Student Initiated Computer Explorations in the Design Studio

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Many schools of architecture have been attempting to integrate computer applications into their curriculum. This paper will briefly discuss computer-aided design courses that are offered at USC, courses that are similar to those being offered at many universities, and then describe three exceptional cases where the student initiated the use of the computer in a way that was unexpected and different from the methods being taught. A result of conscious deliberation by the student, this experimentation resulted in unexpected discoveries by the instructors of the course. It is this digital serendipity that we wish to explore and discuss. Only occasionally do we hear much about these explorations in formal proceedings and conferences, but they are some of the most intriguing and interesting aspects of computer integration in design.

Computer Curriculum

In many respects, the School of Architecture at USC is not significantly different from many other schools in our implementation of computers and related technology into the general curriculum. There are no required computer courses, but there is a significant range of offerings available for both the graduate and undergraduate students from introductory to experimental courses.

The introductory course in computer applications traces an architectural project from a letter to the client describing the design intention through conceptual sketches, three-dimensional study models, cost estimation, construction documents, and project management. The course is intended to provide undergraduate students with an overview of architecture practice while demonstrating how computers can be used in each phase of a building project. An advanced course explores architectural form/modeling, color/texture, and time/animation. Figures 1, 2, and 3 show typical examples of student work from that class. Other upper level courses, evolving each semester, are used to explore additional technology issues. The past semester has seen a seminar on home automation and the future of the home. Next semester, a seminar will be offered on virtual spaces and interactive design tools. CAD/CAM may be explored within another venue if resources permit.

Figure 1: Mansour Farazmand’s rendering of a proposed contemporary art museum (Auto/CAD and Stratusvision).
CAD Studios

Although controversial, the design studio holds a central role in the curriculum, and it is where architecture students spend most of their time and energy. Upper division students choose four studios that explore a thesis or topic such as solar zoning, landscape architecture, urban design, computer-aided design, etc. A range of topics are offered, depending on the interests and expertise of the studio instructors.

In the CAD studios, many techniques are used to incorporate computers into the design process. Computers can be used for idea generation, schematic building exploration, documentation, presentation of projects, transformation of form, and as a communication tool for the designers with themselves, the instructors, and their colleagues. In almost every studio, not only the CAD studios, students are applying these techniques to their projects. Students lose sleep, try to make deadlines, win competitions—the computer is another tool to help them do what students have been doing for years.

Computer Explorations in the Design Studio

A few students each semester initiate a use of the computer that is different from what the others are working on. These students tend to be bright, motivated students, and they share a desire to explore architectural design in non-traditional methods. Unfortunately, they are also often unable to resolve their building design project in a recognizably architectural form compared to other students in the class.

Jeffrey Krause, Dean Geib, and Ryan Smith are three students whose work in the studio are examples of atypical approaches to computer-aided design in architecture. Krause concentrated on programming; Geib explored physical manifestations of curved space; and Smith took advantage of unexpected results on the computer to further his design.
Jeffrey Krause: Programming and Form Generation

The building type selected for the studio was a research station in Antarctica. Krause began with a study of the programmatic needs of the hypothetical clients. He then questioned the validity of designing a building for a type of client (research scientists in this case) rather than specific people and started a studio-wide discussion of arbitrariness in architectural design. This resulted with Krause trying to remove some of the arbitrariness in his own project by setting up a matrix of function, size, and desired placement for each of the physical program elements. He used weighting factors associated with each and entered the data and formulae in Microsoft Excel. Up to this point, Krause appeared to be developing a spatial adjacency matrix. The instructors expected that the next step would include an analysis of spatial configurations through planar graphs and dual graphs.

However, at this point Krause taught himself AutoLisp and wrote programs that would transform the data he obtained into spatial forms. The transformations were far from logical, although they were systematically described, and the process is reproducible. Krause manipulated the spatial data in ways that were not consistent with the meanings associated with the original encoding of the data. The result of operating the program was a three-dimensional model (AutoCAD and upFRONT) in which there was a spatial relationship between the encoded data and the model. Figure 4A shows a partial example of Krause’s spreadsheet, AutoLisp routines, and resultant folding plane forms in both plan (top) and elevation (bottom).

The models turned out to be quite complicated in three-dimensional space and contained many overlapping “rooms.” These forms were reduced by laying ideas about structure, circulation, and construction, etc., to produce quasi-architectural forms. Notice in Figure 4B the introduction of structural elements suggested by his folding planes.

The final description of the project left much to the imagination of the viewer as can be seen in Figure 4C, an interior perspective of the proposed design. Krause was adept at manipulating spatial matrix information, deciding weighting factors in the spreadsheet program, and digitally transforming the resulting data into three-dimensional form. Yet, the formal architectonic results of the project were not well resolved or accepted by the end of the term studio critics. Specifically, the reviewers commented that the arbitrariness of the early decisions and transformation formulae were not overcome by the intricacy of the linework resulting from programming the computer to “connect-the-dots.”

Jeffrey Krause’s Thesis Statement

Experimental form in a space analog station- the form moves past predictable convention, displacing tradition, reality, and gravity . . .

The project is an experiment attempting to define an X-dimensional architecture, an architecture which can truly be derived from and responsive to evolving and fluctuating fields of “spatial,” culture and information. This architecture bypasses the conventional form making methods of sketching, drawing, and self-righteous biased determinacy. This X-dimensional architecture is rooted, created and reduced to instaneously transforming numeric data information. The information is based upon and reflects the fluctuating loads and demands on the essential components of the occupiable building: the systems. The attempt is to analyze the systems demands on individual programmatic elements; thus consumption and waste are reduced and efficiency is optimized. The transformable form holds promise in not only mimicking this “information shift” but implementing and allowing this hyperreal interactive situation to occur . . .

By investigating the possibilities of utilizing computers in design we place ourselves at the threshold— defining the next steps toward the future of technological and human development.

Dean Gell: Physical Manifestations of Curved Space / Time

Gell and Smith were both involved in a studio that had for its program the design of a companion building for the Chrysler Building in New York City. Gell initially explored the dialogue between skin and structure in a building. This exploration transformed
Figure 4A: A partial example of Jeffrey Krause’s spreadsheet, AutoLisp routines, and resultant forms.

Figure 4B: A partial example of Krause’s structure.

Figure 4C: An interior perspective of Krause’s finished proposal.
into an investigation about the duality of light: wave versus particle, continuity versus discreteness. Geib responded architecturally by visualizing and implementing curved space/time as a concept for designing a skyscraper. What does curved space/time look like? How can the computer be used to visualize it? His proposal was beyond simple surface modeling, eventually including a manipulation of curved surfaces using Boolean operations.

Geib explored the interrelationships of his ideas about skin, structure, and curvilinear forms by modeling them on the computer. He composed a design process of sine wave forms intersecting in three dimensional space. Figure 5A depicts an early study of the generation of curvilinear form through intersecting sine waves. Although Geib described the events of the process and the sequence, he relied on the computer to construct the forms. The computer constructed in ways he had not anticipated, leading him to re-compose the process and introduce new information, such as scanned images, in an attempt to emphasize the surprises. In the computer constructs, he found pieces that could be altered in scale, refined, and used in repetition to develop the architectonic details in the forms. The computer models, by presenting three dimensional views of his forms, helped him to discover issues regarding occupancy and construction while he explored ideas of time and space. Influenced by photographs and drawings of the work of Nicolas Grimshaw, Geib’s final explorations were of the facade and double skin of his tall building proposal. Figure 5B is a portion of his final project showing the interstitial space between single and double layers of skin and structure.

Dean Geib’s Thesis Statement

Quantum. Pushing beyond the rectilinear cartesian coordinate system by creating quantum space—space which is simultaneously rectilinear / rectilinear and oscillatory / undulatory. As physics has progressed from the linear to the rectilinear / rectilinear cartesian understanding of forces and space to relativistic quantum understanding where matter is both particle and wave, Architecture must progress from the modernist rectilinear, structuralist concepts of space to a synergistic quantum understanding of space. Quantum space synergistically alternates between extremes, undulating from moment to moment, space to space—a chromeshift of rectilinearly coordinated spaces and disturbed, oscillating spaces. Within and around the perpendicular planar cartesian system there will be a waveform space composed of sine/cosine waves, square waves, sawtooth waves, and triangulated waves. These spaces will be delineated within the interstitial space between structure and skin.

Precedents: Expressionist arch—Eric Mendelsohn—Einstein tower

Figure 5A: A very early study by Dean Geib in producing curvilinear form through intersecting sine waves (form/z). He then repeated these curvilinear forms.
Figure 5B: A portion of Gehl’s project showing the interstitial space between single and double layers of skin and structure (from X).

Ryan Smith: Serendipity in the Design Process

Smith was skeptical as to the usefulness of the computer or other technology as a design tool, but was willing to incorporate chance occurrence into his design process. He built a rudimentary wooden maquing model of his skyscraper proposal. Smith built a model stand out of a used grocery store laser scanner and placed his model on the platen. With the scanner on, the shifting, multiple light beams of the laser traced patterns on the facade of his building. Images of the tracery of light were scanned into the computer; soon after, maps of New York City and the project’s site were scanned in. Smith manipulated these images in many different software programs. Serendipity was added to the design process at two major times, when unknown, and hence unexpected, features of a software program distorted graphic data and when graphic information was lost between software programs.

Smith learned that when one imports a bit-mapped image into Stratavision, it automatically performs a raster to vector conversion on the image. If it is a gray-scale image, Stratavision adds elevation data to the image so that it simulates a three-dimensional object, essentially treating the image as a bump map. A cursory look at the manual would have also determined this feature, which Smith neglected to do. What is unusual is Smith’s acceptance of this new geometry and his incorporation of it into his building design process. Figure 6A shows the transformation of a scanned two-dimensional map to a three-dimensional model; the last form is an example from a second scanned image.
Figure 6A: Ryan Smith's process of taking a scanned image of New York City from Photoshop to Stratavision and the corresponding 3D model produced. The fourth 3D form (above) is from a second scanned image.

Some transfers between programs resulted not in additional (or a different mode of) data, but a diminishing amount of information. This also sometimes occurred when going between paper and electronic formats. For example, Ryan plotted a plan view of his building to a DXF file in AutoCAD, not realizing that he had picked a paper size too large for that selection to understand properly. When plotted on paper, the image, as shown in Figure 6B, was split and shifted longitudinally from its original position. Smith interpreted this new site plan in a manner that opened up more design possibilities. With both the scanned images and the plotter, unexpected actions of the computer resulted in a different visual modeling or display of the data, allowing the designer to interpret a new reading as a part of the design process.
Conclusions

An inherent danger in these methods of generating form is that students may too easily accept the results of any accidental transformation. However Krause, Gelb, and Smith are among the best architecture students in a strong undergraduate program. They seem to be thoroughly analyzing the results of the computer’s actions and keeping or rejecting the results in a non-random way. Unfortunately their efforts in these areas kept each of them from making serious progress in describing the technical aspects of the buildings and instead placed an emphasis on the process of design that detracted from resolving an architectural problem. In the long term, however, these kinds of explorations will generate new approaches to design computing.

Krause chose programming and linking numbers and code to form; Gelb explored current scientific thought spatially, and Smith reacted positively to serendipitous occurrences on the computer. Programming, space-time theory, and chance happenings were not explicit in our course curriculum although now parts of each may be incorporated into the studio. What is taking place at other schools, not just carefully thought out and developed research projects, but spontaneous, innovative student driven initiatives in the studio? Clues are contained therein for the changing role and applications of computers in design.

Figure 68: Smith’s distorted plot (AutoCAD).