Enhancing the Sketchbook

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The architect's sketchbook has been virtually untouched by the march of fashions and theories throughout history. The sketchbook, from its modern beginnings in guild lodges books through the travel journals of Beaux-Arts and Modern architects, has remained the repository for observations and ideas waiting to be synthesized into architecture. However, new opportunities offered by computing technology provide ways to advance the sketchbook, transforming it from a personal log of experiences slowly being buried under a lifetime of work, into a vital, interactive information environment supporting design activity. This is not to argue that the computer may replace the artist's hand and pencil, but that the computer can be used to organize and structure the artifacts of design activities commonly embodied in sketches and notes.

History and Uses of the Sketchbook.

Sketchbooks have been essential design tools since at least the medieval ages. Creative designers have relied upon sketching and sketchbooks as a primary means of uncovering and collecting knowledge. Crowe and Hurtt describe the practice of medieval masons' guilds of gathering visual information into a collective resource:

[The guild's library consisted of essentially one book. Principally, this was the sketchbook of the master mason. However, each such book began in the guild's apprenticeship system as a set of notes and drawings, compiled from the apprentice's mandatory journeys over medieval Europe to gather fragments of building knowledge from far-flung enterprises. For these aspiring architects, their personal sketchbooks were the beginnings of their sole architectural reference book, their entire library. (p. 8)]

In his book on the subject, Francois Bucher described the function of a medieval mason's sketchbook as a double role. The sketchbooks acted as "a repository of existing often much older practices and theorems; and as intimate reflections of the actual creative process." In addition, he has observed that sketchbooks "offered a unique catalog of design choices available to the architect."

Leonardo's sketchbooks are well known and often studied as documents of the creative process of a wide ranging intellect. Crowe and Hurtt remarked, "His sketchbooks contain speculations on the full range of scientific, technical, artistic and architectural issues of the Renaissance world." (p. 9)

The importance of the sketchbook continued into the Beaux-Arts period. Both in the medieval mason's guilds and at the Ecole des Beaux-Arts, according to Donald Egbert, the aspiring architect was required to develop a sketchbook that became a lifelong companion and a primary if not sole reference. During the reign of the Academies as the masters of architectural taste, the sketchbook was also seen as an essential tool for the designer. Sir Joshua Reynolds, the 18th century leader of the Royal Academy, wrote, "It is indisputably evident that a great part of every man's life must be employed in collecting materials for the exercise of genius," a task generally undertaken by creating sketchbooks. Likewise, sketching and drawing on archaeological expeditions was "a pattern characteristic for those architects trained by Viollet-le-Duc." (Middleton, p. 226)

In the modern period, much attention has been given to the sketchbooks of master architects. The sketchbooks of Le Corbusier, Alvar Aalto, Mies van der Rohe, Louis Kahn and others have all been scrutinized and published. The sketchbooks of Le Corbusier number 73 known volumes and were begun in 1907 on his earliest
travels. Besset asserts that Le Corbusier cultivated the habit of carrying a pocket notebook in which he haphazardly jotted thoughts and sketches. In his design work, Le Corbusier referred to the sketchbooks incessantly and talked about them frequently, but he shared them rarely. Schildt has written of Aalto’s sketchbooks that they, “like his painting and sculpture, performed a truly central function in his creative process.” Louis Kahn’s sketchbooks were the means by which he worked out ideas of architectural form. Marshall D. Meyers describes Kahn’s sketchbooks as follows:

Thus his later notebooks are filled with thumbnail doodles which represent his introspective search for “form”, what he called the very nature of a particular building free of the specifics of dimension or material. These were based on his intuitive response to a project and were done alone in his pocket sketchbook whenever he had some spare time.

(p. xxi)

Mary Oamond cites Vincent Scully’s comment that Kahn’s career “can be read and understood through his notes, details, ideas, plans, elevations, character studies, all levels of information...” Mies van der Rohe also made heavy use of his sketchbooks for exploring architectural ideas. According to Arthur Drexler, “his notebooks are filled with drawings developed by himself to convey the essential idea of a building with unforgettable and overpowering clarity.” The ideas which Mies explores appear to be generated from within rather than from observations recorded at an earlier time. However, he did also use the sketchbooks as a means of recording alternatives.

The sketchbook has been used by many architects for a variety of purposes, remaining a consistently useful device for architects throughout history. As travelling, the sketchbook enables the architect to gather experiences and perceptions of architecture. As a design exploration tool, the sketchbook allows the architect to record and envision design ideas. As a source book, the sketchbook catalogues ideas for future reference.

Structure of Sketchbooks.

The sketchbooks of these master architects, although distinctive and individual, share common traits. They typically juxtapose a variety of records and types of information, including words, drawings, diagrams and impressions as well as more finished studies.

Betty Edwards has suggested that a sketchbook should contain both graphic and verbal information. Thomas Beeby comments that “visual notes cannot stand on their own” but require textual notes to complement the expressions in drawings. In an effective sketchbook, "many times words and drawings meld into a synergistic image wherein the drawing becomes the expansive illustration of verbal commentary or non-drawable ideas and the words form an exploratory armature within which the drawing occurs...” (Burns, p. 11) In Leonardo’s sketchbooks, drawings and words mixed to combine in a richer memory than either would have produced separately.

Michael Graves has written about three kinds of drawings, each of which plays a role in the sketchbook. Of most interest to the subject of this discussion are the referential sketch and the preparatory study. The referential sketch may be thought of as the architect’s record of discovery, “a base which may be used, transformed, or otherwise engaged in a later composition.” On the other hand, “The preparatory study documents the process of inquiry, examining questions raised by a given intention in a manner which provides the basis for later, more definitive work.” The definitive drawings described by Graves belong more to the documentation stage of a project and are of less interest to our discussion.

Lasseaux uses Leonardo’s sketchbooks to illustrate desirable qualities in such a book:

1) Many different ideas and subjects are included on a single page.
2) A single entry may combine diverse types of drawings, including perspectives, sections, plans, details and panorama views.
3) The sketches are exploratory and open-ended. (p. 1)

Leonardo emphasised the diversity and open-ended nature of his sketching subjects in prefacing his own sketchbook when he asserted that it “will be a collection without order made of many sheets...” (MacCurdy, p. 43)
Kurt Forrester has observed that Le Corbusier's sketches were more than simply travel companions, filled with the shorthand of his reactions to everything that crowded into view; they were also a journal in time, a very private record of his thoughts and feelings. Virtually no aspect of Le Corbusier's life, hardly a facet of his experience, and barely a subject of his reflections are missing from their pages. A good sketchbook is thus a record of an individual's life.

Critique of the Sketchbook.

Creativity itself depends upon activities which are intimately related to that recorded in the sketchbook. As observed by Richard Coyne, "The ability to form associations between ideas appears to be an important part of design thinking." Again, Andrea Dean has observed in reference to the architecture of Harry Weese that, "The joy and stimulus in architecture is the discovery of fresh combinations of old ingredients appropriate to present problems." Each of these phrases is but an echo of Sir Joshua Reynolds' assertion that "Invention, strictly speaking, is little more than a new combination of those images which have been previously gathered and deposited in the memory; nothing can come of nothing; he who has laid up no materials can produce no combinations."

The inter-weaving of ideas which occur even randomly in a sketchbook is a fountain of creativity, and as such the sketchbook is an essential design tool. A sketchbook or journal is a model of memory and the creative process which achieves insight. It facilitates a synthesis of past knowledge and experience into a design idea. Jim Burns observed that, "Inventors, painters, sculptors and architects use sketchbooks as an emotional and intellectual diary, their records of ideas and potential to use, explore, transform, disassemble and reassemble in their imaginations in search for other forms of art and invention." (p. 7) Crowe and Hurr made a similar statement that the sketchbook contributes to new thoughts and observations by bringing together "thoughts and images that would otherwise be separated from one another in time, a separation that inhibits them from building upon one another as they might when seen in closer proximity." (p. 12) The sketchbook acts as a basic tool of architectural exploration and creativity by collecting and even juxtaposing ideas and insights acquired through time.

Yet the evidence shows that sketchbooks are an imperfect tool. The sheer mass of drawings created during an architect's studies and career impede the usefulness of the sketchbook as a personal or collective reference. Viollet-le-Duc's pupil Edmond Duthoit claimed to have produced 1200 drawings during one six-month archaeological journey to the Mid-East. (Bergdoll, p. 225.) One can imagine the difficulty he must have faced in cataloguing and presenting such a mass of graphic material in a useful form. The editor of The Sketchbooks of Laurence Halprin describes the situation aptly. The editing process "was like rummaging through a chock-full attic where ideas, sketches, design concepts, planning notions, reminders of travel plans and meetings, family confidences and the events of many days in many places had all been shoved higgledy-piggledy for later reference and refinement." (Burns, p. 11)

The cataloguing and organization of sketches has been a recurring problem. When he began conserving his sketches in a collection, Leonardo was hoping afterwards "to arrange them in order in their proper places according to the subjects of which they treat; and I believe that before I am at the end of this I shall have to repeat the same thing many times; and therefore, O reader, blame me not, because the subjects are many, and the memory cannot contain them." (MacCurdy, p. 43) However, Leonardo never halted his investigations to arrange and classify what he had done. It has been left to later researchers to put Leonardo's sketchbooks into some useful order.

Le Corbusier also intended that his sketches be placed into some order. Twice he tried to establish an order for classification, but no document explains the scheme he arrived upon or even if he ever succeeded in creating a scheme that he found acceptable. (Besset) Perhaps because of the difficulty of providing an order to the sketches and retrieving a particular idea from the sketchbook, Le Corbusier rarely used them at his studio in spite of their obvious importance to him, according to Andre Wogenscky.

As observed by Richard Coyne, this information retrieval predicament is a database problem. The process of using and consulting a sketchbook is a matter of "searching through a catalogue of
graphical ideas (as pictures), and navigating through those pictures by association.” (Coyne, p. 92) A computer database of visual images would solve this problem for Leonardo or Le Corbusier alike by providing indexing of a collection of sketches. Dave van Bakergem at Washington University has described a project which employed a database of architectural images teamed with a CAD system to provide designers with a means to organize the collected sketches and photographs which contributed to an urban design project.

The limitations of media on paper, which the traditional sketchbook has unavoidably respected, perhaps no longer apply. Norman Crowe and Steven Hurlt have argued persuasively that the skills of drawing and sketching are fundamental to learning to design, and that they are being lost to new media such as photography, the photocopier, and computer graphics. (p. 10) Although we agree that drawing remains an essential tool for learning about architecture, we contend that these new media expand the architect’s repertoire of information gathering tools. Not only photographs, photocopies, and drawings might be included in a computerised sketchbook, but also audio, motion video and computer models. Can one argue that these media do not add something to the collection of experiences and the formation of associations necessary to creativity?

Thus in summary, we draw three conclusions concerning the demonstrated role of the sketchbook in architecture, one a positive criticism and the other two negative:

1) Drawing is a highly sophisticated and successful way of recording ideas about architecture which is exploited by the sketchbook. Traditional media of drawing should be preserved and reinforced.

2) The variety of information juxtaposed in a sketchbook is a strength of this information storage form. However, new technologies offer information media which are difficult or impossible to capture in the traditional sketchbook yet could expand its usefulness.

3) The traditional sketchbook is severely limited by its lack of organization and accessibility and its limited scope.

Computer methods can be used to enhance the sketchbook, overcoming the limitations while preserving the strengths of traditional media.

Hypertext Methods for Enhancing the Sketchbook.

Hypertext is the computing method which most closely mimics the functions of a sketchbook as a free-form, graphic and textual information storage and retrieval system. The concept of a sketchbook as a collection of hypertext documents leverages the power of the tool immensely. Although we have employed HyperCard stacks to explore our concept of the computer-enhanced sketchbook, it is important to recognize that new and old tools such as Owl’s GUIDE, Asymetrix’s Toolbook and Spinnaker Software’s Plus provide similar capabilities on platforms other than the Macintosh.

Other writers have examined hypertext concepts in relationship to architectural design tools. Coyne described a prototype design resource detailing the construction methods of a Fijian bure which was developed using HyperCard. This system provides a means for rapidly retrieving architectural information in a manner similar to the free associations of a sketchbook. Dana Vanier has also discussed hypertext concepts, this time examining the use of HyperCard in a prototype architectural detail retrieval system.

Unlike the linear, sequential organization of traditional media, hypertext proposes the organization of information into a net of cross-references to individual “nodes” of information. In HyperCard, the nodes are presented as analogous to index “cards” with a “background” containing a standard format and shared information and a “foreground” containing unique information. Text information is contained in “fields,” while graphic information is contained in a graphic “layer” on either the background or foreground. “Buttons” are used to permit the user to initiate actions, such as “navigation” through the information net. A button may be "scripted" to perform a "link" between cards to structure the navigation. This structure may take any conceptual form, from that of a simple sequence with only one option for the user to a very complex branching form with many optional paths for the user. Scripts may also define complex actions in a manner similar...
to programs in typical computer programming languages.

The advantages which these capabilities of HyperCard and other hypertext systems provide to the collection of documents into a sketchbook include multimedia, automatic indexing, hypertext links, "smart" tools and end-user programming techniques.

Multimedia is the integration of various media into a unified form. Graphic records such as drawings and photographs may be incorporated into a computer document by scanning. Text may be introduced by typing or by the use of optical character recognition of scanned text. Of course, computer-originated material may also be included in an integrated document, such as "paint" images, computer drafting, three-dimensional CAD models and even animations. The document may even contain video and sound.

We do not argue that the computer should be a sketching tool to replace pen and paper. There is no need to replace traditional media, which will still be used in information gathering. On the contrary, computer methods can best enhance the sketchbook by acting as cataloguing tools by which sketches and drawings produced with traditional means as well as other media may be introduced and organised.

The free-form indexing of text in a document is provided by many computing tools on virtually any popular hardware platform. For instance, the Find and Sort commands in HyperCard can examine all words in a document, locate a key word and transport a particular context to the user's screen. Such facilities provide a means for rapid retrieval of information and ideas. By associating key words with visual or aural "sketches" these types of information may also be indexed for rapid search and retrieval.

Hypertext permits the user to establish arbitrary links among documents. The Link to... command in HyperCard allows a user to associate two possibly disparate ideas. The user traverses the link simply by clicking on a button. Thus, creative connections among ideas may be made explicit and recorded for the future. There are no limitations to how many links may be established.

Computer programming techniques allow the incorporation of "smart" elements in the computerized sketchbook. Many design activities require some calculations, such as determining areas of a floor plan, deflections of a beam, or rule of thumb estimations of building cost. A paper sketchbook being used as a reference in the design studio might be complemented by note pads and a pocket calculator. Formula for calculations may be stored in the computer in the form of spreadsheets or short programs and integrated into a computerized sketchbook. HyperCard scripts can easily be written to perform calculations and open spreadsheet programs if desired.

Essential to the success of the concept of a sketchbook as a hypertext document, is the concept of "end-user programming". The creation of links and the scripting of actions and calculations should be carried out by the user. According to a common computer literacy text, end-user programming originated in the 1970's with the goal that "the business professional can focus on the problem being solved, rather than on the details of program development." (Day, p. 221) An end-user programming language must be easy to learn and easy to use. A computerized sketchbook should be as personal as a manually done sketchbook. Thus, the environment for the creation of a computerized sketchbook must include a powerful macro language or very high level programming language. For our purposes, HyperTalk, the language incorporated into HyperCard, has proven satisfactory.

Thus, hypertext offers the capabilities of multimedia, automatic indexing, hypertext links, "smart" tools and end-user programming to address the problems of architectural information organization. The incorporation of these five techniques in the creation of an integrated, personalized collection of design information results in an electronic sketchbook which is better than its paper-bound cousin.

Organizing the Computerized Sketchbook.

Although this research is still in a very early stage, we can offer a few very general guidelines to the organisation of a computerized sketchbook.

Similar to that of a paper sketchbook, the
organisation should remain loose, flexible and personal. Care should be taken to allow the interplay of diverse ideas by accidental association in order to retain the characteristics of the sketchbook as a reflection of individuality and a source of creative ideas.

The information which can be collected into a hypertext sketchbook falls into two general categories. Shared resources are those which contain information used by all architects, such as the functional organisation information included in Architectural Graphic Standards, product information, engineering formulas and architectural history. Personal resources are those which address issues of narrower interest in an individual’s creative search. These include collections of observations, design diagrams and sketches, project documentation, architectural theory and customized annotations and references to the shared resources. Both types of resources may contain informational databases and “hot” calculations scripts.

The two categories of resources work in a complementary fashion. The shared resources may be stored on a network or may be accessed through electronic communications. The personal resources may be stored on an individual’s floppy disks or hard disks. Personal resources may contain links to the shared resources or information may be copied from the shared resources and electronically pasted directly into the personal resources.

The establishment of navigation routes through the collected information is the most crucial challenge to the creation of an integrated computerized sketchbook. Time spent in the careful consideration of which information should be most easily accessible, which information should be related, and how the information should be presented is very well spent. With practice and experience, we expect that an architect creating a computerized sketchbook will gain fluency with formalizing his or her way of understanding architecture into hypertext patterns and paths of navigation.

Examples of the Computerized Sketchbook.

The researchers have undertaken various experiments with the computerized sketchbook concept, implemented by ourselves and in classroom exercises. The facilities employed include Apple Macintosh computers, an Apple Scanner, Apple HyperCard software, and SuperPaint, PixelPaint and DynaPerspective applications. It is important to realize that the computerized sketchbook, as we conceive it, is not an application or indeed any unified or standardised tool. It is instead a collection of individualized and shared resources integrated into a personalized design environment. The descriptions of projects below are meant as examples of what one may do with computer methods, rather than as models of what one should do. Note that the scripts to integrate these tools are very simple, and should remain simple. It is not necessary for the architect to become an expert in programming. With a modicum of knowledge, a hypertext author-architect can begin developing a resource. As needs develop for more complex actions, the architect can incrementally increase his or her knowledge of programming.

In Figure 1, a page from an early study for a component of a personal sketchbook resource is shown. The sketches were done using pen on paper on site in Scotland and later digitised into HyperCard 1.2 using an Apple Scanner. Fields were provided for including information deemed to be of interest, such as the designer’s name, the location, the date of construction and so forth. This allows the use of database search, retrieval and reporting functions to access the sketchbook pages. The process was extremely simple and resulted in an effective and workable sketch catalogue. Navigation through the stack is accomplished by buttons, which contain scripts such as the following:

```javascript
on mouseUp
  go to next card
end mouseUp
```

A search for any word in the database may be initiated by simply using the `Find` command with the desired character string.

The same original sketches were used in a second study illustrated in Figure 2. The size of the graphic area was increased in compensation for the low resolution of an Apple color monitor, a step made possible by the use of HyperCard 2.0. Scrolling fields were used to record descriptive text in a free-form fashion. In this case, separate
fields were not provided for typical descriptive information as the objective was to test a very unstructured method of recording information. Care was taken to include in the text a description of the illustrated scene to act as key words by which the illustration would be indexed. In this case, the sketches were reworked using Super Paint software to enhance the scanned images and emphasize qualities in the drawings. The same original drawing was used in Figures 1 and 2, but was enhanced in the second version using computer methods.

Another test study for a computerized sketchbook resource was the creation of a structural calculations tool by second year students in a one credit hour course in computer concepts. After a few hours of introductory lectures on computer programming, students built sample stacks which calculated shear, moment and deflection using standard equations for various types of beams. These students, with rather minimal instruction in computer programming, successfully implemented a usable and comprehensive structural design tool. A sample page from this resource is illustrated in Figure 3. The script to perform a particular calculation is shown below. First, it "puts" the contents of a field into a variable. It then performs the calculations and then shows the results by putting them back into fields. This handler would be initiated by clicking on a button on the card.

```javascript
on mouseUp
    put first word of card field "Length" into l
    put first word of card field "Load" into w
    put first word of card field "Elasticity" into E
    put first word of card field "Moment of Inertia" into I
    put first word of card field "Point x" into x
```
This system employs HyperCard as a front end to a collection of information on architectural history. The resource provides text, scanned drawings and scanned photographs of the buildings. In addition, a user can simply click on a button and retrieve a three-dimensional CAD model of the building which may be viewed from any location in space. An example of a card which can access a model of a house by Richard Meier is shown in Figure 4. Another button initiates a computer-generated animated walkthrough of the building which runs at any speed up to 30 frames per second. After quitting the three-dimensional model or computer animation, the user is returned to HyperCard at the place from which the user began the model exploration. Once again, the script is quite simple. An example is shown below:

```
put mL/2 into R  put R into card field "Reaction"
put w*L/2/8 into card field "Moment"
put w*(L-x/2) into card field "PointShear"
  -convert units, feet to inches
put L*12 into L
put x*12 into x
put w/12 into w
put 5*(L^4)/(384*E*I) into card field "MaxDeflection"
put w*x*(L^3/2-L*x^2+L*x^-3)/
  (24*E*I) into card field "PointDeflection"
```

Further studies on another track have explored the creation of a hypertext historical reference.

Figure 2: Reworked sketchbook
### Structures: Moment, Shear and Deflection

**Simple beam, uniform load**

| Beam Name: | Herman |
| Length(l): | 16 ft |
| Load(w): | 100 lbs/ft |
| Distance(a): | 7.3 ft |
| Moment of Inertia(I): | 98 in^4 |
| Elasticity(E): | 1200000 psi |
| Point xcs: | 2 ft |

**Reaction:**

- Reaction: 800 lbs
- Shear (max): 800 lbs
- Point Shear: 600 lbs
- Point Moment (max): 1400 ft-lbs
- Moment (max): 3200 ft-lbs
- Maximum Deflection (Midspan): 1.253878 in
- Point Deflection (At x): 0.486857 in

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**Figure 3: Structures resource**

```plaintext
put field "model name" into
modelName
open modelName with modeler
eend mouseUp
```

Work is proceeding to provide three-dimensional diagrams explaining concepts behind the building design in a similar fashion.

Other experiments have explored subjects such as vernacular American architecture, building codes and building diagnostics. The possibilities for the development of useful design tools appear limitless. A collection of these experiments was compiled into a package to demonstrate the potential of an integrated computer environment for architectural design. Figure 5 illustrates an index to this integrated sketchbook. Each label is actually a button permitting the user to “go” to that segment of the sketchbook. In addition, the user may use the "floating palettes" to switch to a different section of the sketchbook.

The response from architects, faculty and students has been very positive. Current efforts are directed toward an experimental class in which interested students construct their own personalized design resources.

**Experimental Conclusions.**

We have found that HyperTalk scripting is very easy to learn, requiring a minimum of effort before students are capable of building useful design tools. The language is also sufficiently sophisticated to permit ever more complex scripting by more advanced students. Likewise, contemporary scanning technology is readily mastered by students.

There remain limitations to overcome in using
the computer technology. Although drawings may be captured at 300 dots per inch (dpi) resolution and more, HyperCard is oriented toward the screen technology of the Macintosh which displays images at a coarse 72 dpi. This can be overcome, although somewhat awkwardly, by saving the scanned images as PICT files which can be scaled to reveal greater detail. Although at this point students exposed to the technology have expressed an eagerness to share their efforts, security and privacy issues should be considered. It must be understood that any sketchbooks that are “published” by sharing with other architects have left the control of the author and may be very easily “borrowed.” While shared components may be made available on a network, the personal components of an architect’s sketchbook should perhaps be kept on floppy disks to avoid violation of the creator’s privacy.

Freshman students have demonstrated as much capability as senior or graduate students in these experiments. We would not hesitate to introduce the concepts of hypertext, end-user programming and computerized sketchbooks in a first year program. In addition, it seems very reasonable that professional architects may begin to explore these techniques as the means to storing the collective knowledge of a firm.

The Benefits of a Computerized Sketchbook.

Hypertext can solve many of the problems associated with paper sketchbooks. Information may be indexed for rapid sorting and retrieval; many media may be combined in the sketch documents; and the sketchbook may also store active elements to perform routine tasks. However, we see the most important aspect of this research as the creation of personalized Interactive Learning Environments, a term used
by Elliot Soloway. According to Soloway, education must be seen as an active search undertaken by students with the guidance of a teacher. The computer provides the tools for discovery. Many learning tasks can be seen as design activities: a scientist designs a research project, a writer designs an essay, and a computer programmer designs software. Likewise, many design tasks can be seen as learning activities. Soloway argues that students should be provided with design systems, "CAD for Kids," which assist in structuring problems. These CAD systems could provide outlines, templates or kits for learning through personal experimentation and discovery.

In a similar manner, Project Jefferson at the University of Southern California attempts to provide students with computer tools to facilitate research. (Chignell and Lacy) A HyperCard front end to campus databases acts as a personalized "notebook" into which students retrieve data and automatically store bibliographic information. Study questions provided by the system help direct the student's thoughts into productive analysis of the assignment. The notebook then serves as an aid to composing a research paper using word processing tools.

This concept of personalized computer software tools lies at the heart of many computing companies' strategies for the future. New computing platforms such as the NeXT Computer will provide "the possibility of moving from a world of discrete applications to a world of cooperating, integrated, and user-customized environments." (Weiseman, p. 6) Weiseman envisions "CAD, spreadsheet, project-management, instrumentation and data acquisition tools, specialised analysis tools, visualization, and statistical objects that communicate to create an
engineering environment." (p. 7) Such an environment should not be a software package obtainable from a mass market vendor, but would be created by an individual for that individual using very powerful and very high level software kits and integration tools.

The computerized sketchbook may act in a manner similar to these examples. It should be a personalized tool which is the framework for an architect's research and quest for knowledge. For instance, an architectural curriculum could introduce end-user programming in the freshman year. At that early stage, student architects begin building personal resources by collecting and digitizing information. Notes from lecture classes would be entered into the computer and indexed, along with bibliographic material and references. Technical calculations from structures and environmental controls classes would be implemented as scripts or short programs by individual students. Architecture history examples would be catalogued, complete with scanned photographs and student essays. Three-dimensional models and animated walk-through would extend the visual experience of historic monuments available to students. Design projects in CAD format would be referenced in the resource, along with commentary and criticism which the student could record for future reference. Video clips would record significant places and events of special importance in the architecture student's memory. Indeed, the effort can be summarized as an attempt to model memory and to make creative synthesis explicit.

After five years of such a curriculum, the student architect would have produced a tangible document of architectural studies. The architect would have a personal design library, not unlike those of the medieval masons and guilds, containing all that individual has deemed to be important.

In addition, the digital sketchbook exploits the characteristic of digital media of being easy to share. The collected sketchbooks of students can easily be made available over a network or simply by disk to disk copy. The creativity of the collective, whether it be a class or a school or a firm or a profession, may be leveraged to greater heights by providing the documents of design conceptualisation to all of those who are interested. As argued by Forrest Wilson, "Creativity must be shared, and shared with everyone from dowel knocker to 'lieber Meister.'"

The computerized sketchbook can thus be a collective endeavor which may increase the resources and abilities of the individual as well as that of all individuals together.

Bibliography


