ADAPTING DIGITAL TECHNOLOGIES TO ARCHITECTURAL EDUCATION NEEDS

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Abstract. Adapting digital technologies to architecture school settings is a topic of universal interest. Properly construed, adapting digital technologies to architectural education emanates from philosophical underpinnings. For architectural programs, the scientific-artistic attribute notion can be a powerful reference for mapping program mission, goals, and curriculum. A program plan developed with scientific-artistic attributes of performance in mind can tap on the use of digital media from the perspective that the media has scientific-artistic characteristics itself. Implementation of digital technologies adaptation can be challenged, among other things, by scarcity in resources. This paper focuses on the role of digital equipment resources in adaptation. A case in point is the use of digital technologies at the Architecture and Environmental Design Studies (Arch/EDS) Program of Bowling Green State University. The study considered the utilization by the third and fourth year design studio students of the digital resources at the Center for Applied Technology, a College based, but University wide serving unit. The objective of the study was to build up a theoretical understanding of the adaptation problem and come up with strategy guidelines for adapting digital media resources to architectural education. A survey of students and interviews with the Center's personnel were methods used to collect data. The study has placed the adaptation problem in a philosophical context, turned out a set of theoretical generalizations about digital utilization, and suggested strategy adaptive guidelines. Beyond facilitating adaptation specific to the Arch/EDS Program, the results of the study are bound to affect digital adaptation in a general sense.

1. Introduction

Digital technologies have been introduced into architecture education probably in ways as diverse as the number of schools that considered them.

Although some hold that hand drawing will preserve its place in future (Basa and Senyap 2005, p. 269), the digital lure continues to fuel the debate worldwide on the rationale and strategies for adapting digital technologies to architecture school settings. Ehn (1998) advocated instilling in students the spirit of exploration, learning, and incorporation of new digital technologies. Kurlansky (1998) went further to stress the value for students to explore the impact of different digital tools on their thinking and communication processes. The result is a bewildering gamut of experiments, models, and "adjusted" thoughts on the subject applied with varying degrees of success. On one end, we find schools with modest thought and resources given to digital technologies, perhaps in the form of a few computer units confined to drafting applications; on the other end, we find schools with eminent planning and resources dedicated to digital design studio with top-of-the-line applications.

Self-assessment of the place of any school of architecture in the digital world is presumed. All schools are to face the challenge of closing the gap between their digital needs and available resources. Acquiring resources helps close the gap; however, the manner in which the resources are used is equally important. A case in point is the use of digital technologies at the Architecture and Environmental Design Studies (Arch/EDS) Program, a unit of the College of Technology at Bowling Green State University. Students in the Program are required to complete two computer applications courses, one is mechanically oriented and the other is architecturally based. An elective course in computer modeling and visualization in architecture is also available. This study does not address such courses in particular; rather, it turns our attention to the availability of a set of digital technologies, such as powerful scanners and printers, for design project presentation purposes and the way these instruments have so far been used to support students' project presentation materials.

A space reallocation in the College of Technology three years ago resulted in moving the upper level design studios of the Arch/EDS Program to the ground floor of another building on campus and also in moving the Center for Applied Technology, a College entity, to an adjacent space on the same floor (Figure 1). The reallocation was based on the expanding space needs of the College rather than on the working relationship between the Arch/EDS Program and the Center.

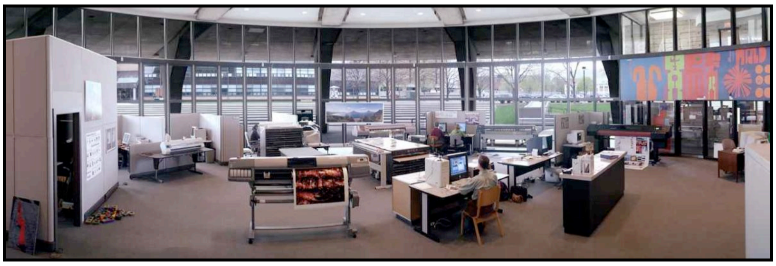

Figure 1. Comprehensive view of the Center's space and equipment

However, architecture students in the third year and fourth year studios operating in the new space have been exploring and gradually tapping into the Center's digital capacities in laser cutting, prototype modeling, printing, and scanning primarily to produce design project outcomes in the form of presentation boards and physical models. Available to the public at large, the Center services provide: a) laser cutting and engraving of a variety of boards and materials using 2D image files or line drawings, b) rapid prototype physical modeling generated from 3D programs, c) large format inkjet printing up to 72" width on a variety of materials, and d) high resolution scanning for originals up to 36"x48".

Driven to realize its own growth objectives, the Center's personnel has lent a hand to students on an individual, ad hoc basis. The students' growing aptitude for using digital tools, on the one hand, and the Center's incessant updating of digital technologies, on the other, has begun to reveal insufficiencies in the mode of service. For one, it is no longer viable for the Center to continue operating on a sporadic, uneven assistance mode to students. Secondly, students' access to the service only partially taps the full potential of the available technologies. In the midst, the architecture faculty members have tended to keep at bay, more of passive, but restless, observers—trying to grasp the situation.

There is a growing understanding among all parties, especially the faculty, that an opportunity exists to bring the architectural curriculum in general, and the upper design studios in particular, into a more harmonious and productive relationship with the Center's digital resources. Out of this understanding, the objectives for this study were set as follow:

- To place digital adaptation problem in a philosophical context
- To examine the Center for Applied Technology's digital technologies and their capabilities
- To review the manner in which the technologies have been used by architecture students
- To develop theoretical basis and strategy guidelines for adapting digital technologies to architectural education needs

Besides our own observation on the utilization of the Center's digital technologies, we had conducted a survey for the third and the fourth year students as a source of data for the study. Further, we had conducted interviews with the Center's leading personnel. It is to be noted that all figure images in this study were courteously provided by the Center for Applied Technology. Further, the Center provides online information on its digital equipment (The Center for Applied Technology 2005).

2. Philosophical Context of the Adaptation Problem

Properly construed, adapting digital technologies to architectural education emanates from philosophical underpinnings. The belief that digital methods are efficient and supportive of creative endeavours has long been established. What remains unclear is the question of how to tap on digital media to support academic objectives. In this regard, the ever-changing, more enabling nature of the media poses difficulties. The core challenge, however, lies in formulating strategies and charting modalities for taking advantage of the media. Consummating such strategies and modalities springs, in one outlook, from diversity of tools, and subsequently from versatility of use, of the digital media and computational methods: prescriptive and predictive on one end; discretionary and creative, on the other.

Curricular needs, in substantive and methodological learning terms, can be contemplated through the all familiar "scientific-artistic" spectrum notion. Curricular schemes with "appropriate" measures of scientific (prescriptive and predictive) and artistic (discretionary and creative) components vary widely. For example, while physics is bluntly scientific in content, it can be taught with degrees of creativity. On the other hand, while painting is creative in intent, it can be taught with some degree of systemic guidance. Turning to architecture as a discipline of learning, we find more of a scientific-artistic balance in its makeup, substantively and methodologically.

For architectural programs, the scientific-artistic notion can be a powerful reference for mapping program mission, goals, curriculum, down to individual course assignment—with a concomitant impact on program assessment. A program plan developed with scientific-artistic attributes of performance in mind can tap on the use of digital media from the perspective that the media has scientific-artistic characteristics itself. Stated otherwise, adapting digital technologies to architectural education needs can take place within the framework of the proposed scientific-artistic model.

To succinctly illustrate the use of the model in an architectural curriculum, two common, but pivotal, areas of design studio activities are considered: generating design and representing design. How do these two areas fair on the scientific-artistic scale? Which area hangs closer to one end of the spectrum or the other? Each area pondered separately, which aspect—of several—for the area is more prescriptive? Which aspects are more creative? Which digital tools are appropriate to use for enhancing the orientation (prescriptive or creative) of the element in question? The depth and breadth of the analysis are, of course matters defined by the concerned faculty.

Implementation of digital technologies adaptation can be challenged, among other things, by scarcity in resources and expertise. This paper focuses on digital resources, and in this framework, on the use of digital production equipment by the third and the fourth year design studio students of architecture at Bowling Green State University.

3. The Center's Digital Technologies and Their Capabilities

The digitally based functions that the Center administers are introduced below through the equipment name and type, equipment capabilities, and the operational context. Observations on the students' access and use of each function are also made.

3.1. LASER CUTTING AND ENGRAVING

The M-300 Laser by the Universal Laser Systems is the main piece of equipment that supports the cutting and engraving function (Figure 2). The machine is controlled from a computer work station using Corel Draw, a software provided by the system supplier. Other software, with varied capabilities, can be used. The machine handles a variety of materials including wood, art board, brass, and glass with some variations in effectiveness. The 24"x12" size of this machine's bed limits the subject boards to be cut or engraved up to this size.

Figure 2. The laser cutting and engraving machine (left) and cut products (right)

Students have access to the M-300 Laser system from 8:00 am to 5:00pm during the five working days of the week. Because of the popularity of this device, its use is regulated by a signup list, for one-hour blocks of access per request. Architecture students so far make the bulk of the clientele, and because of the unit organizational relationship, these students are given priority of service. Students in the nearby School of Art are becoming more and more active users as they continue to discover the potential of the machine.

Making the M-300 Laser system available for use is not without difficulties to both the students and the Center's personnel. Curious to explore the system and driven by an interest in taking advantage of its capabilities, first-time students soon realize difficulties in developing an operational facility with the machine. The Center's personnel provide guidance to student users as their time permits. However, because of inadequate staffing, such guidance is meager at best, and, accordingly, the students are left to their own devices to achieve their learning aims.

3.2. RAPID PROTOTYPE PHYSICAL MODELING

The Model 2402 Rapid Prototyping Printer by Z Corporation (Figure 3) builds up physical models through printing (adding) thin layers of plaster powder or starch material. The machine uses the software Z Print; the software reads CAD or other 3D files in the Stereo Lithography Text Language (STL) format and sends them to the printer. Somewhat demanding in preparation, operation (printing), and cleaning, the machine produces rather limited model sizes, confined to 8"x8"x12" envelope. A model of this size runs into hundreds of dollars in cost, a reason why the machine use by student is rare. As modeling and prototyping is becoming an approach for architectural design in which stages between conceptualization and construction tend to collapse (Mandour, 2004), the excessive utilization costs of the rapid prototype machine has a depriving effect on learning new skills. However, the machine 3D modeling capabilities is attracting users from other units of the university, such as the School of Art's Sculpture Program and the Department of Chemistry, especially for projects that have funding. A promising technique for architecture, rapid prototype modeling found it's way in critical applications such as fabricating the mould for artificial bioactive bones (Chen et al. 2004, p. 327). Kieran and Timberlake (2004) lamented architects for using computers mainly in 2D drafting and 3D rendering instead of developing solid modeling capacity through such systems as rapid prototyping.

Figure 3. The rapid prototype modeling machine (left) and a product model (right)

3.3. LARGE FORMAT INKJET PRINTING

The HP 5000 is the main and the mostly used printer in the Center. Usually operated by staff, it prints up to 72" width on a variety of materials. Because of the versatility of the materials that can be used for printing (vinyl, fabrics, fine art paper, etc.), this equipment is more utilized by the fine arts students than any other student group, including architectural students. Other smaller printers with specialized use also in operation at the Center including Colorspan Mach 12 and Series XII and Mimaki JV4 and TX-1600.

Figure 4. The large format inkjet printing machine

3.4. HIGH RESOLUTION SCANNING

The Cruse CS 155 ST is a well known scanner of the Center. It is capable of scanning 36x48 inch images in one operation. The CREO Eversmart Supreme, another scanner, has a scanning area of 12x17 inch. These scanners have been helpful for architectural students who want their large drawings scanned before reducing them to a portfolio format.

Figure 5. High resolution scanning machine

4. Assessing Students' Access and Utilization of Digital Technologies: the Survey

The interface of students' needs with the Center's resources generated modalities for accessing and using available digital technologies. To assess in more certainty the access and utilization of the resources by students, a survey questionnaire was the basic instrument employed. The discussion below includes descriptions of the attributes and questions of the survey instrument and a comparative analysis of resource utilization by both classes.

4.1. SURVEY ATTRIBUTES AND QUESTIONS

A survey questionnaire was the basic instrument for assessing the use of digital technologies by students. The questionnaire contained ten questions revolving around attributes deemed relevant to the characterization of the use of technologies. The opening question addressed the student standing, junior or senior. The final question invited student open-ended comments on any matter relating to the digital technologies. The eight intervening questions addressed the following attributes:

1. Frequency of access and utilization of the four main equipment (four questions)
2. The source through which the student had learned the use of two pieces of the equipment (selected based on an assumed most heavily used equipment; two questions)
3. The level of importance that the student attach to the use of the technologies for increasing his or her technical skills (one question)
4. The nature of cost that the student ascribes to using one particular piece of equipment (selected based on the assumed high cost of this piece use; other equipment costs were not considered because either they are, up to now, free of charge for architectural students (Laser Cutter) or because the cost is too prohibitive to begin with that hardly any contemplates using it (Rapid Prototype); one question)

4.2. COMPARATIVE ANALYSIS OF UTILIZATION: THIRD YEAR VERSUS FOURTH YEAR

Handling survey attributes individually, students' responses on access and utilization have been summarily compared and comments were made on the comparison.

1. Frequency of access and utilization of the four main equipment

Third Year	*Fourth Year*
30% indicated "a Lot," "Some," or "Rarely." 70% indicated "None."	62% of participants indicated "A Lot" or "Some"

Comment: The extensive utilization by fourth year students and modest utilization by third year students reflects the effect of student opportunity and maturity on utilization.

2. The source through which the student had learned the use of two pieces of the equipment

Third Year	*Fourth Year*
Regarding Laser Cutter: 40% of participants responded. 81% (9 responses) indicated "Peer Student" and 19% (2 responses) indicated "Faculty." Regarding Rapid Prototype machine: *4% of participants responded (1 response)* indicating "Supervisor at CAT."	Regarding Laser Cutter: 100% of participant responded. 77% indicated "Peer Student"; and 23% indicated "Supervisor at CAT" and "Faculty" combined. Regarding Rapid Prototype machine: 40% of participants responded. 22% of responses indicated "Peer Student"; 33% indicated "Supervisor at CAT"; 44% indicated "Faculty".

Comment: The extensive responses by fourth year students and modest responses by third year students reflects the effect of student opportunity and maturity on utilization. The third year's lower responses indicate no learning had occurred relating to the operation of this machine. For both groups, "Peer Student" is the definite source of learning. The complexity of the Rapid Prototype machine made it more handy to be utilized by fourth year student, and hardly by third year students.

3. The level of importance that the student attach to the use of the technologies for increasing his or her technical skills

Third Year	*Fourth Year*
65% indicated "Very Important"; (23%) indicated "somewhat important".	81% indicated "Very Important"; 19% indicated "Somewhat Important"

Comment: There is a clear appreciation for the importance of digital technologies by both groups, although this is stronger in case of the fourth year students.

4. The nature of cost that the student attribute to using the Large Format Ink Jet Printer

Third Year	*Fourth Year*
66% of participants responded. 66% of respondents indicated "Too Much"; 34% indicated "Reasonable" or "Fair"	36% indicated "Too Much"; 36% indicated "Reasonable"; 28% indicated "Fair" and "Very Affordable" combined

Comment: The third year students' lower responses reflect their unfamiliarity or non-experience in using the machine. The third year perception of cost is skewed in the "Too much" level; the fourth year perception of cost is much more even, and can be more reliable.

5. Theoretical Generalizations and Strategic Directions

Our direct observations of the Center's resource utilization, understanding of the survey results, and quest for a congruent digital integration into architectural education led us to some theoretical generalizations and strategy guidelines for the utilization of production digital resources in particular, and the digital technologies in general. The theoretical generalizations provide a background for the strategy guidelines.

5.1. THEORETICAL GENERALIZATIONS

The theoretical generalizations are associated with faculty, students, and the supporting unit (the Center), and explained below in the context of the Center's digital resource utilization.

5.1.1 Faculty is the Source of Digital Utilization

Being a response to studio project assignments, all the student work that flows into CAT is, to a great degree, influenced by instructors' expectations of the final, representation products. Such expectations gear students to use the digital resources excessively or lightly. As a way of example, project presentation requirements may allow manual drafting, with no digital production; plotting on a standard CAD plotter; or modeling by a sophisticated prototype printing machine. The implication for the level of digital utilization in the three cases is widely different.

Faculty members' role in taking advantage of digital production tools is an extension of their individual and collective responsibility towards their programs. Digital utilization in design studios permeates for pre-production (drafting and design) tasks and is becoming so for design outcome production tasks as well. The ideal service of the faculty of any unit to the curriculum they are entrusted with is to collectively give a serious scrutiny of the abounding digital opportunities and to chart strategies for filtering in the opportunities that further curricular objectives. Guided by strategic bearing, individual instructors will be in a better position to anticipate the digital needs in their studio. In absence of a collective outlook, individual instructors remain to navigate their way regarding how to put the available digital resources in service of their studios and classes. It is still a responsibility each has to reckon with.

5.1.2. Students Are a Measure and an Instrument for Digital Change

At the receiving end in the instructional milieu, students are prompted to action by the nature of studio assignments. They proceed to capitalize on whatever digital resources are available despite the fact that they are left to their own devices in inadequately supported digital settings. Inundated to begin with by a myriad of academic and non-academic trepidations, students grow more and more concerned about having to deal with such inadequately supported settings.

The survey questionnaire we have administered to the 49 third and fourth year studio students was—particularly through the responses to the open comments question—instrumental in measuring digital service inadequacies (or adequacies) in the eye of students. The students focused on three areas of concern: a) availability and accessibility of the technologies, b) orientation and training on the technologies, and c) affordability of the services. Primarily centered on time, the availability concerns were voiced through suggestions for 24 hour accessibility, extended hours, or weekend hours. Some comments reflected pressing desire for shrinking the three day normal order service, especially for the large format printing. Some other comments focused on the need for larger size bed for the laser cutting machine or adding another machine. It is of notice that a number of responses suggested adding CAD plotting machines (to the two already exist on other premises) although the questionnaire was meant to measure the digital technologies utilization at the Center's grounds. All in all, many more responses were received from fourth year students compared with third year students, which reflect the first group's longer experience in the utilization of digital equipment.

The other two areas of concern were less emphasized. The area pertaining to orientation and training on the technologies was marked by suggestions for training sessions, more knowledgeable staff, and information explaining the use of machines. These suggestions came primarily from junior students, which reflect this group's limited experience in using the digital equipment. The area pertaining to affordability of services was marked by suggestions for reducing costs to students.

The students direct involvement with digital equipment makes them not only a measure for digital resource adequacy (or inadequacy), but also an instrument for digital utilization improvement. This is possible in their capacity as peer "teachers". A clear majority of our survey respondents in both student groups indicated "Peer Student" as the source of learning. The role of student as a learning facilitator is not necessarily uncommon in reflective architectural environments, but here it is marked in its effectiveness.

5.1.3. Digital Centers Have Curatorial Function

For university supporting units, like the Center for Applied Technology, client service is a part of the unit's mission. The unit's staff would seek student users' satisfaction through running efficient, safe, and financially viable operations. The interviews completed with the Center's leading staff in connection with this investigation established that the Center's concerns are, in many ways, parallel to those of students, but of course from the unit's perspective. Having a regular working day hours, the Center regulates the access and utilization of most popular machines, such as the laser cutter, through a signup list for specific time slots. Receiving repetitive questions and providing repetitive help to individual students, the Center's staff is very much aware of the need for a training program, and actually has plans to offer student training workshops. Aware of the unwieldy manuals for the machines that are directly accessible to students, the Center issued a few user's guiding sheets. The price structure for different services is well defined, with a graduated scale for student, university personnel, and external clients.

5.2 STRATEGY GUIDELINES

Developing strategies for adapting digital technologies to architectural education needs is an ambitious, but a tedious objective. Tediousness stems from not only the difficulty in determining the needs, but also from the changing nature of such needs. With this understanding, the utilization of the Center's current digital technologies by students seems too specific a topic of investigation in its contextual and temporal references. Developing utilization strategies with assumed unchanging nature of the technologies (types, number, etc.) and fixed needs of student users will work just for a short while. On the other hand, developing strategies with assumed changes in the technologies and users' needs will work much longer. Developing strategies for technology utilization will best be considered under the following guidelines:

- Considering architectural education thought on integrating digital media.

- Expecting erratic digital change.
- Recognizing the interests and collaborations of faculty, students, and the digital unit personnel.
- Building in flexibility in planning and scheduling.
- Adopting digital planning and assessment on a cyclic basis.
- Conducting on-going digital training program.

The training program, in particular, could incorporate topical workshops, on-line tutorials, and a mentor program. The latter could benefit from the relationships of the parties involved in the digital game to have: unit staff mentor students or faculty, faculty mentor students or faculty, and students mentor students.

6. Conclusions

This study dealt with a specific context of digital technologies utilization involving 49 third and forth year architectural design students, the Center for Applied Technology resources, and the faculty. The study has sufficiently identified and described the Center's resources, the manner in which the technologies have been used by architecture students, and the challenges to students and the Center's staff. Prompted to meet such challenges, the study looked into adapting digital technologies to architectural education in a general sense. For the adaptation, it was necessary first to place the adaptation problem within a philosophical context and propose a set of theoretical generalizations about digital utilization which served as a foundation for more specific discussion on strategy guidelines for digital utilization.

The results of this study will contribute to the adaptation of digital technologies to architectural education in a number ways. Facilitating adaptation specific to the Arch/EDS Program, the results will, more importantly, cast light on possible strategies for effecting digital adaptation in a general sense—anywhere. Further, the results provide a precedent for augmenting strategy guidelines on the assumption that a holistic, long range plan for integrating digital tools in architecture studio is appropriate.

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