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The Ideal Computer Curriculum

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We argue that a re-integration of computer technology into a design curriculum is possible without necessarily displacing traditional subjects or time-honored notions of building and place. An ideal computer curriculum might be one that merges computer technologies into existing courses more progressively than is typical today and at the same time looks to the studio teaching method as a catalyst for shifting perspectives on the relevant areas of design theory and methods. This position paper asserts a framework for a design educational program which integrates the use of computer technology. In posing such a curriculum, this position paper also attempts to work within some professional accreditation constraints that Schools may need to address.
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Introduction

Design schools have over a period of twenty years increasingly incorporated computer aided design into studio and non-studio subjects. In some schools, the technology may be introduced within an isolated course in order to give students a jump on the job market of entry-level computer based drafting positions. In other Schools, an intensive integration of computers within design studio and research courses has been more completely realized. A demographic change may be occurring where greater numbers of teaching faculty are skilled at harnessing computer technology to design. Yet, it is not clear if the basic structure of a design education program needs to fundamentally change in order to fully realize the new opportunities and changing perspectives offered by computer technology. This paper proposes a broad outline of computer related subjects that could be included in an architectural curriculum. It then examines two alternative curriculum models, one model that is set within the framework of a typical curriculum structure today, and a second model that displaces a greater number of traditional courses.

Assumptions

We do not wish to suggest that all Schools would take to the same path. Nevertheless, we believe it is possible to make some general assumptions about the growing use of computers in design education:

1. Computer based media and design methods will integrate into the background of most courses such that their basic use will no longer carry any special significance.
2. Specialized courses focused on the use of computer technology will still be needed.
3. The design disciplines no longer need to awaken to the use of computers, but there is still uncertainty over their place within the curriculum.

4. Computer studies contribute a "new" understanding of design as a knowledge-based profession.
5. Basic computer literacy is no longer a necessary objective of an architectural design curriculum [see citation of 1999 National Academy Press report under references].
6. Design school cultures have not necessarily shifted orientation from paradigms associated with traditional media to those that may now engage the distinct possibilities of working more effectively with computer based media.

Motivation – the eCAADe 2000 Roundtable

The paper follows up on a roundtable discussion held at eCAADe 2000 in Weimar, Germany co-chaired by Earl Mark, Rivka Oxman and Megan Yakeley. Some potential issues and objectives were identified in the eCAADe 2001 roundtable (from minutes provided by Thomas Seebohm). They were to strengthen or introduce algorithmic aspects/skills into design (Robert Aish), address social contexts with respect to the distribution of computer resources (Robert Johnson), review the computer as a vehicle for strengthening design communications and collaboration, and consider the changing place of information designers in society (Urs Hirschberg), get beyond the limits of thinking in terms of computer based subjects and enhance the theoretical understanding of design (Rivka Oxman), consider the revolutionary aspects of the technology in education (Antonino Saggio), review what subjects may need to be displaced to make greater room for computer based courses (Michael Mullins), further develop the "how" of making computers an integral part before making too many assumptions about change (Oren Lieberman), challenge assumptions about the foundations to architectural knowledge (Martha LaGess), review the unique concerns and talents of the faculty as a guide to computer integration in distinct academic settings (Bob Martens), consider early childhood development and other educational theories as a model for curricula change (Megan Yakeley), recruit practitioners who have more intuitive knowledge (Jinyeu Tsou), look to establish rigor in relevant critical thinking skills which goes beyond introducing the technology (Earl Mark).

We offer a snapshot of what we think an architectural curriculum could be, and yet realize that each of the round-table topics from eCAADe 2000 may need closer consideration. For example, if we consider the role of information designers in society, then does an architectural curriculum need to serve a broader set of career paths than can be supported under the constraints of professional accreditation requirements? We have not set out to re-align wide subject areas or redefine the architectural discipline, but find more compelling a wholesale integration of computers into the framework of a time-honored architectural education sequence.

Discussion Points in Digital Design Curricula

This position paper takes a leap of faith by proposing a specific course sequence for a complete architectural design curriculum. The following discussion points are suggested for the eCAADe 2001 round-table:

1. How can educational philosophy clarify the type of integration that should be achieved?
2. Are new types of design courses needed to relate to the emerging technologies (e.g., information architecture, information visualization, interface design, etc. in an integrated environment)?
3. Are new types of theory courses needed that account for computer based design methods (i.e., "algorithmic thinking" or "knowledge-based design" approaches versus the traditional studio workshop approaches)?

Specific Subjects Areas

The following subject areas are incorporated into the two curriculum models of the appendix. They are specific to advancing computer use in architectural design and are differentiated in three levels (A-C), representing the idea of an educational pyramid with a large base:

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A – Basic Level

A1 – Digital Design Media - This subject area covers a broad set of computer based design applications at an introductory level, including interactive communications (web page development), basic geometrical modeling, digital image processing, and mixed media productions that involve the use of digital video, scanning and output media. Learning universal principles and basic concepts serves as the main focus. within the context of Information Technology (IT) related to architectural design education. Furthermore mMethodological issues will beare counteredexamined, including exercises on the nature of physical and virtual space (as well as current "hypes", such as Cyberspace, Virtual Reality, etc.). In this framework on one hand individual m.). Individual and edia will be examined isolated but on the other hand also in series: multimedia applications are explored. The function of design media in an explorative way mediamay lead to a knowledge base farmay embed an interactive knowledge base that moves beyond the blimitations oundaries of plain simple illustration.

B – Intermediate Level

B1 – Geometrical Modeling and Rendering - This subject area examines the full spectrum of three-dimensional modeling and rendering applications from a beginning to an advanced level, including color theory, image processing, digital terrain modeling, and basic animation. It includes the handling of file management (intelligent naming convention etc.) and data conversion (import and export).

B2 – Digital Media and Drawing - This subject area explores the relationship between photography, two-dimensional drawing and digital media, including technical issues of scanning, image resolution, color models, and file formats.

B3 – Structural Analysis - This subject area examines the full spectrum of structural analysis tools, including Finite Element Modeling and other advanced simulation techniques.

B4 – Digital Moviemaking and Animation - This subject area explores moviemaking as a way to critique or forward design propositions. The use of a narrative or storytelling is considered. Special attention is given to panoramic projections.

B5 – Computables of Design - This subject area explores the quantitative basis and invisible geometrical order of shapes found in nature and architecture as explored through writing computer programs. The use of (evolutionary) algorithms within a morphological context is treated as a powerful input towards the digital generation of form. (B1) Modeling and Rendering - This subject area examines the full spectrum of three-dimensional modeling and rendering applications from a beginning to an advanced level, including color theory, image processing, digital terrain modeling, and basic animation. It also includes handling of file management (intelligent naming convention etc.) and data conversion (im- and export).

B6 – Spatial Simulation Techniques – This subject area considers the appropriate use of digital verses analog techniques, which can enhance the depth of evidence and the realistic content of a design "under construction". Interactive experimentation is used extensively. Ample scope is given to parallel techniques such as stereography, endoscopy and holography as a means to record three-dimensional scenes with respect to different points of view. "Hands-on construction" such as that in wood/metal workshops is not treated as a goal in itself but as a mean to explore full-scale models. Furthermore the transfer between digital and analog representations is tested.

C – Advanced Level

C1 – Computer Aided Manufacturing and Robotics - This subject area considers the possibilities of numerical control processing, rapid prototyping and building component manufacturing. Developments of (digital) form generation find their completion in physical products.

C2 – Digitalization of the Third Dimension – This subject area focuses on three-dimensional scanning of physical models resp. objectsobjects, which leads to an accurate three-dimensional digital source for the creation and further development of complex geometry.

C3 – Laser Surveying and Photogrammetry - This subject area explores the range of ccomputer applications that provide photo-realistic and accurate three-dimensional models to be constructed from field data and sites.

C4 – Performance Simulation: Energy - This subject area examines the use of particle flow analysis and energy simulation software, HVAC design software, and other computer applications used to evaluate, analyze and solve the heating, cooling and air handling needs of buildings.

C5 – Performance Simulation: Digital Acoustics and Synthesis - This subject area examines topics in digital acoustical analysis and simulation as a specialized area within the design disciplines.

C6 – Performance Simulation: Artificial and Daylight Representation – This subject area examines light analysis in different stages of the design process. Specialized lab installations such as an artificial sky are also examined.

C7 – Digital Technology and Communications Media - This subject area explores asynchronous and synchronous communications based on a dynamic mix of digital design media. Collaborative teamwork with remote participants within a Virtual Design Studio serves as a basis for testing design alternatives. Communication relies on video conferencing. (C5) Performance Simulation: Energy - This subject area examines the use of particle flow analysis and energy simulation software, HVAC design software, and other computer applications used to evaluate, analyze and solve the heating, cooling and air handling needs of buildings.

C8 – Computation of Construction – This subject area explores the computational relationship between structural engineering and architectural design. The use of infinite elements is a topic that could be explored at an advanced level.

C9 – Geographic Information Systems - This subject area examines the use of polygon overlay technologies for site analysis and area information management, possibly extended to space planning and facilities management.

C10 – Spatial and Data Analysis Methods– This subject area explores the setup and implementation of relational databases as a design aid. Cost estimations serve in this context as a case study.

Subject levels A through B are not untypical of what a progressive program may offer if not require of its students. Subject level C identifies additional technologies that may be beyond the scope of a typical design education, but may be found in some Schools.

One challenge that such a broad set of topics creates is to overcome the constraints imposed on curricula by professional accreditation guidelines. If the target student population is engaged in studying architecture, then a typical program with distribution requirements in the liberal arts and other areas might severely limit the number of new courses that can be added to an already packed course sequence.

Conclusion

We believe a change in design culture with respect to computers may be possible only if the incorporation of the technology occurs in areas that have direct bearing on what we care about in architecture. The first curriculum model in the Appendix below provides for a coupling of time honored architectural courses with computer related subject areas. We seize upon the magic and creative potential of the studio to incorporate and most effectively respond to shifting methods towards design, but at the same time, believe that change is not possible unless the external courses that a design studio draws upon are also changed.

The second curriculum model in the appendix demonstrates what occurs if more computer subject areas are embedded within an undergraduate curriculum as independent courses. However, there

is little room left for a typical design studio sequence or the standard courses associated with architectural design. Such a curriculum could be well placed within the design and visually oriented culture of an architectural school, but would not likely prepare students well for a career in architecture as the profession is likely to demand.

We think it is essential that an architect's education continue to be focused on issues of building and place. We therefore favor the first curriculum model for architecture students, and we see the second curriculum model as potentially serving separate design interests outside of the field of architecture.

References

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Appendix

In the first curriculum model, two of the computer-related subjects are required and the remaining ones are incorporated into studio and required courses, or are available as open or architectural elective courses. Letters *(A1), (B1)*, etc. in *italics* indicate where computer subject areas have been integrated into an existing course. The required computer courses from the list above are underlined in upper-case ITALICS, e.g., *COURSE B1*. In the second curriculum model, more of the computer related subjects are required, but many standard architecture courses are displaced. The undergraduate program shifts more substantively from a professional design education. A comprehensive thesis project in digital media concludes the second curriculum model sequence.

Curriculum Model I

1st Year

First Semester

ARCH 101	Fundamentals of Design: Architecture as a speculation on origins *(A1)* 3
AR H 101	History of Architecture: Ancient to Renaissance 3
ENWR 101	Accelerated Academic Writing 3
_____	Humanities/Science elective 3
_____	Open elective 3

SUB-TOTAL 15

Second Semester

ARCH 102	Fundamentals of Design: drawing and the visual arts *(A1)* 3
AR H 102	History of Architecture: Renaissance to Modern 3
MATH 101	Applied Calculus or Calculus I 3
ENLT ___	Literature elective 3
_____	Open elective 3

SUB-TOTAL 15

2nd Year

First Semester

ARCH 201 Introduction to Architectural Design: Formal analysis, synthesis *(A1,B2)* 4
PHYS 201A Architectural Physics: Applications of physics to architecture 4
LAR 101 History of Landscape Architecture: Ancient Egypt, 16th - 20th Century 3
_____ Humanities/Science elective 3
_____ Social Science elective 3
SUB-TOTAL 17

Second Semester

ARCH 201 Introduction to Architectural Design: Formal analysis, synthesis *(A1,B2)* 6
AR H ___ Arch. History elective 3
_____ Humanities/Science elective 3
_____ Social Science elective 3
SUB-TOTAL 15

3rd Year

First Semester

ARCH 301 Architectural Design: Building, site, total technology integration *(B1,B2)* 6
ARCH 302 Building I: Construction, materials and their practical assembly *(C1)* 3
ARCH 303 Architectural Theory and Ethics: Critical writing, philosophy, aesthetics 3
COURSE B1 *Geometrical Modeling and Rendering 3*
SUB-TOTAL 15

Second Semester

ARCH 302 Architectural Design Building, site, technology integration *(B1, B2, C2, C4)* 6
ARCH 304 Environmental Control Systems and Lighting *(C4)* 4
COURSE B3 Introduction to Structural Design 4
_____ Open elective 3
SUB-TOTAL 17

4th Year: Architectural Design Concentration

First Semester

ARCH 401 Architectural Design: complex programs, intermediate scale *(B1, B2, C2, C3)* 6
_____ Architecture elective 3
_____ Architecture elective 3
_____ Open elective 3
SUB-TOTAL 15

Second Semester

ARCH 402 Architectural Design: Comprehensive studio *(B1, B2, C1 - C7)* 6
ARCH 403 Building II: ethical responsibilities, social and political issues 4
_____ Architecture elective 3
_____ Open elective 3
SUB-TOTAL 16

TOTAL CREDITS 125

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Curriculum Model 2

1st Year

First Semester

ARCH 101 Fundamentals of Design: Architecture as a speculation on origins *(A1)* 3
AR H 101 History of Architecture: Ancient to Renaissance 3
ENWR 101 Accelerated Academic Writing 3
_____ Humanities/Science elective 3
_____ Open elective 3
SUB-TOTAL 15

Second Semester

COURSE A1 *Digital Design Media 3*
CS 201 Software Development Methods 3
MATH 101 Applied Calculus or Calculus I 3
ENLT ___ English elective 3
_____ Humanities/Science elective 3
SUB-TOTAL 15

2nd Year

First Semester

COURSE B1 *Geometrical Modeling and Rendering 3*
PHYS 201A Architectural Physics 4
COURSE B2 *Digital Media and Drawing* 3
_____ Humanities/Science elective 3
_____ Social Science elective 3
SUB-TOTAL 16

Second Semester

COURSE B4 *Digital Moviemaking and Animation 3*
COURSE E5 *Computables of Design 3*
_____ Humanities/Science elective 3
_____ Natural Science elective 3
_____ Social Science elective 3
SUB-TOTAL 15

3rd Year

First Semester

COURSE C5 *Performance Simulation: Digital Acoustics and Synthesis (or C5, C7) 3*
COURSE C7 *Digital Technology and Communications 3*
ARCH 308 Architectural Theory and Ethics 3
_____ Architecture elective 3
_____ Open elective 3
SUB-TOTAL 15

Second Semester

COURSE C1 *Computer Aided Manufacturing and Robotics 6*
_____ Open Elective 3
_____ Open elective 3
_____ Open elective 3
SUB-TOTAL 15

4th Year: Architectural Design Concentration

First Semester

ARCH 404 Thesis Research Seminar 6
_____ Architecture elective 3
_____ Architecture elective 3
_____ Open elective 3
SUB-TOTAL 15

Second Semester

ARCH 405 Comprehensive Thesis Project 10
_____ Architecture elective 3
_____ Open elective(4) 3
SUB-TOTAL 16

TOTAL CREDITS 122