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Climatic Factors in Regional Design: An Interactive Tool for Design Education

This paper describes the development of an interactive computerized module developed as a digital resource for architectural design students that incorporates the premise of using architectural form as a primary environmental control system in a building. The first in a series of such modules, Climactic Factors in Regional Design illustrates the factors involved in regional design strategies. With the recognition that many design practices of the latter twentieth century are not environmentally sustainable, this module is to be used in a curriculum which recognizes that sustainable architecture begins by using architectural form as the primary environmental control system and the mechanical and electrical systems supplement that system not dominate it.

With recent advances in recognizing sustainability issues, the country is now more willing to embrace environmental stewardship. The path to reduce environmental problems is through the integration of practices recognize architectural form as a primary environmental control system. As such, the latest generation of designers must view design comprehensively. If future building designers are to succeed, environmental control integration needs to be included pro-actively within the initial design rather than reactively appended to the end.

Climatic Factors in Regional Design is designed to foster this paradigm shift and is divided into several topics and subtopic sections which include Introduction, Regional Design, Microclimate, Regional Guidelines, Design Strategies, Glossary, and Sample Examination. The module contains 260 screen displays and more than 250 illustrations, figures, and diagrams. Users can progress through the module in any sequence as their needs warrant. The module was developed using the academic version of Authorware Star by Macromedia.

Les facteurs relatifs au climat en design régional: Un outil de média interactif pour l'éducation en design

Ce papier décrit le développement d'un module interactif basé sur l'ordinateur, développé comme ressource digitale pour étudiants en architecture, et qui comprend la prémisse de l'utilisation la forme architecturale comme système de contrôle primaire dans un édifice. Le premier dans une série de tels modules, Les Facteurs relatifs au climat en design régional illustre les facteurs impliqués dans des stratégies de design régional. Avec la reconnaissance que plusieurs méthodes de design pratiquées vers la fin du vingtième siècle ne sont pas environtalement soutenables, ce module doit être utilisé dans un curriculum qui reconnaît qu'une architecture soutenable commence par l'utilisation de la forme architecturale comme système primaire de contrôle environnemental, et que les systèmes mécaniques et électriques supplémentent ce système, mais ne le dominent pas.

Avec de récents progrès en ce qui concerne la reconnaissance des questions de soutenabilité, ce pays est maintenant plus prêt à protéger l,environment. Le chemin qui mène à la réduction de problèmes environmentaux est l'adoption de pratiques qui reconnaissent la forme architecturale comme étant le premier système de contrôle environmental. Ainsi, la dernière génération de concepteurs doivent voir le design de façon compréhensive. Si les concepteurs de bâtiments futurs veulent réussir, l'intégration du contrôle environnemental doit être inclus pro-activement , plutôt que d'être réactivement inclus vers la fin.

introduction

In his book *Powershift: Knowledge, Wealth, and Violence at the Edge of the 21st Century*, Alvin Toffler describes how educational practices will need to change to accommodate the growth of informational technology systems that are becoming widely available:

> ". . . Education will require a proliferation of new channels and a vast expansion of program diversity. A high-choice system will have to replace a low-choice system if schools are to prepare people for a decent life in the new Third Wave society, let alone for economically productive roles (Toffler, 1990:369)."

Not surprisingly, the education of architects has been actively engaged in the assimilation of the high-choice system to which Toffler refers. The past two decades have seen a tremendous shift in the way that the craft of architecture is taught and the way that the profession of architecture is practiced. Perhaps the most significant aspect of that paradigm shift has been the introduction and continued expansion of the role that the computer has played in both of these areas. Initially a computational analytical tool largely used for engineering oriented applications, the use of the computer was subsequently refined into a computer aided design tool. This realm of computational analyses was eventually transformed into a multiplicity of design and drafting tools. The primary focus of that era was to provide analytical and production tools so that design / production activity time could be reduced through integration and enhanced communications capabilities. More recently, much research activity has been focused on the architectural aspects of using the computer as a preliminary design tool for conceptual modeling and experiential illustration of spaces and built forms. Along with this activity has come the overall realization of the potential of the computer along the entire spectrum of the practice of architecture. As the use of the computer has matured within the profession and schools of architecture, a growing acceptance of the computer both as a learning tool and a reliable source of information transfer has emerged. Distance learning demands and internet access capabilities have also drawn attention to the informational transfer aspects of the computer and the apparently infinite opportunities that they afford the educator, the student, and the practitioner.

The seemingly exponential expansion rate of implementation of computer technology and its decreasing acquisition costs make information technology accessible at an unprecedented rate. Previously available to only a significantly minor percentage of the population, computer technology and information transfer technology have matured to the point where it is becoming increasingly obvious that traditional instructional media in an text-based format will need to be supplemented if not largely replaced by instructional media in a digital format to align with this overall growing trend. As computers and information technology become more portable and as digital resources demands become more common, the use of text-based resources such as textbooks and printed reference manuals will decline. This is nowhere more obvious than in the classroom. Even though the modern computer has been around for several decades, the introduction of the microcomputer or personal computer has provided computer access to a much larger population segment in a more incrementally yet exponentially expanding market. The past two decades have witnessed a revolution in the way computers are used in the public school systems and the demand of their use in the business world. There has been a extreme sense of urgency within the collegiate academy to teach the use of the technology to the student and eventual practitioner but also for the faculty of the academy to acquire those skills needed to understand the computer well enough to begin generating the digital resources to foster the development of the informational infrastructure for the modern digital classroom.

As the recent attainment of the digital tools such as Form•Z, Lightscape, 3D Studio, and other software have enabled faculty to reach new levels of design investigation electronically, the opportunity now presents itself for the retrenchment of traditional teaching practices such that digital learning resources can be used "online" to supplement those tools. It is imperative to develop these online tools to facilitate not only classroom-based lectures but also foster the growing demand for distance learning curricula. In a sense, the cycle has come

full circle in that, as the digital tools have begun to penetrate the full spectrum of education and practice, there is an incumbent need to begin the process of providing the digital reference resources to fill in the information interface gaps between those tools. These digital references will provide not only the resources for the initial instruction of design methodologies but also, if appropriately configured, will provide the practitioner with a subsequent digital electronic reference tool. This paper provides the following case study of the experience of the author in attempting the first step in filling this digital resource gap.

digital resource overview

The interactive computer module *Climatic Factors in Regional Design* (Figure 1) has been designed as the first in a series of such modules which together will form an "electronic course-pack" that will be available to the students either on separate diskettes or as a resource on the school's computer network. This course-pack was conceived in part due to a specific shift in design pedagogical thought that has not been published significantly in traditional text-based resources. While the author initially considered approaching a publisher with a proposal for a traditional textbook, the growing trend for distance learning accessible resources provided compelling justification to approach the solution through a series of computerized electronic modules instead. Thus this module was conceived, developed, and to date has been used for the past two years as an environmental controls design studio reference tool.

The shift in pedagogical thought that formed the primary genesis for this module stems from the author's belief that sustainable architecture begins with the use of architectural form as the *initial* component of the environmental control system and the mechanical and electrical systems only serve to supplement that system. Demand for sustainable design practices has sent architects searching for "new" design strategies. However, the recent rate of technological development over several decades has outpaced many designers' ability to anticipate interdisciplinary aspects of their design decisions. These impacts include the subsequent constraints and demands placed on mechanical, electrical, and structural designers as well as the subsequent

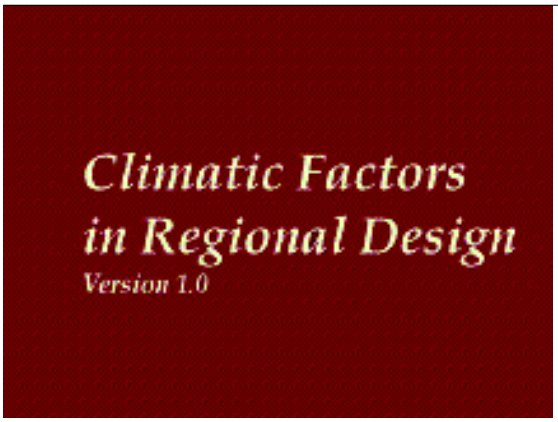

Figure 1. Climatic Factors in Regional Design Title Screen.

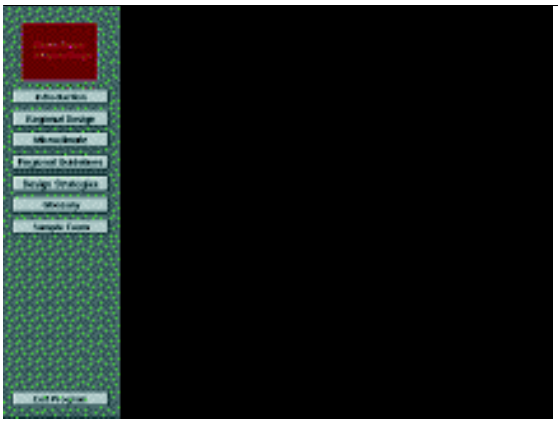

Figure 2. Main Topic Selection Menu Screen.

Figure 3. Architectural Technology Examples Screen.

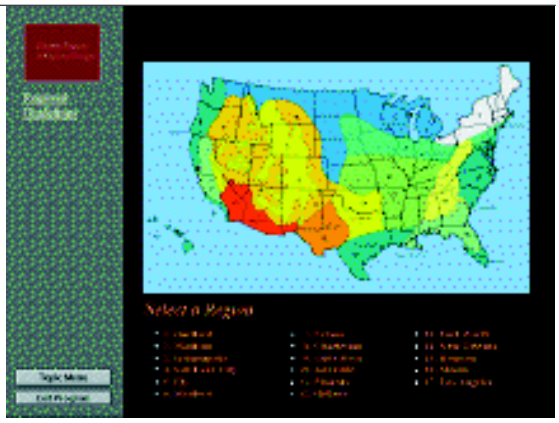

Figure 4. Microclimatic Analysis Screen.

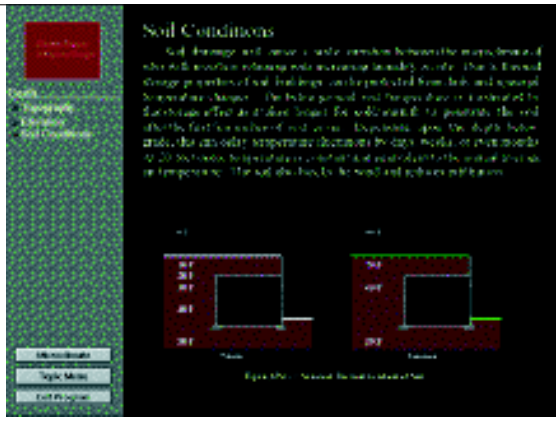

Figure 5. Regional Guidelines Selection Menu Screen (adapted from Lechner, p. 53).

Figure 6. Region 4 Climate Description Screen.

effects on the environment through the manufacture and fabrication of materials used to build and operate the building. This observation is especially valid for the environmental control systems found within the building. The perception that future designs are to be just a continuation of the practice of relying on allied disciplines with engineering training in the latest technologically driven products to solve environmental control problems is antithetical to true sustainable design theory. With the current informational technology systems that are emerging, architectural educators have a chance to restructure architectural education delivery to open new pathways to reach a greater sensitivity to regional design strategies. This opportunity is shaped by two factors. First, the source of the problem is the current design amnesia that prevents many architects from designing buildings that maximize architectural form as an environmental control system. Second, the realization needs to be achieved that good design and functionality are equally the responsibility of the architect.

architectural form as an ECS

The modern unsustainable design practices common today came about through two successive and interweaving paradigms. The first paradigm occurred during the period just after World War II. Advances made in technology and fabrication process achieved before, during, and after the war were being widely promoted for use in architectural design solutions. Clients demanded the latest technologies and the architectural community complied. At this juncture architects rapidly lost the earlier finite control that they had enjoyed over the overall building design, as engineering specialties grew stronger and more visible. The attendant technological developments of the era provided the means to “eliminate” many thermal and lighting constraints imposed by the local microclimate. Pre-war design practices such as daylighting, passive solar heating and cooling, and regional design rapidly disappeared as the latest man-made environmental control technologies made these strategies seem outdated. At this point, the second paradigm emerged. A collective amnesia developed with regard to the recognition of the importance how appropriate architectural forms can *naturally* maximize environmental comfort and minimize energy usage. While seemingly “freed”

from the design constraints imposed by the environment, architects have subsequently lost a critical awareness of the design opportunities afforded by ecologically sensitive design. This process is best exemplified by many conservation measures implemented after the energy crises of the 1970s. Early energy conservation strategies revealed numerous flaws within the previously accepted modern design practices. Due to how the buildings had been designed and constructed[1], many of the only economically feasible solutions were technological devices overlaid onto existing systems.

In reshaping academic pedagogical strategies to re-explore "natural" design concepts, educators can provide the professional foundation for an updated design vocabulary. This re-exploration will result in the integration of these "lost" fundamental concepts into current designs which meet the environmental comfort demands of society and evolve into a new design sensitivity which can mitigate resource depletion as part of the initial design phase.

rediscovering lost design strategies

In an effort to reverse many unsustainable building design strategies, *Climatic Factors in Regional Design* provides an interactive computerized module for an environmental controls curriculum for architectural design students. The module includes both microclimate and regional design typologies for seventeen climatic regions in the United States. *Climatic Factors in Regional Design* identifies the tectonics of vernacular regional building design practices that were previously common before World War II. Because the HVAC systems common in today's built environment had not been fully developed at that time, designers relied on anticipating the forces inherent to the natural regional climatic to enhance comfort within the building. However, mechanical and electrical systems' advancements and innovations that have occurred since the mid-twentieth century have caused an ever-increasing dependence on man-made technology for the environmental control. This approach has disconnected buildings from their regional locations and has caused buildings to lose the subtleties unique to regional climate.

The contemporary designer is confronted with a complex environmental control paradigm. Technology however can not anticipate every circumstance and one factor interrelates with so many others that a seemingly simple solution generates numerous previously unforeseen problems. These difficulties result from solutions to the energy consumption problems that were, borrowing a term from environmentalist vocabulary, based on "end of the pipe" methodologies. Recent recognition of the importance of sustainability has prompted an acceptance of environmental stewardship. With this emerging paradigm, the latest generation of designers are finally exploring more comprehensive design solutions using computer aided design methodologies in which they can view design more comprehensively during the initial phases of the project design.

module design premise

Climatic Factors in Regional Design was initially conceived as part of a ten module sequence for a thermal system environmental control course that serves as the foundation for an electronic course pack rather than the more traditional text-based course-pack. This module would be used in the course in four ways. First, it provides the basis for an actual in classroom delivered lecture using the images to illustrate the climatological forces that affect building design. Second, it is a lecture supplement in which the lecture text and imagery are summarized for student review away from the classroom itself and at the students' individual pace of learning. Third, it eventually is to be integrated into a distance learning course implemented on the worldwide web. And finally, this module is to be expanded to serve a reference tool for students in their design studio and subsequently for professional designers who develop conceptual designs for projects located in regions away from their usual domain of climatic design familiarity. It is this longer reaching aspect that will perhaps provide the greatest benefit from the development of this module.

Overall the module was designed to take advantage of the current significant opportunity to reduce sustainability problems through the integration of practices which utilize architectural form as the primary environmental control system. Environmental conservation and environmental control integration both need to be incorporated at the *ini-*

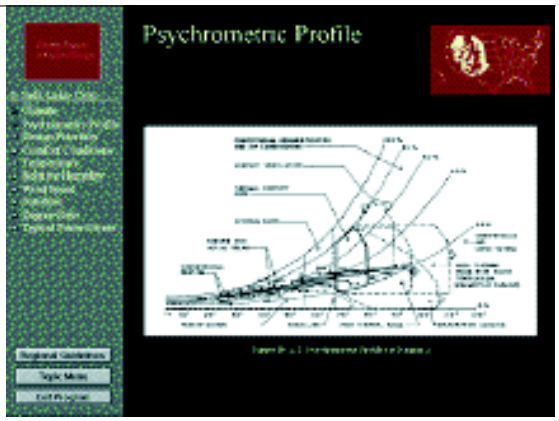

Figure 7. Region 4 Psychrometric Profile Screen (image adapted from Lechner, p. 53).

Figure 8. Region 4 Design Priorities Screen (images adapted from AIA Research Corporation, pp. 72-76).

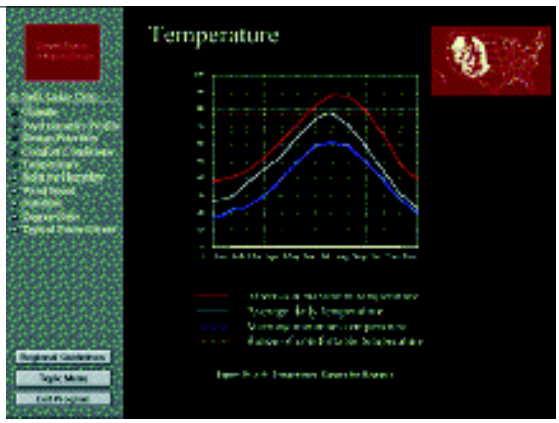

Figure 9. Region 4 Comfort Conditions Screen (image adapted from Lechner, p. 53).

tial design phase rather than tacked on at the end as commonly happens. The synthesis skills enhanced by *Climatic Factors in Regional Design* will facilitate the concept that future designers will rely on many of the physical principles which pre-1940s designers understood well. This in turn allows the use of the mechanical and electrical systems as supplements to those portions of the building specifically deficient in environment control rather than having these systems dominate the overall design. However, this approach does not eliminate the designer's responsibility to balance the environmental control needs with the opportunity to refine a design aesthetically. In this context the architectural form is not merely a machine for the environmental control system but also takes advantage of regional design opportunities that serve to inform the final design aesthetic.

development background

The module was created using the interactive software program Authorware Star by Macromedia Corporation[2]. Authorware was originally developed as a computer-based training authoring system which allowed for student use on an individual basis and has subsequently been augmented by the computerized add-on "Shockwave" for conversion to a web-based training module (Phillips1998:53-55). The Authorware Star program is an academic version of the commercial version of Authorware and has several size and programming limitations not found in the commercial version which will be described in further detail below. Otherwise, the programs are extremely similar (AIA Research Corporation 1978). Other software used to develop the module included Hewlett Packard Deskscan II, Adobe PhotoShop v.3.5 and Microsoft Word v. 6.0. The hardware used in developing this module included a PC-compatible desktop microcomputer operating Windows95 at 133 MHz with 32 Mb of RAM, an SVGA high resolution color monitor, removable external high density memory drive, and a high resolution scanner with a transparency media adapter.

This project was funded by a statewide Higher Education Technology Initiative Starter / Mentor Grant Program to encourage the use of interactive computer media in the classroom. The original

foundation for the development of this module was drawn from early work performed during the 1970s energy crises by the AIA Research Corporation. This work was published and distributed nationally as *Regional Guidelines for Building Passive Energy Conserving Homes*.[6] Subsequently, this book provided the background material for the chapter on climate in *Heating Cooling Lighting: Design Methods for Architects* (Lechner 1990)that is a textbook used in the environmental controls course for which this module was initially developed.

To date, the development process has consisted of creating a beta test version of the module that has been distributed to the students enrolled in the environmental controls course that is a corequisite course to a design studio course in the senior year of the undergraduate portion of a professional degree program. This distribution included placing the module on a student accessible network and / or providing copies of the module on a 100 MB Zip disk. As part of the course requirements, the students were required to evaluate the module. This evaluation included questions on technical content, structural format, module flow, graphics, and ease of use. These comments were collected, reviewed and incorporated into the current version of the interactive module.

authoring software

The Authorware authoring system has been rated nationally as one of the leading computer-based training systems available (Phillips 1998:53; Connell1998:128). There are several strongly positive factors which make the Authorware program attractive for interactive computer instruction. First, the program is designed to prepare a "packaged" module that can be used without the Authorware program being installed on the host computer. This feature enabled installation of the module on the local area network that is accessible only by students registered in the school. Second, the object-oriented programming structure makes the module readily adaptable for modifications and revisions. The programmer can select from a menu of object elements to define a specific activity or course of events in the module. This allows for a great range in creativity and design for the instructional package. These objects include interactive response sequences, animations, audio clips, video clips,

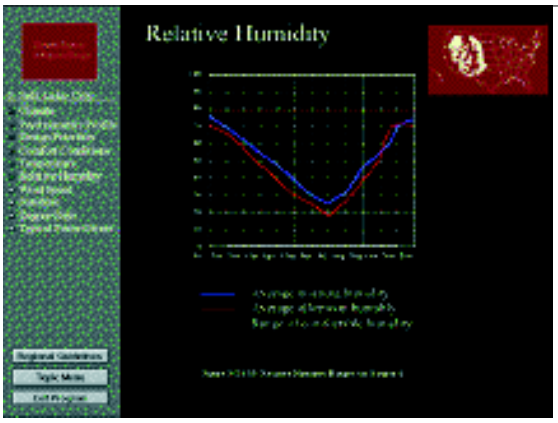

Figure 10. Region 4 Temperature Profile Screen (image adapted from Lechner, p. 53).

Figure 11. Region 4 Relative Humidity Screen (image adapted from Lechner, p. 53).

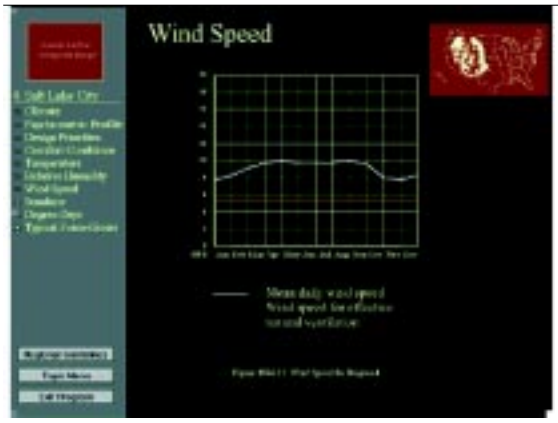

Figure 12. Region 4 Wind Speed Screen (image adapted from Lechner, p. 53).

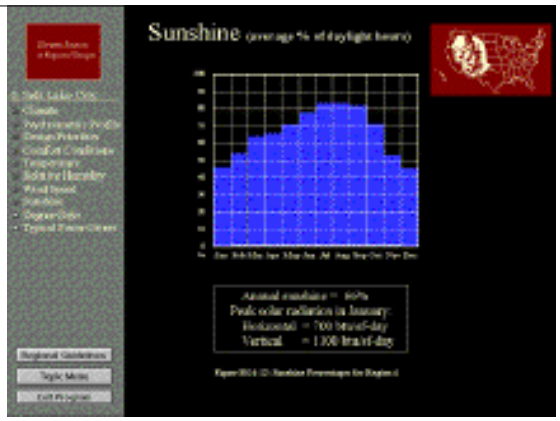

Figure 13. Region 4 Sunshine Screen (image adapted from Lechner, p. 53).

Figure 14. Region 4 Degree Days Screen (image adapted from Lechner, p. 53).

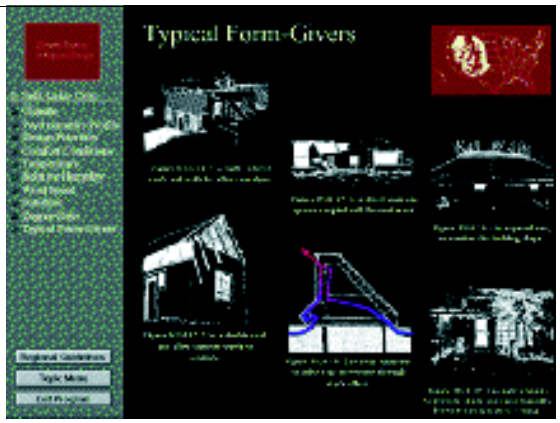

Figure 15. Region 4 Typical Form-Giver Screen (images adapted from AIA Research Corporation, pp. 72-76).

and other instructional items. Third, the program features an on-line editor that allows the operation of the module to be suspended momentarily for immediate revisions and then resumed to observe the effects of those modifications. Conversely there are several features which serve as a barrier to its immediate use in the academic environment. First, the program has consistently been described as having a steep learning curve. The author's experience with this learning curve echoes this common perception. Second, the program in its full commercial version is extremely expensive when compared to other authoring systems. Overall, the wide extent of programming tools within the Authorware family of products and its packaging capabilities justifies this expense somewhat but not entirely. Third, an early disadvantage was the lack of web-based accessibility. Since the program was originally conceived as an individual computer based training program, its format was intended to be stand-alone and not be Internet accessible. However, more recent releases of the Authorware program come with a program adjunct called "Shockwave" which converts the program to an Internet accessible element that can be used in a web-based distance learning curriculum.

The Authorware Star program, while is described as identical to the commercial version of Authorware, has several limitations that proved to be significant in the development of the module. First, it is limited to only five hundred objects. While this limitation may not be a problem for many smaller academic applications, the complexity and breadth of *Climatic Factors in Regional Design* essentially used all of these objects and forced some reworking of the module to allow for all the desired information to be included. This reworking also forced the exclusion of some navigability aspects of the module. Second, the Authorware program features a navigational object that would allow direct linkages between different components of the module that is absent in the Authorware Star program. This absence eliminated several "natural" tendencies for navigation that would be available when using a comparable text-based resource (e.g., moving from a table of contents directly to a specific section and back again). Third, there are no options to print out pages from the packaged module. Without the development of a text-based "user's manual" there are no means available to

the user for reviewing the contents of the module away from the computer. Surprisingly, this lack of printed reference material has been a noted concern for both iterations of the course in which the module has been used despite much of the material having been similarly described in the course textbook. Overall, however, the use of the Authorware Star program was considered valuable as it did allow for an inexpensive means to learn how to use the Authorware program without the significant expense associated with the acquisition of the full version of Authorware.

module description

Climatic Factors in Regional Design users employ a menu display (Figure 2) to navigate through the module in any order, either sequentially or randomly. Thus the user can initially read the material and move through the module as needed to review components of interest. The user may leave the module and resume examination at a later time and return to specific components as reference needs warrant. The module contains 260 screen displays and more than 250 illustrations, figures, and diagrams. The menu-driven screen displays present specific information related to the major topic or subtopic of the individual component. These module topic selections are described below:

Introduction: This topic selection provides an overview of the program which includes the user instructions, acknowledgments, listings of hardware and software resources, and the bibliographic resources used in generating text and screen images throughout the module. :

Regional Design: This topic selection discusses vernacular architecture and how immigrants from Europe adapted their traditional building practices to meet the climatic and resource demands of their settlement region. The climate adapted vernacular subsection includes representations of the climatic driven architecture built in North America in the period 1600-1997AD and describes forms and materials used, regional parallelism, and regional design examples. The climate disjointed design subsection describes the development of mechanical systems technology and the typical forms that are derived from its use and illustrates architecture from around the United States constructed since 1945. The regional design subsection illustrates architectural forms as an environmental control system and examples of this design approach from around the United States constructed since 1970 (Figure 3).

Microclimate: This topic selection describes how to evaluate the local climate and such microclimatic factors as earth (topography), wind, fire, and water. The illustrations include computer graphics and photographs that demonstrate the basic principles used to analyze and identify the microclimatic advantages and disadvantages of a proposed project site (Figure 4). Each topic selection is divided into subtopics to enable the user to navigate through them in any order desired.

Regional Guidelines: This topic selection (Figure 5) is the key feature of the module as a design education learning and reference tool. It describes (Figures 6-15) annual profiles for climate, design priorities, psychrometrics, comfort conditions, temperature, relative humidity, wind speed, sunshine percentage, degree days and the typical building forms found in seventeen climate regions in the United States. These subtopics are individually accessible on single screens for viewer clarity in the interpretation of the graphic information and, as with the rest of the program, may be accessed sequentially or in any order desired by the user. The regional climates are referenced by a climatically representative city in each region to typify the climate of the region. The seventeen regions and their climatically representative cities are: Hartford, CT; Madison, WI; Indianapolis, IN; Salt Lake City, UT; Ely, NV; Medford, OR; Fresno, CA; Charleston, SC; Little Rock, AR; Knoxville, TN; Phoenix, AZ; Midland, TX; Fort Worth, TX; New Orleans, LA; Houston, TX; Miami, FL; and Los Angeles, CA.

Weather information (e.g., annual temperature extremes and precipitation, snowfall, wind direction, degree-days, etc.) should be obtained from a site-specific local NOAA meteorological station to confirm weather impact on actual design parameters. The most critical subtopics are the design priorities and the typical forms. In the first subtopic, illustrations reveal prioritized architectural elements that should be included in some aspect

to facilitate a successful design. In the second subtopic, illustrations reveal the built form that has evolved within a region based on vernacular component adaptations.

Design Strategies: This topic selection illustrates strategies that generally can be used to allow the architectural form to serve as a significant component of the thermal environmental control system. This incorporates many regionally specific strategies into a generic series of strategies that overlap several regions. For example, the subtopic "to keep heat in and cold out" (Figure 16) lists several strategies that are common in multiple regions. Therefore, the user can derive forms from other regions which were only singularly illustrated in the region specific topics (e.g., the guidelines for several regions suggest underground or earth-contact construction and illustrate it differently in each region). This enables the user to adapt the concept into a form that may inspire new design concepts and building element configurations that may be as equally effective as the one specifically illustrated within the region of interest.

Glossary: This topic selection defines terms used in other components of the module. It contains both visual examples and text descriptions of the term being defined (Figure 17).

Sample Examination: This topic selection provides examination questions (Figure 18) for users to check their retention of the materials in the module. At the end of the examination, the user's score is given.

The initial genesis of the module was the development and adaptation of the *Regional Guidelines* and *Design Strategies* topic selections from the existing course materials and the author's experience in energy conservation consulting. It was recognized early on that while providing a reference resource to the user, the module needed to be augmented by the *Introduction* and *Glossary* topic selections to forego the need for a printed text-based user's manual. Similarly, the *Regional Design* and *Microclimate* topic selections were developed to assist the user in understanding the fundamental premise of the module. Lastly, the *Sample Examination* topic selection was added to provide users with an opportunity to test their knowledge of the module subject material.

user reaction and comment

The students were assigned to complete an evaluation form on the module as part of their coursework. This form included questions on content, format, presentation methodology, and suggested improvements. Student reaction to the module has been extremely positive. The module has been viewed as a means of getting design information about climate-based design in other parts of the country that allows the students to explore not only differences in climatic design but also similarities as well. Positive comments on the ability to review and translate many of the concepts into designs for their studio projects were the most frequent. Other comments have included those related to how the module will assist in their future designs and enable them to become familiar with regional design for areas where they have no prior experience. The common reaction is that the module provides an effective resource to understand the climatic forces that affect regional design and to develop strategies which inform a sustainable design based on the energy consumption implications of the architectural form as the primary environmental control system.

Most negative comments centered around what were actually limitations of the Authorware Star software itself (e.g., structural limitations, limited hypertext navigational features, no printout capability, etc.). Several expressed a desire for features that more closely follow applications found on the Internet and for Internet access to the module. Both of these aspects are being investigated with the upgrade to the full commercial version of Authorware and the web-based training adjunct programs that were unavailable for the original module development. Other comments were related to compatibility with older personal computers. The module does not work properly on monitors with lower resolution or on microcomputers with less than a Pentium processor. Several students who did not own the higher end technology noted this problem. This is a minor defect since the primary delivery system consisted of personal computers in the school's computer laboratory. However, this will be a continuing factor once the mod-

ule is adapted to the Internet web-based training distance learning course that is anticipated in the future.

One of the more surprising reactions and ongoing comments from the students is the desire to use the resource in a printed text-based format. This potentially indicates two things. First, it indicates that computer technology has not fully penetrated the student market where students have either network workstation access at their studio desk or the ability to purchase appropriate technology for their own use that is capable of running this software. Second, this may also indicate that the academic and perhaps societal culture is not quite ready for the digital based resource capacity that this module and others like it can provide. On this point, it can only be inferred that the computer is not yet as portable as comparable text-based resources and that the computer networking access is not as readily available as it needs to be so as to use this module truly as a digital resource. In response to these comments, a printed text-based user's manual is being developed which will include an image of each screen in the module and organized to provide a printed reference for students without the appropriate computer technology. This manual is expected to be approximately 350 pages in length.

author's caveats and comments

The author experienced significant early difficulties in moving along the learning curve for the Authorware Star software. Access to the software was provided through the use of a funding initiative that allowed for the acquisition of the software and equipment upgrades to develop the initial module. At the initial planning of the programming activities, it was conceived that the author would be able to learn using the accompanying tutorials and supplementary references. Despite the tutorial and pre-defined sample modules, this self-education process proved to be far more difficult than originally anticipated. Given the hindsight of this experience, the author would have benefited from participating in (and recommends to others that they attend) one of the workshops offered by Macromedia, developer of the Authorware system, to work through some of the initial foundational approaches to designing a train-

Figure 16. Example of Design Strategies Screen.

Figure 17. Example of Typical Glossary Screen.

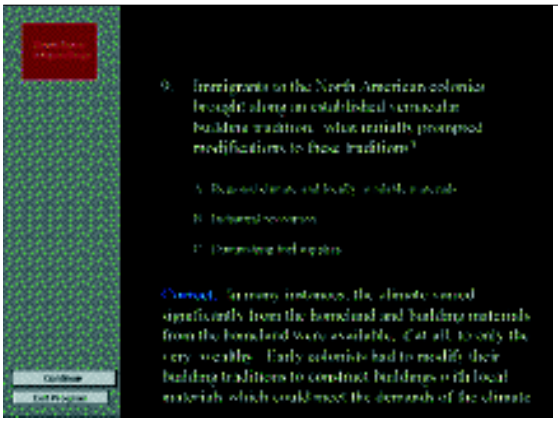

Figure 18. Sample Examination Question.

ing module.

The second caveat is to be aware of difficulties associated with the acquisition of the digital images used in a training module. Current copyright laws and fair use policies are becoming more specific as to the use of images not copyrighted by the program developer and the use of images whose copyrights are held by others. There needs to be time allotted into the development process to confirm the permissions to use copyrighted materials and / or to develop or acquire images that are copyrighted to the programmer. Most of the images used by the author are either from public domain documents or were developed by the author directly.

The third caveat is that anticipating the equipment on which the module will be used is critical. At the onset of development, the anticipated audience was expected to be students using the school's local network infrastructure and equipment within the computer lab. A standardized platform was defined to accommodate the module. Actual implementation of the module on the network revealed that although most workstations in the lab were compatible with the module (e.g., SVGA screen resolution, Pentium processor, etc.), several workstations in the laboratory were in fact incapable of properly operating the module. Likewise, the projection and display equipment used in the classroom and available for presentations outside the school were of a lower screen resolution which eliminated its use in those environments. This equipment has since been upgraded within the laboratory and classroom facilities.

The fourth caveat stems from the expense associated with purchasing the full commercial version of the Authorware system of software. Currently the Authorware suite is offered for approximately $3,000 but it may be difficult to justify that expense if the proposed developer has no experience with Authorware. This means that training expenses to attend Macromedia training workshops need to be allocated as well. The author's approach of using the much less expensive Authorware Star program has provided the initial training opportunity at a significantly reduced cost, excluding the author's time. The academic priced version of the full commercial version of Authorware is only slightly more than the Authorware Star program and is well suited for the educational task goals. However, the academic pricing agreement constrains the use of the software to non-commercial purposes. If the intent is to develop interactive modules for commercial distribution, then the full commercial price must be paid and the appropriate contractual arrangements must be defined through the university's intellectual properties office. Beyond the question of using university resources for the development of commercial software products (which can be accomplished following guidelines specified through the university's office of sponsored projects) commercial distribution will also necessitate obtaining permissions and royalty agreements for all materials whose copyrights are not held by the developer.

Overall, the experience and the results of developing this module have been extremely fruitful and rewarding. The opportunities for creating the digital resource have been joined with a growing demand for computer-based resources. It is expected that with the experience gained from this project the author will expand the breadth and depth of these training modules. Subsequent modules will include such thermally oriented topics as solar geometry, solar aperture design, passive solar design, heating and cooling loads analyses, mechanical systems sizing and selection, and energy conservation economics. As such, the author intends to continue filling the digital interface gaps that currently exist in the areas of his teaching and curriculum expertise.

digital resources: beginning of a conclusion

As a step along a potentially vast digital resource continuum, *Climatic Factors in Regional Design* illustrates how common low-technology design strategies formerly only presented in a text-based form can now aid in refining sustainable design strategies by incorporating them into the modern information technology mainstream. The pace of change in computer technology has created an opportunity to reintegrate many of the foundational design issues such as regional climatic design factors and represent them in a contemporary information technology form. While the principles and concepts described in the module dem-

onstrate the use of architectural form as a primary environmental control system is an important emerging trend in its own right, the larger issue at hand is the integration of text-based resources into a digital form to complement the growing number of digital design tools already available in the marketplace.

Growing demand and development of modules such as the one illustrated in this paper indicate the advancement of education and practice to the final stages of the computer aided design spectrum. Future development of teaching and reference tools such as this will transform pedagogy into a more effective digital mode of design education and design exploration. As accessibility to computer technologies and the portability of computer systems increase, demand for digital resources will continue to expand as well. The relevant text-based design education resources will consequently be converted to the digital resources needed to fully enable design educators to provide the educational tools necessary to effectively facilitate both classroom and distance learning teaching strategies.

endnotes

[1]The deficiency is well illustrated in *How Buildings Learn: What Happens After They're Built* by Stewart Brand. His premise throughout this book is that modern design practices have lead to the design and construction of building forms that do not adapt well to changing times and technologies.

[2]The Authorware Star program is an academic version of the more powerful Authorware program, both of which are copyrighted by Macromedia Corporation. Academic pricing agreements preclude the commercial distribution of modules developed using these programs and as such the modules are intended for use only as part of course related usage by the author.

[3]The academic priced commercial version of the Authorware program was later purchased after the initial beta version of the module was developed. This commercial version was designed to accept Authorware Star based modules and convert them to the full range of Authorware capabilities. As with the initial Authorware Star program, the academic pricing agreement precludes the commercial distribution of the module.

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