Mission Possible:
Computer Aided Design for Everyone

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A pragmatic model for the building of an electronic architectural design curriculum which will offer students and faculty the opportunity to fully integrate information age technologies into the educational experience is becoming increasingly desirable.

The majority of architectural programs teach technology topics through content specific courses which appear as an educational sequence within the curriculum. These technology topics have traditionally included structural design, environmental systems, and construction materials and methods. Likewise, that course model has been broadly applied to the teaching of computer aided design, which is identified as a technology topic. Computer technology has resulted in a proliferation of courses which similarly introduce the student to computer graphic and design systems through a traditional course structure.

Inevitably, competition for priority arises within the curriculum, introducing the potential risk that otherwise valuable courses and/or course content will be replaced by the “newer” technology, and providing fertile ground for faculty and administration resistance to computerization as traditional courses are pushed aside or seem threatened.

An alternative view is that computer technology is not a “topic”, but rather the medium for creating a design (and studio) environment for informed decision making... deciding what it is we should build. Such a viewpoint urges the development of a curricular structure, through which the impact of computer technology may be understood as that medium for design decision making, as the initial step in addressing the current and future needs of architectural education.

One example of such a program currently in place at the College of Architecture and Planning, Ball State University takes an approach which overlays, like a transparent tissue, the computer aided design content (or a computer emphasis) onto the primary curriculum.

With the exception of a general introductory course at the freshman level, computer instruction and content issues may be addressed effectively within existing studio courses. The level of operational and conceptual proficiency achieved by the student, within an electronic design studio, makes the electronic design environment self-sustaining and maintainable across the entire curriculum. The ability to broadly apply computer aided design to the educational experience can be independent of the availability of many specialized computer aided design faculty.

Continuing the educational mission

The fundamental mission of architectural education is the continual quest to provide a quality and appropriate professional education. The assumption is that the definition of “quality” and “appropriate” continually changes and that the differences in definition assigned by different institutions at different times adds richness to the architectural profession as a whole. This fundamental mission, which certainly is not new, has become complicated by the intrusion of electronic design technologies simply because these design technologies are internal to the design process and education. The experience of educators is largely limited to technologies associated with external physical construction rather than with the intellectual decision/design process. Electronic technologies are not topics for courses, discussion and presentation, but rather form an environment in which all other
architectural issues and topics are examined. The mission has not changed, only the context.

The debate

Architectural educators need to carefully and actively, examine, and re-examine, the pedagogical role of and professional preparatory responsibility for the utilization of electronic design technologies.

Unfortunately, the process of such an examination quickly becomes a study in change. Irrespective of the detail and content of any specific analysis of computer systems, the final result is that faculty and administrators, both collectively and individually, are challenged to consider new issues, revise course content, learn new skills, abandon hard earned skills, speak a new language, reconsider long-held values, and work in a seemingly alien environment. Such a sweeping array of potential challenges becomes fertile ground for emotional resistance to change, often evidenced as subjective opinions presented as rational truth for retaining the status quo. Rationality and statistics, pro or con, does little to sway the position of either the proponent or detractor of computer aided design.

In some institutions, this computer aided design technology debate may be clearly evidenced as aggressive conflict, in which instance little, if any, computer design is introduced into the curriculum, or the proponents of computer design are (apparently) given free reign to offer computer courses. Although the first case may appear to be “anti-computer”, while the second case may seem just the opposite, both “solutions” to the debate, in effect, are strategies for the avoidance of fundamental changes in the educational environment. Either the debate continues noisily, or proceeds quietly by creating courses as forums for ancillary computer content. Neither solution may adequately serve the future needs of the student.

The real challenge for architectural educators is finding mechanisms for dealing with an age, now and tomorrow, in which the constant is change. Computer design technology is less a topic then it is symptomatic evidence of a world striving to maintain control of itself, however contradictory it may seem, by developing tools, which so readily maintain the records of change, that they become devices accelerating that very change. Educators need to accept, without judging it right or wrong, or better or worse, that a high probability exists that the professional lives of today’s student will be dominated by such electronic information/design technology. The computer will be a “commodity”, purely routine, as is the pencil and sketch pad or drawing board today.

The consensus

The computer design debate points to positive evidence of a common concern for providing students with a quality and appropriate education. If the probability of a future electronic design environment can be agreed upon, again without judging that future better or worse than the past or present, then an accord will have been reached, as a first step, on the on the context in which quality education is to be offered. Such an agreement need not define with any specificity what is an “electronic design environment” except to the extent that such an environment (attitude) involves a designing, learning, and working predominately with electronic technologies including computer design systems, information systems, video, and digital photography over a significant period of the student’s education.

Once an electronic context, however loosely defined at the beginning, is accepted, the debate becomes a common vision for defining, as an evolutionary change process, the electronic environment, and creating both a quality and an appropriate educational content. Because educators have little experience with electronic design educational environments, and, therefore, no real basis for an informed judgment, each institution should create, as an overlay on the existing curriculum, that electronic environment. This overlay will provide the requisite structure for examining and evaluating educational quality within the specific goal and philosophy of the specific institution, while providing the mechanism for the longer term transition to an information system based educational format.

The curriculum

The majority of architectural curricula address technology through the identification of technology content courses which appear as an educational sequence within the curriculum. The
technology topics have traditionally included structural design, environmental systems, and construction materials and methods.

The introduction of computer technology is likewise often treated as a "new" technology to which a similar teaching methodology is applied. Two major approaches, or a combination thereof, have been generally applied to the introduction of computers into the curriculum.

The first method adds or substitutes computer courses either as required or elective curriculum components. This additive methodology has practical content and time limitations; as courses are added, the competition for topic content may result in computer courses which infringe upon and/or replace otherwise equally valuable courses and/or course content.

The alternative and second approach is to "integrate" the computer into existing courses. Although conceptually appealing, the integration often is merely an additive process which occurs at the course level rather than at the curriculum level. Introducing the computer into existing course work potentially results in the same losses and/or substitutions that occur at the curriculum level and also runs the risk of forcing "artificial" computer use solely for the purpose of demonstrating the desired objective of integration.

However, as computer applications and use within the design professions become broader, both the demand for additional courses and pressure to assign priority to computer content becomes greater. Many current architectural curricula now have little room for the introduction of additional courses and/or content substitutions without potentially sacrificing other content, whether in required or elective course offerings.

The curriculum, as a system, is dynamic and holistic; curriculum revisions derive from experience with the interrelationship between courses and content in a context of educational objectives. The virtue of the curriculum structure is that it provides the mechanism for judgments regarding curricular change. Such experience and certainty with computer topics and their relationship to the larger curriculum is largely absent. The decision structure provided by the curriculum suggests that the prudent course is to assign computer topics a generalist and/or ancillary role. As a result, computer topics appear primarily in broad introductory, and special topic or elective courses.

Although well intended as a device for the introduction of computers into the curriculum, inserting computer courses as topics will not well prepare educators for the eventual pervasive use of computers in design practice and education, nor does such a method recognize the power of the computer as a highly influential design-decision medium.

Proposed is a secondary, yet quasi-independent structure, that supports the larger curriculum by serving as a vehicle for gaining experience with computer topic content and relationships without placing the larger curriculum at risk. Initially, the primary relationships developed would be between computer topic courses, with secondary links to current non-computer courses only when such relationships clearly enhance the educational value and minimally impact the conduct of those courses. Although subject to the broader educational goals of the curriculum, the computer stream should enjoy adequate independence in order that, as experience is gained, the detailed objectives set at the year levels and/or specific course offerings/content may be modified.

The computer emphasis structure proposed is a pragmatic device for long-term curricular planning and mechanism to maximize the utilization of computer resources as they become increasingly available.

Computer technology is inert in the absence of intelligent human utilization. The goal of the computer emphasis program is to establish an environment in which the computer serves as a medium that interactively impacts the "thinking" or decision making process.

Deployed as a "tool", computer technology serves as the device for acting upon decisions already made, such as design decisions reached through sketching on paper. In such a case, the design decisions may need to be placed in a formal, hard-lined presentation format, i.e. drawn on the computer, or computational procedures completed which lend themselves to use of a computer spreadsheet rather than manual methods.
Viewed as a "decision medium", computer technology provides the environment for the manipulation of quantitative information that fuels qualitative human judgments, or, stated in another manner, the interaction between man and machine constitutes an information processing system. The emphasis becomes human, not technological. In this view, the design decision is made during interaction with the computer technology, not external to it, as in the prior "tool" example.

This writer's experience in the teaching of the computer based studio, discussions with faculty from other institutions, and related research, strongly suggests that the introduction of computer technology as a new resource and work medium changes the thinking, decision, and design process. In simple terms, the changes are analogous to the differences in cultures, traditions, societal values, and architectural vocabulary observed in differing regions of the world and over time. The environmental and construction medium, including available materials, tools, and geographical and climatic conditions, is reflected in the decision process as to what to value, believe, and build. In a similar manner, the computer potentially provides a medium that significantly influences the design decision process.

It is imperative that the computer be understood as a change medium, rather than one relied upon to necessarily heighten the quality of the educational experience. Whereas revisions to the curriculum have the intended purpose of "improvement", the desire for a qualitative improvement by virtue of introduction of the computer may be a false expectation. We should seek a structure in which the influence of computer technology may be freely felt, explored and evaluated without infringing upon and/or being restrained by the qualitative core of the larger curriculum. The issue, yet to be resolved, is whether the current values that define "quality" and drive "improvement" in the larger curriculum are directly and/or always applicable to a computer based educational program. As educators, faced with a technology that potentially influences the design decisions of our students, we must be willing to examine the definition of design and design quality in an Information Age which will form the cultural and professional context for those students.

The structural design courses currently identified in many curriculum may serve as an example of the change vs. quality issue. The course content includes the structural design procedures applicable to specific materials, including wood, steel and concrete. The design procedures are based on an understanding of the principles of statics and elastic design theory, both of which lend themselves to relatively simple calculation requirements. The alternative is to understand structural action as dynamic rather than static, and perform design in terms of work (energy) theory and nodal modeling, requiring the solution of potentially hundreds of simultaneous equations. The computer environment suggests the alternate approach, but to judge that alternate as better has no basis in fact. The procedures are only different.

The Information Age future includes the widespread use of the computer, a society economically polarized and demographically represented by a non-European cultural majority, and an economy dependent on the products of mental acumen rather than those of manual labor. Computers certainly cannot address the multitude of current and future issues that will impact the professional lives of students; the computer emphasis program must rely on the larger curriculum content and structure if a broadening educational experience is to be provided. For example, drawing visiting faculty from other cultures is an important educational initiative not dependent on computer technology. The computer environment may, on the other hand, be more appropriate forum for the exploration of other issues. For example, the architectural heritage has generally established values that "believe" each building site demands a unique, individualized design response and finds notions of mass production an enigma. If the computer is inherently an automation device, exploring the results of mass produced design and construction might be a suitable computer studio topic relevant to a society increasingly dominated by "un-affordable" housing and a growing homeless population. Philosophical analogies might be drawn between architectural services and the production of books. Manual production methods often produce wonderful graphics, which in themselves have value as works of art and craft, as did the manuscripts produced in the medieval monastery. With the introduction of the printing press, the "art" of the manuscript has been lost,
but literacy and the access to knowledge has become within the reach of many. The point is that the computer environment serves up a different menu of valid issues.

The rationale is that the computer environment, when taken beyond the “tool” level, generally does not provide support for traditional courses and may, in fact, create contradictory educational signals at best and provide inadequate preparation for sequential course work at worst. Developing a secondary computer track provides the methodology for introducing a new set of relevant architectural issues suggested by the Information Age without compromising the supportive and qualitative interrelationships among courses in the larger curriculum.

Simultaneously, faculty will be relieved from the “perceived” responsibility for utilizing the computer in current course work when they honestly, and most likely correctly, see no meaningful content and/or educational benefit to be derived from computer use. Eventually, based on the current level of computer technology growth in the design professions, future curricula will be founded on computer methodologies. Until that day arrives, educators should be equipping themselves with the experience required for the continuation of valid curricular decisions.

An example curriculum structure overlaid with a computer emphasis, and brief example course descriptions are illustrated on the following pages. The example also identifies computer resources used in the program developed by the author at the Ball State University College of Architecture and Planning located in Muncie Indiana.

Example electronic design program

The following sections outline an example curriculum program currently in operation at a Ball State University. The architectural program has typical enrollment levels of 60 to 75 students in each of the third, fourth and fifth year levels. This document outlines a curriculum framework which offers students the opportunity to utilize electronic design technologies alongside traditional communication media within the existing design studio sequence. Included are the following:

1. A program summary.
2. A curriculum outline.
3. A listing and brief description of those courses included in and/or supporting the Electronic Design Communication program.
4. Further detail and discussion of the “TechShare” resource acquisition program.

Program summary

This program provides the formal structure through which 1) all students will be introduced to electronic design concepts and technologies, 2) students are offered the opportunity to continue to develop a design process in the context of the electronic communication environment, and 3) provides the mechanism for funding the required educational resources required by an Electronic Design Communication program.

This program is a subset of and parallels the existing primary curriculum. Any future modifications to the primary curriculum would be reflected in the electronic media option. Those students who select the Electronic Design program option would have direct and personal use of electronic media during the third through fifth studio years.

A preliminary decision to participate in the Electronic Design program is to be made at the end of the second year, with a final commitment delayed until the end of the third year. Although students will have had exposure to electronic design media, including computer and video systems, at the first and second year levels, that exposure may not provide an adequate base for the decision to participate in a long-term electronic communication/media program. Therefore the final decision may be delayed until the completion of an electronic studio experience.

Those students indicating a likely interest in the Electronic Design Communication program would enroll in a dedicated Electronic Design Studio (EDS) environment. This EDS component (Arch 301-302) of the program provides the conceptual groundwork and technical skills necessary for the student to continue to use electronic design systems in subsequent (non-dedicated) studios.
at the fourth and fifth year levels. The final commitment to the Electronic Design sequence includes participation in "Tech-Share," a lease-to-own program in which the student and University share the cost of the required electronic technologies.

Those students who do not enroll in the EDS studio will have available to them an elective (Arch 498) during the Summer in which they enroll in the Arch 401 studio. Distributing the electronic media instruction over three periods (1 academic year = 2 summer sessions) gives all students (90 max) access to the EDS resources (30 stations).

The first two design studio years, which remain unchanged under this recommendation, do not currently employ electronic systems, although the concepts and vocabulary of the computer design systems could be introduced, with or without computer hardware, during a single semester of the second year. Such an introduction could help the student to better understand the curricular paths available beginning at the third year. Those faculty currently teaching at the first and/or second year levels may wish to explore the integration of information system concepts and vocabularies into existing course content.

The Electronic Design Communication option would operate generally as follows:

**End Year 2:** Preliminary student selection of Electronic Design Studio (current enrollment limited to 30 students).

**Start Year 3:** Student enrolled in Electronic Design Studio sequence (electronic studio sections of Arch 301 and 302). Student may elect not to continue the Electronic Design Studio sequence following completion of Arch 301.

**End Year 3:** Student elects Electronic Design Program and participates in the Tech-Share program.

**Start Year 4/5:** Student enrolled in design studios, which include a mix of traditional and electronic design media students. Electronic Design program student also enrolls in information technology and management related electives along with required architectural electives.

The curriculum outline illustrates the parallel structure of the Electronic Design Communication sequence. The design sequence is linked to lecture courses which either currently or potentially offer the opportunity for maximizing the utilization of the computer equipment within the electronic studios. Links may include direct studies which require computer system methods and/or consist of indirect assignments which may be completed irrespective of the studio environment, although the electronic environment may require some alternate project submission requirements. Links are subject to both the course subject, instructor efforts to develop computer related content, and section enrollment and scheduling.

Only the framework and logistical mechanisms for the operation of an Electronic Design Communication program are identified. Beyond the general identification of those courses which either currently do or could readily and appropriately incorporate content/discussion related to information systems, specific course content, design ideologies and/or methodologies, etc. remain the responsibility of each individual faculty.

**Example undergraduate professional curriculum**

The Ball State Architectural curriculum is as follows, with those courses forming and/or linked to the electronic design program shown in **bold** type.

**First Year (Autumn Semester)**
- CAP Design 101 3
- CAP DCM 1 161 2
- Introduction Envir. 100 3
- General Studies 9

**First Year (Spring Semester)**
- CAP Design 102 3
- CAP DCM 2 162 2
- General Studies 9

**Second Year (Autumn Semester)**
- ArchDesign 201 4
- StructSysI 211 3
- ArchHisI 223 3
- DCM3 261 1
- General Studies 6
**Second Year (Spring Semester)**
- ArchDesign: 202
- ArchHist2: 224
- StrucSys2: 212
- DCM4: 262
- General Studies: 6

**Preliminary Electronic Program Application**

**Third Year (Autumn Semester)**
- Electronic Design Studio: 301-E: 3
  - StrucSys3: 311
  - BldgTech1: 315
  - ArchHist5: 329
  - DCM5: 361
  - EnvSys1: 371

**Third Year (Spring Semester)**
- Electronic Design Studio: 302-E: 3
  - StrucSys4: 312
  - Bldg Tech 2: 316
  - EnvSys2: 372
  - General Studies: 3

**Final Electronic Program Application/Tech-Share**

**Fourth Year (1st or 2nd Summer Session)**
- ArchDesign: 401
- Computer Elective: 498-E: 3
- General Studies: 3

**Fourth Year (Fall/Spring Semester)**
- ArchDesign: 402 5
  - ArchTechCom: 417
  - ArchPhil: 427
  - Docum: 442
  - Research: 451

**Fifth Year (Autumn Semester)**
- ArchDesign: 403 5
  - ThesFrep: 452
  - Arch Elective: 498
  - CAD Mgt: 498-E: 3
  - General Studies: 3

**Fifth Year (Spring Semester)**
- Arch Thesis: 404 5
  - Professional Practice: 459
  - History/Theory Elec: 498
  - General Studies: 3

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**Example course descriptions**

**CAP 161/162:** Topics include an introduction to computing, hardware, MS-DOS and Macintosh operating systems, information processing concepts, file and directory tree structure as data management techniques. Applications include word processing, database and spreadsheets.

**DCM 261/262:** (suggested link and content): Topics include methods for environmental design communication using a variety of 2-D computer graphic software including paint, draw and illustration applications. Manual techniques for enhancement of computer output are illustrated in a variety of media including prismacolor, watercolor, and collage.

**Electronic Design Studio 301/302-E:** Electronic Design Studio. Complies with current design studio curriculum objectives and University Undergraduate course description. Topics: Employs 3-D modeling in a computer environment.

**Architectural Design 401:** Complies with current design studio curriculum objectives and Undergraduate course description. Electronic design media not used in this studio. Tech-Share equipment on order during this summer session.

**Computer Elective Arch 498-E:** Options include courses currently offered in Computing Science, and Telecommunications. Elective topics could include computer information systems, networking methods, macro programming, computer simulation techniques, animation, hardware systems, video production, etc. Courses available include:

- CS 200  Intro. to Computer Info. Systems
- CS 333  Computer Hardware Systems
- CS 342  Simulation Techniques
- CS 438  Computer Graphic Systems
- CS 472  Mini-Computer Systems
- CS 476  Operating Systems
- TCOM 201 Prod./Perfor. in Telecom.
- TCOM 300 Programs and Audiences

**Architectural Design 302/402:** Complies with current design studio curriculum objectives and Undergraduate course description. Encouraged Topics/Work include mixed media presentations including collage, marker, prismacolor, video, etc.
Building Technology 417 (suggested link): Principles of informational continuity link studio project to construction document preparation assignment in this course. Students may build on database developed in 302 as foundation for building technology study and production of construction documents. Some faculty coordination required.

Professional Practice 459 (suggested link): Introduce content related to professional office operations using electronic technologies. Coordinate with CAD Management (Arch 498-5) content as described below.

Architectural Design 403: Complies with current design studio curriculum objectives and Undergraduate course description. Encouraged Topics/Work include Advanced computer rendering, photo-realism, lighting studies and animation. Studio may utilize Unix based workstations, rather than solely PC environment.

Architectural Thesis 404: Complies with current design studio curriculum objectives and Undergraduate course description. Independent project development consistent with current curriculum. Project development deploys all University/College computer and video resources.

CAD Management Arch 498-5: Topics include management of personnel, finances, and computer technology in the professional practice environment. May also be open to all students as an elective.

Example resource scheduling requirements

Computer resources utilized in the program include:

- **UML:** University Micro-computer Lab, 35 stations
- **EDS:** Electronic Design Studio, 30 stations
- **TSP:** Tech-Share™ program resources
- **UGL:** Graphics Lab, Workstation (12) systems

**CAP 161/162: UML.** All students. Introductory courses conducted in micro-lab.

**DCM 261/262: ED5/UM5.** All students. Subject to scheduling and interest. EDS used as an instructional facility, morning schedule, two to three hours per week. Micro-computer Lab and design studio (manual) used for completion of course assignments.

**Arch 301/302: EDS.** Electronic Design Studio offered as option and initial course in the Electronic Design Communication program.

**Arch 401: None.** Electronic media not used directly in this studio pending delivery of Tech-Share resources.

**Arch 498/598: EDS Summer Session.** Elective offered to all students not enrolled in Electronic Design Studio during third year.

**Arch 402/403/404: TSP/UGL.** Studio sequence.

**The Tech-Share resource program**

Tech-Share, as part of the voluntary computer curriculum selection, is a program in which the student and the University contribute to the technological equipment requirements of the specialized and unique educational opportunity afforded by the Department of Architecture Electronic Design course sequence.

The student contribution and program contract would generally include:

1. Purchase of a personal computer (2-year lease-purchase plan) in compliance with program specifications. (estimated at $2800-$3400)
2. Placement of the computer equipment in a studio space for the duration of the program.
3. Connection, if required, of the computer equipment to a file server network as provided by the University.
4. Insurance coverage for replacement value under a homeowner or personal property insurance policy.

The University share and obligations include:

1. Acquisition of all personal computer equipment under a vendor commercial Master Lease.
2. Sub-lease of personal computer equipment to enrolled students at rates which reflect the University group purchase and/or educational discounts.

3. Supply, installation and maintenance of those peripheral devices used in the instructional program.

4. Supply, installation and maintenance of that computer software used in the instructional program.

5. Maintenance, including parts and labor, of student computer equipment during the lease contract period.

6. Supply and maintenance of studio furnishings and the allocation of fixed studio space for the lease period.

7. Provision of reasonable and prudent security measures and devices.

8. Access, as required by the instructional program, to the University advanced graphics workstation systems.

9. Release, subject to completion of the lease terms, of personal computer equipment to the student at graduation.

The following contingencies would likely apply to the lease agreement:

In the event that the student should withdraw from or fail to satisfactorily complete the instructional program prior to completion of the lease period, one of the following options would apply:

1. The student could acquire the personal computer upon payment of any remaining lease balance.

2. The University could acquire the personal computer upon reimbursement, less depreciation, of any lease amounts paid by the student up to the date of withdrawal.

The potential for the computer track program, beyond major furnishing and network equipment purchases, to become self supporting should be evaluated:

1. Develop a time-share program which would offset both student and University equipment acquisition costs. Offer computer/CAD workshops to practicing professionals and business organizations utilizing the electronic studios during off-peak, including Summer session periods.

2. Use a strategy similar to that above to request software support. Utilization of specific software in the educational environment tends to produce, over the long term, a larger user base.

3. Offer equipment acquired as a result of contingency item 1. above to students at lower cost based on financial need.

4. Distribute equipment acquired as a result of contingency 1 above to support of non-computer track computer graphics/design lab.

5. Explore options, including corporate and alumni support, equipment "unit" adoption programs, training contracts, and the lease of the studios as corporate training centers. Income generated could offset student equipment purchase cost.

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