an initial state.
CAAD-curriculum

This paper focuses on the first year CAAD-curriculum, which is divided into three parts.
In the first part, the architectural students are learning several basic computer concepts like database management, calculations and wordprocessing. This is done by using a third party application MS-Works from Microsoft.
MS-Works is a multifunctional program. It supports a database, a spreadsheet, a simple wordprocessor and communication facilities. The advantage of using a multifunctional program is obvious. Students only need to learn one program, that is, one userinterface. Another advantage of the Works program is the presence of a very nice userinterface that includes comprehensive helpfunctions and a tutorial. Furthermore it is inexpensive; an important aspect when it comes to selecting software for a curriculum.
MS Works runs on the IBM PC's and the Apple Macintosh's. This gives students the opportunity to explore the differences between the two computer systems.

Another commercial program, Superpaint, is used to teach about basic graphic and sketching concepts. The students learn for example about the difference between bitmapped and linebased graphics, the different graphical entities and edit commands. They also get acquainted with basic mouse operations in relation to graphics.

During the third and last part of the first year CAAD-curriculum, the students learn about the use of computer techniques in the design process using the program CALinCAD. This program is an example of Implicit CAL, developed by CALIBRE, ABACUS and LEMA. CALinCAD stands for Computer Aided Learning in Computer Aided Design. It is a computer aided learning system intended to inform and excite students in Schools of Architecture and those in architectural practice over Computer Aided Architectural Design. The program consists of three modules. The most important module is the Designmodule. In this module the student has to design a small building, with several design objectives and constraints such as required floor area, type of wall elements to use, building- and runningcosts, annual energy consumption and daylightfactor. We use the "Analysis Synthesis Evaluation"-model as a suitable theoretical base.

![Figure 1. Concept of CALinCAD.](image-url)
The second part of the program is the Application module divided into several submodules each focusing on a particular design objective because there is little or no point in having knowledge without understanding. Understanding or comprehension implies the ability to apply knowledge, whereas knowledge does not necessarily imply that there will be understanding. Example: one may know that three times five is fifteen without understanding the concept of multiplication. Examples used are: Heat transfer through a wall, or the thermal comfort and layout of a room. Several other modules are planned. The third and last module of the program, the Protocol module, gives a first introduction to several parts of computing systems and CAD techniques (the D is for drawing).

**Computer anxiety.**

A difficulty with first year students is the distinction in computer knowledge and experience. In general, most of the students have no familiarity with computing systems.

It is known that this unfamiliarity with computers results in a certain degree of fear of computers. It is also known that this anxiety has a negative influence on learning. Therefore it is important to reduce computer-anxiety. Honeyman and White found that people with some computer experience have less trouble overcoming their fear for computing systems and programs, than people with no experience. Their investigations showed that beginners needed at least 30 hours of contact with the computer to reduce their anxiety level. No relation was found with age and sex.

Concerning the use of computers, Cambre and Cook (1984) reported that teachers had an higher anxiety level than students.

So, when using computer applications in education you have to be sure that the students have some basic knowledge and experience of computer systems or are able to get this experience during the courses. Otherwise learning results can be very disappointing.

For example: sending employees with little or no computer experience to one week course in order to learn wordprocessing or other applications, normally isn't very effective. The employees will need a lot of time to get familiar with the computer system without learning about the application itself.

To give our students the opportunity to explore computer systems, they have at their disposal quite a number of PC's and AT's for practicing. Most of the microcomputers are located in the computercentre of the university. Six Compaq AT's and six Apple Macintosh's are located in a computer room on our floor and are available for students till eleven o'clock in the evening.

**CALinCAD, a simulation based instruction.**

CALinCAD is a development of three universities, Calibre, Abacus (Glasgow) and Lema (Liege). Together we decided to write our own courseware because there was no suitable program or environment found that we could use to teach CAAD. Our aim is to bring the different design disciplines together into a workable whole, an integration of disciplines. All commercial applications have in common a
specialization in one or two specific areas. They are also closed systems, not suitable for internal changes. Source codes are never available nor are runtime libraries, making adaptations or additions to these programs almost impossible to do.

Figure 2. CALinCAD.

To develop courseware, different skills are needed: Pedagogical knowledge, software engineering and architectural knowledge. When discussing the use of microcomputers as instruments of education, too often the central theme tends to revolve around facilities which the machine can offer or techniques of programming; i.e., speeds of response, animation techniques, screen formats, motivation. The overwhelming emphasis appears to be placed upon the technical skills of programming. An educational analysis of the programs, how they relate to a theory of learning or philosophy of education, is rarely conducted to the same depth. What we can do with the machine seems to be more important than the question of what we should be hoping to achieve. Therefore it is essential to first develop a clear philosophy of education in order to provide a framework within which the use of the computer can be explored, and the work can be related. Calincad is an attempt to provide such a framework.

**Pedagogical framework**

Initially there were several questions to be answered. One of the question was: “Which kind of instruction do we want to use?”

There are five major types of computer-based instruction programs. They are: Tutorials, drill, simulation, games and tests. Of these five concepts, simulation based instruction of the design process suited our needs best because our philosophy is that the need for education and training in CAAD is best met by deploying it. Simulations typically have three major advantages over the other instruction types: They enhance motivation, they have better transfer of learning and they are more efficient.

In general a simulation is a simplified imitation of the real world, in our case the complex design process. On a highly interactive base students learn to solve design problems in a comprehensive way, learn to make evaluations and to take appropriate decisions. They learn about architectural procedures, come to understand and use computer aids such as drawings, calculations and data-management. The idea is that
students are not only highly motivated by simulations but also learn by interacting with them in a manner similar to the way they would react in real situations.

There are different strategies to approach this process of searching for a design solution. For example, there is the problem solving approach (Woodbury), the puzzle making approach (Archea) or design by constraints approach (Gross), as described in 'Computability of design' by Y.E. Kalay. A big advantage of using simulation in teaching CAAD is the possibility to adapt all these strategies, or even the use of a combination of them. In a simulation constraints can be disabled and hidden, can be made static or dynamic and can be added throughout the process of design. Other possibilities using simulations in the CAAD curriculum explore the way the solution is found. The teacher can specify goals students have to aim at, ie. the cost of a building (goal driven), or specific requirements to find a unknown solution (data driven).

Software engineering

The most obvious problem affecting the development of courseware is that of time. It takes several hundred hours to develop one single hour of courseware. Not only is the problem related to programming the computer but, to the time required to analyse a situation also. It requires an analysis of both the potential and the actual learning that is expected of students. Also, it makes demands on teachers, in terms of analyzing the kind of thinking that they wish the students to partake in. To deal with these problems, we selected a more systematic approach, deviding the process of software development into six phases. They are:

- Definition study (GOAL)
- Functional specifications (WHAT)
- Technical specifications (HOW/WITH)
- Implementation
- Testing
- Distribution and maintenance

The essence of the goal, as already mentioned is to teach CAAD. The functional specifications concern the following issues:

- Pedagogical framework
- Geometry modeller
- Datamanagement
- Calculation algorithms
- Userinterface

The project CALinCAD is now in the third phase, defining the technical specifications. The computerlanguage is Pascal and as a development environment we use SUN workstations. Later it will transferred to the Macintoshes and AT's.
ICAL

Whether the computer is used as a tool in architectural design or as a tool in teaching, the success or failure of the program depends a great deal on the design and implementation of the user interface. Well designed screen layouts, fast responses, graphics and a wide range of help functions are all standards involved in designing a good user interface. In general there are four major components: The human factor, the task to be performed, the environment and the machine. A user interface must allow the user to obtain an answer to next four questions at all times:

- Where am I
- How did I get here?
- What can I do here?
- Where can I go?

To answer these fundamental questions in a systematic way, the designer of an interactive system must formulate an elementary user's model of the system: a structure that explains the main concepts that the user needs to understand. The user's model is usually a state machine: it has an internal state and an input/output behavior. It allows access to current data, current commands, and dialog history. At the moment it is only possible in CAL in CAD to record the students actions resulting in a history of the learning process. This can be used to improve the courseware, to assess the student or just as a demonstration (playback). A next stage would be the application of AI techniques to augment and improve conventional CAL methods. This is known by the term ICAL, short for Intelligent Computer Assisted Learning. We consider of the use of expert systems technology as a resource to facilitate the implementation of computer based teaching and learning processes. For example to perform low-level reasoning operations in the process of design. The expert system should be able to give students a qualified advice, relevant to design problems. Also, the expert system could guide the student through the learning process.

Conclusions

Computers can be an important aid in education. Compared with the traditional educational methods, they offer several advantages. When using CAL, students will learn faster and teachers will have more time available to spend on research. The time consuming process of courseware development is a major limitation. Therefore a systematic approach based on software engineering techniques is essential, without losing track of the pedagogical issues.
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