THE MINIMUM THRESHOLD OF INFORMATION TECHNOLOGY SKILLS IN ARCHITECTURAL DESIGN PRACTICE

Empirical IT Benchmarks for Architectural Design Practice and Education

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Abstract. This paper describes what information technology skills are required in current architectural design practice. With the integration of new information technology, the new horizon of design practice offers opportunities for global, interdisciplinary work as well as new interpretations of the design and construction processes. In this context, some benchmarks of information technology literacy for practitioners and educators are defined through case study.

1. Introduction

The objective of this research is to verify the minimum requirements of knowledge and skills in information technology that are necessary for current and future architectural design practice. It is also intended to give some benchmarks to instructors who teach architectural students at design institutions. In this research, they are examined through investigation of architectural design firms in the US and in Japan that are listed in table 1.
1.1. RESEARCH METHOD

This research is a part of my doctoral research on recent collaborative architectural projects. With the integration of new information technology, the nature of collaboration within professional architectural practice is being altered. Therefore, there is a need to define information technology skills necessary for proficient architectural design practice.

The cases studied involved interdisciplinary design and construction participants from separate and sometimes geographically distant organizations collaborating to define project needs and goals, develop a common design language, and make the design reality. Recent advances in affordable information technologies have provided new opportunities, not only for design and coordination tasks but also for global collaborative work. The technology may enhance design practice by creating new settings that take advantage of opportunities to build and sustain a diverse design organization. The cases examine the necessary skills for the architects and for the project managers to work in this information technology-mediated collaborative environment.
2. Case Study

The cases were selected for exploratory research regarding knowledge and skills in information technology because of:

- their relevance to the research being pursued,
- their schedule, which permitted the study to cover the entire design process and preferably the construction process,
- and the accessibility of critical resources.

The case study methodology mainly consisted of interviews, in person, via phone, and via email, and secondarily relied on literature reviews.

3. Information Technology Applied to Architectural Design Practice

The application of information technology in architectural design is divided broadly into two categories: design tasks and coordination tasks. In addition, as found in the MIT Stata Center case, the coordination tasks are classified into two modes: design mode and construction administration mode.

3.1. DESIGN TASKS

Design technology (information technology applied to design tasks) is a rapidly advancing part of the architectural design discipline, and it is a challenge for the architect to cope with this change. The case study projects reveal that two-dimensional (2D) CAD is a commonplace and, for the recent projects, that the design is often visualized in three dimensions.

Although some of the cases studied, such as the Grand Louvre, are somewhat older projects, they employed CAD because it was not possible to carry out the project without using information technology. The Grand Louvre, in particular, used 3D visualization to justify I. M. Pei’s pyramid design, which caused a polemic among the French. 3D models were also used in structural analysis of the pyramid carried out by Peter Rice and RFR and were used by the manufacturers for the Grand Louvre. Alfred Lerner Hall at Columbia University can be considered as an extension of this application of information technology. Its design was fully visualized in 3D, and for some parts, such as the glass brackets and steel frame of the bridge, the computer model was used for manufacturing.

3.1.1. MIT Stata Center

Gehry Partners, LLP (hereafter GP), use cutting-edge design technology in order to materialize the dynamic curves and complex geometry of the works of Frank O. Gehry, including the Guggenheim Museum Bilbao and the recently completed Stata Center at MIT. Figure 1 shows his technology-
mediated design process. Gehry has been breaking new ground in the use of 3D computer models. While his design process is very physically tactile, his sculpted figures necessitate exploring new methodologies including software, such as CATIA, and the firm’s organization has changed so that they can integrate design and production instead of outsourcing construction documents.

For GP, while no specific computer skills are officially required, most architects are fluent in AutoCAD, about a third are fluent in Rhinoceros, and a fourth in CATIA. In addition, about half of the architectural staff knows graphics programs such as Illustrator and Photoshop. According to Dennis Sheldon, holder of a Ph.D. from MIT and chief technology officer at GP: “People are pretty much expected to know AutoCAD 2D [two dimensions], or you can’t do production. Many junior people enter from school just on the basis of interesting design work and work in the physical modeling area. They need AutoCAD 2D to get to the next level, and we don’t teach it, so they are expected to either know it coming in or learn it somewhere.” GP teaches CATIA and Rhinoceros, although increasingly people come in with good understanding of 3D modeling. “The use of 3D modeling is not universal; you can get along well here without touching the 3D side of things directly, although that’s starting to change as the tools become more widely dispersed. This dispersion is partly due to management intention, and partly is just happening by virtue of the fact that more people have learned 3D and have an interest,” commented Sheldon.

3.1.2. MoMA
Architects of both firms involved in this project, Taniguchi and Associates and KPF, were required to have some information technology skills. At KPF, they varied a great deal, but everyone except the senior design and
management people are conversant with at least MicroStation and AutoCAD in two dimensions; two or three of the staff are good at 3D applications. Senior people have varying skills and are conversant with CAD, but do not necessarily use it on a day-to-day basis. Taniguchi’s office, where 2D VectorWorks skills are necessary for the design staff, had to learn MicroStation. For interorganizational coordination, the MicroStation data (*.dgn) was translated into AutoCAD data (*.dwg), except at one engineering firm that used MicroStation. Although no special computer-aided manufacturing (CAM) was used in this project, it is now part of the manufacturing process for many contractors, e.g. for curtain walls, perforated panels, etc.

An in-house designer at KPF also did virtually all of the 3D modeling and renderings in MicroStation. Whatever system the office uses, the current architect is required to have minimum skills in 2D CAD along with generic use of word processing and email. 3D modeling and rendering skills are becoming commonplace, though not strictly required yet.

3.1.3. Alfred Lerner Hall, Columbia University

Based on expertise that redesigned Columbia University’s Architecture program, Bernard Tschumi brought advanced computer technology for both visualization and production to this project. However, Gruzen Samton’s office, a New York-based design firm that formed a joint venture with Tschumi’s office, was in transition according to Timothy Schmiderer, associate partner of Gruzen Samton. For Gruzen Samton’s office, the cutting edge depends on the individuals on the team who are involved, but thanks to Tschumi’s influence computer modeling became a key tool in their office. “We were not at that same level, so I think that was one of the things that we learned from his office,” said Schmiderer. Working with someone who has different talents was a good facilitator for the project.

Gruzen Samton did most of the drawings in AutoCAD. They developed the design by starting with the conceptual work already in AutoCAD, and they developed the model as the project evolved. They did the plan and elevation studies, while Tschumi reinterpreted them in 3D form using formZ software. He used the 3D model very effectively in making the cast brackets, which were important components of the design because they resolve, within just a single piece, the problems resulting from the geometric complexity of the building. According to Tschumi and Dutton (2001), the actual casting process began with 3D computer modeling. The models were transmitted directly to the tool-and-die manufacturer to be made into molds. They used the

Figure 2. Cast bracket
lost-wax casting technique, whereby the mold tool was used to make a wax version of the piece, which in turn was coated to make a strong ceramic shell. The wax was then melted out of the shell and replaced with a pour of molten stainless steel. After grit blasting, the piece was machined for necessary bolting and threading connections. 3D models were also partially used for structural analysis by Ove Arup. They were used to evaluate the interactive behavior of the different structural components, and in particular the relative stiffness of the two different trusses and the ramps that they support.

Tschumi’s office used form·Z for the 3D modeling and renderings for this project. The architects in Tschumi’s office are skilled in various representation methods. The office uses AutoCAD on PCs for ordinary jobs, and almost all of the architects know both 3D and 2D software. However, the development and maintenance of their skills depends on their specific areas of work.

3.1.4. Engineering Project
On the other hand, an engineering project, such as Qatargas, employs full 3D models. Because of the size and complexity of the project, engineering firms have been using 3D CAD, such as Intergraph, for more than fifteen years, and the entire design and construction process has relied on 3D CAD.

3.2. COORDINATION TASKS

3.2.1. Design Mode
In the design mode, email is widely used for communication and exchanging design data as file attachments. Some still prefer fax for design dialogue because it is easier to send sketches and markups. Extranets are rarely used in the design mode. While the MIT Media Lab and MoMA projects initially employed FirstLine and Citadon respectively, both systems were terminated due to the then-slow connection speed. Instead, file transfer protocol (FTP) has been widely used, and the design firms host the FTP servers themselves.

3.2.2. Construction Mode
In the construction administration mode, people still rely on email and FTP for design information transfer. In addition, in this mode some projects, such as the MIT Stata Center, the One-Stop Center at the University of Cincinnati, and the MIT Brain and Cognitive Sciences Complex, involve extranets as construction management tools, at the initiative of project manager or construction manager. Coordination of the Qatargas project also significantly relied on information technology in order to design and build in a remote location that had no infrastructure.
4. Conclusion

This research has found that because AutoCAD is very common, architects are required to have knowledge of AutoCAD even when their firms use other systems. Architects at KPF, for example, are required to have at least 2D skills in AutoCAD, while their main system is MicroStation. Translation problems between the two systems are becoming less likely to inhibit collaboration, as long as the team has an appropriate transfer protocol.

Table 2 summarizes the minimum threshold of information technology skills for the architects of each firm, which is expected to present some indications for design practice and education. With the integration of manufacturing processes, more 3D knowledge is required in some aspects.

### Table 2. Minimum threshold of information technology skills for architects

<table>
<thead>
<tr>
<th>Firm/Company</th>
<th>Required Skills</th>
<th>Recommended Skills</th>
<th>Notes</th>
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<tbody>
<tr>
<td>1. Cannon Design (CRP)</td>
<td>AutoCAD Expert</td>
<td>AutoCAD Generalist</td>
<td>Some people don't necessarily use AutoCAD in the office.</td>
</tr>
<tr>
<td>2. KPF</td>
<td>AutoCAD Expert</td>
<td>None specified</td>
<td>Specifies no specific systems, only AutoCAD.</td>
</tr>
<tr>
<td>3. Cesar Sanna (CS)</td>
<td>AutoCAD Expert</td>
<td>None specified</td>
<td>Specifies no specific systems, only AutoCAD.</td>
</tr>
<tr>
<td>4. Colby Brothers (CB)</td>
<td>AutoCAD Expert</td>
<td>None specified</td>
<td>Specifies no specific systems, only AutoCAD.</td>
</tr>
<tr>
<td>5. Coors, Coors, Associates</td>
<td>AutoCAD Expert</td>
<td>None specified</td>
<td>Specifies no specific systems, only AutoCAD.</td>
</tr>
<tr>
<td>6. A and Associates</td>
<td>AutoCAD Expert</td>
<td>None specified</td>
<td>Specifies no specific systems, only AutoCAD.</td>
</tr>
<tr>
<td>7. Lee Wielenga (LW)</td>
<td>AutoCAD Expert</td>
<td>None specified</td>
<td>Specifies no specific systems, only AutoCAD.</td>
</tr>
<tr>
<td>8. CharlesCorrea Associates</td>
<td>CAD Generalist</td>
<td>None specified</td>
<td>Specifies no specific systems, only AutoCAD.</td>
</tr>
<tr>
<td>9. RemoTec Associates</td>
<td>None specified</td>
<td>None specified</td>
<td>Specifies no specific systems, only AutoCAD.</td>
</tr>
<tr>
<td>10. Integrar and Associates</td>
<td>None specified</td>
<td>None specified</td>
<td>Specifies no specific systems, only AutoCAD.</td>
</tr>
<tr>
<td>11. Calabash Corporation</td>
<td>None specified</td>
<td>None specified</td>
<td>Specifies no specific systems, only AutoCAD.</td>
</tr>
<tr>
<td>12. Tishman Corporation</td>
<td>None specified</td>
<td>None specified</td>
<td>Specifies no specific systems, only AutoCAD.</td>
</tr>
<tr>
<td>13. Kajima Corporation</td>
<td>None specified</td>
<td>None specified</td>
<td>Specifies no specific systems, only AutoCAD.</td>
</tr>
</tbody>
</table>

**Legend:**
- **Necessary Skills:** Architects must have these skills, but not necessarily at a high level.
- **Recommended Skills:** Architects are recommended to have these skills at a high level, but not necessarily necessary.
- **Notes:** Specific notes on systems used or preferred.

**Acknowledgments**

I want to acknowledge the many individuals who have provided my research with indispensable resources. In formal interviews and informal conversations, these architects, professionals, and scholars shared their worlds with me: James Becker, Charles Correa, Edward Duffy, Hugh Dutton, Lizzie Hodges, Nancy Joyce,

References