Web-based CAAD instruction: the Delft experience

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In the early 1990s, the introduction of an extensive CAAD component in the compulsory curriculum of the Faculty of Architecture, Delft University of Technology, stimulated experimentation with computer-based instruction systems. The emergence of the World Wide Web presented new possibilities. Nevertheless, the reasons for investing in Web-based CAAD instruction were mostly pragmatic, i.e. a reaction to necessity, rather than an intention to explore, experiment and revolutionize.

One of the problems addressed in our Web-based CAAD instruction is CAAD literacy. Help files and manuals that accompany software have proven to be unsuitable for introductory courses in design computing. This led to the development of a series of dynamic Web-based tutorials, in the form of interactive slide shows. The implementation of the tutorials is based on a cooperative framework that allows teachers and students to contribute at different levels of technical and methodical complexity.

The use of the Web in CAAD education also stimulated a more active attitude among students. Despite the limited support and incentives offered by the Faculty, the Web-based CAAD courses became an invitation to intelligent and meaningful use of Web technologies by students for design presentation and communication. This is not only a useful addition to the opportunities offered by CAAD systems but also a prerequisite to new design communities.

Keywords*: WWW technologies, teaching.*

Introduction: information and instruction

Hypermedia and multimedia have held a prominent place in the improvement of teaching facilities and approaches. Based on concepts such as associationalism (Bush, 1945), hypertext connections between disparate texts have been proposed as an enlargement of the scope of human thought and memory (Engelbart, 1963, Nelson, 1980). The ability to correlate different information sources in a way that permits wider exploration, deeper understanding and interactivity signalled new opportunities for teaching, which were initially explored in computer-related areas such as technical documentation (Barrett, 1988). The development of interactive online help and reference systems supported the return of the hypermedia paradigm to wider issues like knowledge representation and information enrichment (Barrett, 1989). The Internet and in particular the World Wide Web can be seen as an expansion of the paradigm to a global scale.

With the benefit of hindsight, it is rather surprising that Web technologies were initially relatively unexploited in academic education. What makes the arrival of Web-based instruction surprisingly long is that there has been no lack of research and development in related subjects. Investigations into the role of multimedia and hypermedia in education have covered areas such as information dissemination, communication, integration and related technological development -up to the level of complete, dedicated networks, which provide the informational background to whole academic institutions (Hodges and Sasnett, 1993, Stewart, 1989). Use of the Web for presenting and sharing design information has been explored in virtual design studios, conferencing and collaborative environments, which reaffirmed the significance of collaboration and established the utility of the Web for its implementation (Caneparo, 1997, Kosco, et al., 1999, Vásquez de Velasco and Jiménez Trigo, 1997).

One of the reasons for the delay is that the World Wide Web started life lagging behind the state of the art in interactive multimedia systems. A direct transfer of existing applications was in many cases not possible and even not desirable, given the technical and economic differences between dissemination through the Web and other media such as CDs (Hedberg, et al., 1997). As a consequence of its immense popularization, the Internet has been closing the gap with considerable pace, which has become explosive with the integration of pre-existing multimedia technologies.

A probably more significant reason for the relatively late development of Web-based instruction systems is that the Internet has been envisaged more as an electronic library than a digital classroom. The Internet became an interesting background to CAAD education because it incorporated transcriptions of analogue information, electronic copies of research papers, lecture notes in HTML and collections of digital resources (Bridges, 1996). The lack of coherence and validation made it of limited direct use for constructivist learning and incompatible with most forms of instructivist education (Kafai and Rensick, 1996, Reeves and Reeves, 1997, Wilson, 1996).

Transition of Web resources from global information system to interactive learning environment involves two components. The first is production or identification of relevant information. The inability to validate the content of the Web poses few problems in a controlled academic environment, where the teacher remains the authoritative editor of Web resources into a learning environment. Similarly, the lack of constancy on the Web is resolved by teacher supervision. The second component is the structuring of activities that lead to the "attainment of intended, specific learning goals" (Smith and Ragan, 1993). Such activities derive from jointly from conventional teaching resources and new digital experiences, including computer games and Web surfing (Hedberg, et al., 1997).

The Delft experience

The combination of the top-down decision to introduce a substantial CAAD component to the compulsory curriculum in 1992 and the choice for bottom-up development of CAAD courses (Koutamanis, et al., 1993, Koutamanis, et al., 1994) had resulted in a productive but tense period characterized by:

- *Large numbers of students*: Annually over 500 students took the (compulsory) second year courses, of which 10% was devoted to CAAD.
- *Short course development periods and frequent adaptation and modification of CAAD courses*: As each CAAD course formed part of a larger thematic block, the CAAD courses had to respond to subject modifications, changes in orientation and priorities, so as to utilize the background knowledge of students (Koutamanis, 1996).
- *A wide spectrum of CAAD subjects*: The intention of the Delft CAAD curriculum was to present a comprehensive overview of methods and techniques in CAAD. Integration

into larger thematic blocks meant that each course was conceived as a microworld design exercise with digital means. This microworld came complete with:

  - background information on CAAD theory and empirical or normative analyses of the design problem
  - relevant CAAD tools
  - instructions on the use of the tools
  - explanations of the proposed approach in a manner that linked the CAAD methods with tools
- *Rapidly evolving information and communication technologies (ICT):* Within the first five years of the CAAD curriculum at Delft it became obvious that the democratization of ICT was constantly redefining our learning objectives by:
  - making more refined and more powerful tools available
  - making more computational solutions possible
  - changing the computer literacy level of students, who currently start not with a minimal but with a distorted understanding of design computing

In the first stage of development of our CAAD curriculum, we allocated a large amount of time to the production of detailed textbooks. The textbooks provided the theoretical component of CAAD by means of comprehensive overviews of design computing. The overviews were translated into operational approaches to the solution of specific design problems. The approaches were linked to the available CAAD tools as guidelines on the meaningful use of relevant facilities (Koutamanis, 1993).

Parallel to course development, research on subjects relating to multimedia image databases, retrieval support and automated recognition (Koutamanis, 1995, Koutamanis, 1995, Koutamanis and Mitossi, 1993) helped us realize the potential of the Internet as a supportive, unobtrusive informational background (Koutamanis, 1995). Consequently, the second phase of CAAD course development at Delft involved the transfer of already developed textbooks to the Web. The textbooks were expanded to cover new technological possibilities such as the Web and scientific visualization. In addition, the Web started playing a role as communication environment in the learning process.

Course structure

The CAAD curriculum at Delft consists of two types of courses:

A. Exercises integrated in thematic first and second year blocks. Each exercise comprises five or six supervised sessions of four hours each (Koutamanis, et al., 1994).
B. A third / fourth year course exclusively on CAAD. It occupies a whole period (eight weeks), during which students work fulltime on this course only (Koutamanis, 1999).

Our second year exercises fall under two main types, the *instructivist* and the *constructivist* type (Kafai and Rensick, 1996, Streibel, 1991). Instructivist exercises define learning activities by means of detailed and explicit instructions and objectives. These are structured in sequences of learning tasks, unified into coherent groups by relevance to specific design problems or aspects. A typical instructivist CAAD session at Delft consists of:

1. Initial short presentation: the teacher outlines the session subjects and corresponding main CAAD techniques.
2. Study of instruction material on the Web: students acquaint themselves with the necessary CAAD techniques in a prescriptive manner, under the supervision of instructors who explain finer points, correct errors and facilitate the exploration of the Web pages.
3. Production of required results on the basis of

prescribed sequences of design actions. Again instructors are available for local guidance and feedback.

4. Control of results by the instructors or the teacher: conclusion of the session by monitoring student progress, with limited feedback.

Each session normally builds on the experiences and results of previous sessions. At the end of the exercise students are evaluated on the basis of a report they produce from the session results. An oral presentation of the same material may form part of the evaluation (as a means of discouraging copycats).

Constructivist exercises stress the learning experience students create from the instructional environment, their prior knowledge of computing, architecture and design, the particular design problem and experiences with relevant CAAD methods and techniques. Rather than emphasizing the acquaintance with instructional objectives, constructivist exercises focus on the exploration of cognitive and design strategies that meet these objectives.

A constructivist CAAD session at Delft dispenses with the initial presentation, detailed instructions, prescriptive approaches and prescribed results. Instead, it presents a design problem in a learning environment that has to be as rich and diverse as possible. Richness and diversity are measured by the comprehensiveness of proposed approaches, examples and precedents, coupled to a coherent body of technical instructions on specific tasks. Students are expected to select an approach, formulate it in terms of local goals, link these goals to CAAD techniques and perform the necessary tasks. Each session concludes with a description of the chosen approach and of achieved results on the Web. This description goes beyond a conventional design presentation in that it forms an externalization of the students' evolving body of knowledge and skills. Evaluation is based on an oral presentation given by each student of his results, as described in his Web pages. This presentation is seen as essential training in the use of new ICT in design communication.

An interesting aspect of the constructivist exercise is the sharper definition of the role of each party involved in the instruction. From passive recipients of preordained information, students become responsible for recognizing and judging information and for constructing learning strategies. Instructors assume a facilitative role, as readily available guides through the available information and troubleshooters of local, technical problems. The teacher retains his didactic role, albeit at a higher level of abstraction, that of course development. The connection between these parties is the Web-based instructional environment the teacher has developed for the course.

The third / fourth year course also follows the constructivist approach. The basic difference with the second year exercises lies in that the duration of the course is ten times that of an exercise. Students are exposed to a wider spectrum of CAAD methods and techniques and have the opportunity to study these more deeply. The increase in information and complexity also intensifies the responsibility of the student to devise and follow consistently learning strategies.

Roles for Web-based instruction

Despite our reliance on the Web for CAAD instruction, it was not intended that the medium should exercise influence on the spatial or temporal aspects of CAAD teaching. The idea of a "virtual teaching space" was discouraged for a number of reasons, including:

- The relatively low number of students with Internet-facilities at home, especially in the early days of Web-based CAAD instruction at Delft.
- The large number of students in relation to the available facilities for self-paced study.
- The necessity for social interpersonal contacts within the instruction group.

In our experience, students following the courses virtually generally do not attain the same level as students following the courses in the conventional way. We attribute this lower performance to a number of reasons, all stemming from lack of interaction with fellow students, instructors and teachers.

In recent years we have been experiencing a gradual move towards student-centred education, which stems from the combined influences of constructivist learning, Web-based instruction, the problem-based learning model adopted at Delft and the democratization of ICT (Cuban, 1993, Relan and Gillani, 1997, Wilson, 1996). Following the reorganization of the Delft curriculum in the early nineties, anything "traditional" or "conventional" has become suspect as being problematic or dysfunctional. This attitude echoes similar general views that derive from a need for instructional innovation and higher performance (Reigeluth and Garfinkle, 1994). Nevertheless, despite being Web-based CAAD teaching at Delft remains teacher-centred, in that instruction is determined temporally and organisationally by teacher, with limited computer-mediated communication.

On the other hand, instruction is given to small groups of fifteen students supervised by an instructor who provides individual feedback. Students also enjoy a certain degree of flexibility in each session, as they are required to interpret CAAD assignments and correlate them to their own design activities. Moreover, several exercises stimulate use of the Internet as an informational background, thereby abandoning the teacher and his Web-based textbooks as the single content source. The shift to multiple sources relates to the constructivist approach, but also to the frequent inability of a single teacher to act as an authoritative source of information and learning strategies, especially at the technical level.

The move towards student-centred learning environments curiously requires instructivist components that address basic and advanced CAAD techniques. As the CAAD exercises are not intended as package training, only a selection of the available facilities are taught. This selection is specifically based on the learning goals of the exercise. Manuals and help files that accompany software have proven to be unsuitable for introductory courses in design computing. The amount of information they attempt to convey and the lack of connections to designing form severe limitations for the highly focused first steps in design computing, both on the theoretical and the technical level.

As a replacement, we developed instruction material in the form of Web pages. The first version had the form of long HTML documents with a large number of screen captures as illustrations. On-line reading of these documents made window scrolling was inevitable. Use of this type of documents between 1995 and 1997 taught us that, in the case of step-by-step instructions, scrolling distracts from the content of the document, especially with sequences of screen captures. Consequently, the second version of the instruction material was based on another presentation paradigm, the *button-operated annotated slide show.*

At the heart of the HTML file that runs a slide show resides an ActiveX component that enables the HTML file to read data from a separate, record-based file on the Web server. This *data binding* technology is part of Microsoft Internet Explorer (from release 4). It allows the content of the Internet page, the "Web data", to be kept separate from the HTML code (Pardi and Schurman, 1998). The division between content and structure facilitates development of Web pages with a team whose members have varying skills. One of the problems with developing computer mediated instruction (CMI) material is that the majority of the teachers do not have the time to develop and maintain the necessary skills. One solution for this is co-operation between teachers who supply the content and CMI specialists. The CMI specialist develops HTML frame sets, HTML template files, scripts and a structure of hyperlinks. This set of files and detailed documentation enable the average teacher to produce Web-based instruction material on his own. All he needs to do is adapt the template files with a simple

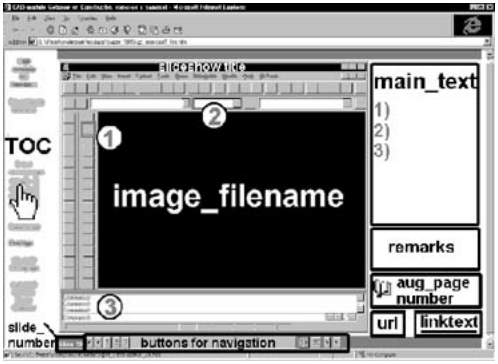

Figure 1 (left). Button-operated annotated slide show

text editor and produce and annotate screen captures with standard image processing software. This division of roles has been tested in the development of Web-based CAAD instructions for several exercises.

Future development

The Web-based CAAD instruction environment at Delft is evolving under the influence of a number of factors:

- The increasing number of relevant ICT, which allow computerization of more aspects of our educational approach.
- The growing computer literacy among students, which necessitates continuous adaptation of our instruction material.
- The transfer of new research results to education.
- Integration of Web-based CAAD instruction in design education.

These direct development towards a comprehensive, coherent and flexible instruction environment. Such an environment is largely constructivist. However, a truly constructivist environment seems unattainable both in the early stages of a Web-based instruction programme and in later stages, when the types of potential uses increase far beyond what was originally envisaged. Under these circumstances, one is tempted to fall back on instructivist solutions. Having worked in a mixed instructivist-constructivist environment, we feel that this is not necessarily a bad solution, provided that the environment is transparent and supportive enough for students to resolve local conflicts between the two approaches.

As use of the slide shows for nearly a year now shows, student performance has improved in terms of time and comprehension. Students appear to appreciate the clarity and specificity the slide shows. These positive reactions have led to the decision to expand the existing material and improve the implementation. A major drawback of the current form of the button-operated slide show is that it is browser sensitive. We are obliged to use the Microsoft Internet Explorer because other browsers do not handle ActiveX components. This is not an impediment so long as the slide shows are used in the controlled environment of our CAAD teaching facilities. In the future, as distance learning becomes an acknowledged part of our teaching, we have to redefine control of software, for example through integrated Flash animations or Java scripts which control the visibility of DHTM layers.

Extension of system to involve more Web features, such as computer mediated communication, is becoming one of our priorities. Use of e-mail for communication between students and instructors or teachers during a course session has been discouraged so far, due to its asynchronous and one-to-one character. However, as the number, complexity and specificity of design computation problems increases, no single instructor or teacher is capable of providing all answers. Computer mediated communication is the probable solution, as it dispenses with the necessity to all specializations physically available at all times in the classroom. The informality of Web communication also facilitates recognition of the new role of teachers and instructors as full participants in the learning process: rather than dispensing ready-made solutions, they have to understand and explore each problem together with

the students. Moreover, use of open communication channels, including blackboard systems and group forums, may reinforce the sense of community among students taking a course. We notice that the intensity of the CAAD courses diminishes this sense, as each student focuses on his own problems and activities.

The move towards self-directed and just-in-time learning is heralded as one of the most important contributions of Web-based learning (Carr, 1992, Goodyear and Steeples, 1992, Romiszowski, 1997). This is an obvious necessity in the face of rapidly evolving technologies but does not always fit the framework of academic education. For one, it conflicts with the idea of comprehensive grounding. In the area of CAAD it attenuates the methodical coherence of design computation.

A prerequisite to self-directed and just-in-time learning is high student motivation. At the level of the individual student this asks for interest and prior knowledge that can be translated into aspiration and control. These guide the choices a student makes as to the objectives he wishes to attain and determine

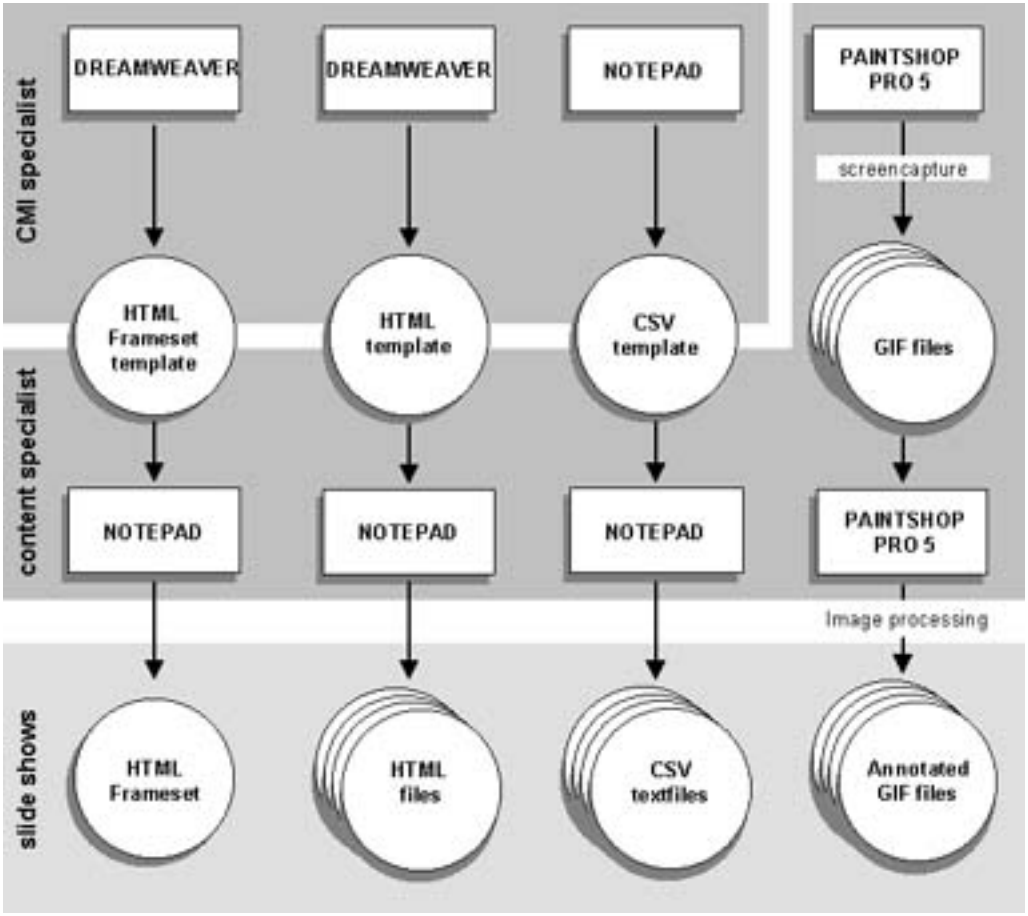

Figure 2 (right). Outline of the production process

the effort he exerts in that respect (Keller, 1983, Martin and Briggs, 1986). Web-based learning appeals to many because of its novelty and modernity, but may also intimidate students with insufficient background, phobias about technology or limited prior experience with computing and/or Web facilities (Cornell and Martin, 1997). Peer support in a group often supplements individual motivation and assists in overcoming practical problems.

From the teacher's viewpoint, a course can be designed to support interest, relevance, expectancy and satisfaction (Keller, 1983). However, the degree of interaction is probably the main factor that influences student motivation. Opportunities to guide learning through discussions and presentations reduce the intellectual burden of the student and help redefine objectives in progress. This also assists in a conceptual subdivision of learning into shorter-term goals. Coupling such goals to student interim presentations is instrumental for the completion of a course in good time.

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Notes

[A] The construction of a slide show uses a HTML template file which is available as a separate document. at the eCAADe 99 conference.

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