Teaching Tectonic Design Studio with A Digital Design Approach

Mao-Lin Chiu, Chien-Rung Lou
Department of Architecture, National Cheng Kung University, Taiwan
http://www.arch.ncku.edu.tw/

Digital design education is shifting from software and hardware application to issue-based, methodology-driven and technology-driven exploration. The attempts in design education have to address the future needs for architects, for instance the tectonic design. Our design studio tries to structure the design process to help students understand the principles and use the digital technology to operate tectonic design issue in the process. The dialogue with the materials (virtual and physical ones) is integrated with the exercises. The attempts in the design studio undertaken in National Cheng Kung University provide the foundation for observation and discussion. The pedagogy and approaches are examined and the potential directions are reported.

Keywords: *Design studio; digital design; tectonic design; design education.*

Introduction

The emerging information and communication technologies have fostered a new era for architecture, and consequently influence the way we practice and teach. The search for new design methods for computer aided architectural design (CAAD) teaching is critical (Achten, 2003). Schmitt (2003) illustrated that both the design content and the training programs are changing in the 21st century. More importantly, design education has to address the needs for the education of the 21st century architects and designers. The difference of architectural education before and after adopting digital design is worthy further investigation.

In a preliminary survey of digital design education in world-wide architectural schools, Chiu (2006) found that the relationship between design studio and digital design education are essential important to the successful program from the practical point of view. The introduction of digital education into design studio mainly relies on the instructor and resources available at the institution. Various approaches in some institutions focusing digitally enhanced curriculum that may promote the practices of software and hardware, but not necessary lead to the innovative design. The choice of right tools for digital design is more than representation and manipulation (Chiu et al, 2003). Furthermore, the design curriculum is often constrained by the faculty and supporting courses. The worst scenario is that digital design education and design studios are separately instructed. In general, digital design education is shifted from the practice of CAAD software and hardware into the theoretic, technological, and tectonic approach in digital design related courses and studios. The paper therefore aims to illustrate a graduate design studio that adopts a digital design approach for tectonic design.

Methodology for Tectonic Design Studio

Tectonic is about the exploration of what we have to know in order to proceed how to do (Frampton, 2001). It is a feature of constructing logics that is formalized between materials and how-to. We are encountering new paradigms of design. The recent development of digital design thinking has translated "dialogue with the materials of problem" into redefining the concept of "material" (Oxman, 2006). Our design studio tries to structure the design process to help participants understand the principles and use the digital technology to explore tectonic-related issues in the process. The duration of the graduate design studio is 16 weeks. Every student in this studio is expected to consolidate their unique insights by various kinds of tasks in the tectonic culture, and consequently, inspire and apply their method to define activities, roles, places, the role of technologies, and translate them to be the material for tectonic design. Particularly, the hand-on experience contributes in-depth studies of the appropriateness of materials as well as digital technologies applied.

The digital design process should be integrated with knowledge and skills for supporting the design synthesis and design collaboration (Sazlapaj, 2005). This studio emphasizes the tectonic issue and digital design process, and the integration of both. It is important to use precedents for associating some useful ideas in design teaching, particularly connect the concept and forms with design issues (Oxman, 1994). The issue-concept-form (ICF) relationship becomes the basis of tectonic design via the exploration of simple form exercises.

The teaching attempts in our institution continued in the past 10 years provide the foundation for examining the approach in digital design education. The past attempts can be divided into three stages, i.e. the technology-driven, the theory-driven or methodology-driven, and the content-driven phases (Chiu, 2006). Each transition was evoked by new technological advancement (such as the web, virtual reality, CAD/CAM) as well as design thinking. More important questions such as integration of "thinking" and "making," the incentives for learning, and the evaluation of performance are raised. To examine "how-to" conduct the tectonic design studio with a digital design approach, this paper therefore

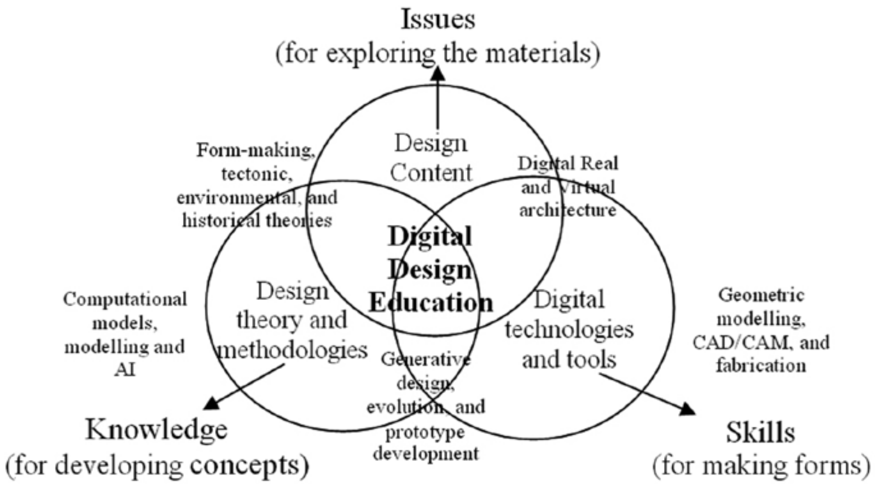


Figure 1
The framework of digital design education

proposes a framework to examine the focus of digital design education and the relationship among (1) design contents, (2) digital technologies and tools, and (3) design theory and methodologies in digital design studios, Figure 1.

Design Process

The 16 weeks of studio is subdivided into 2 phases – (1) generative design, and (2) tectonic design, Figure 2. The steps of each phase include: (1) understanding issues via case studies and trial tests, (2) developing concepts and problem-solution schemes via mock-up study and rapid prototyping, and (3) refining solutions via simulation and modification subject to various constraints. In particular, tectonic issues let us to face the existing problems in digital design teaching, including the gap between thinking and making. Therefore, the approach applied to the studio should be able to narrow the gap between digital design in theory (thinking) and in practice (making). The process is often divided into two directions: the thinking is top-down oriented logic and the making is bottom-up oriented logic. Our approach depends on this studio design process to recognize the difference between both orientations, and hopefully integrate both.

In Phase-I, the Generative Design Workshop (GDW) was given at the beginning as a warm-up exercise to familiarize with both top-down and bottom-up processes. Meanwhile, students conducted precedent analysis and prototype development at same time, while isolating the context issues. A "tree house" was tested for formulate the problem and form generation.

In Phase-II, students define their tectonic issues and develop the support-and-infill system, and develop their own digital solution. For digital realization or implementation, students learned how to realize the design scheme by 2D/3D drawings, rapid prototyping, and fabrication. The key concept is translated from the virtual to the real, from 1/10 scale to the full scale, and new kinds of problems are generated. From the transition experience, students can explain what the tectonic is about and how technologies can be applied to their solution. The details are elaborated in the next section.

The studio is also integrated with lectures, workshops, and readings to serve the purposes below.

1. Process formulation: This is implemented by

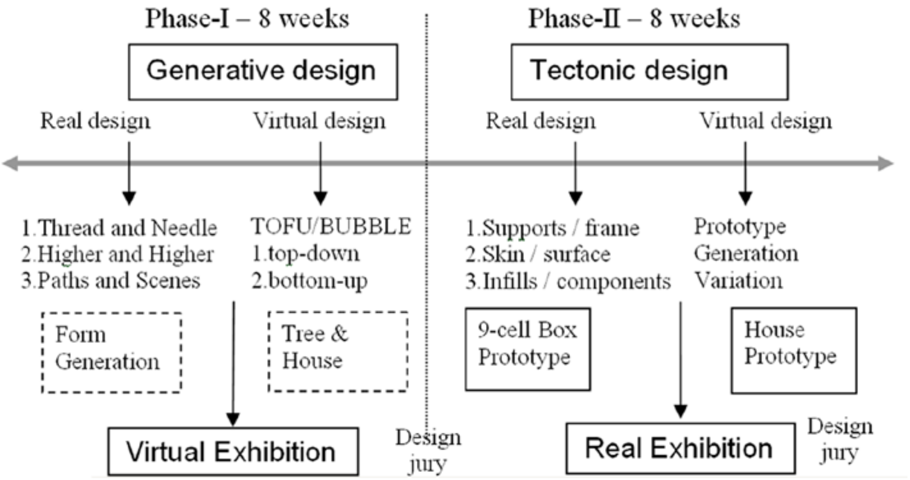


Figure 2
Process of the Tectonic Design Studio

a GDW workshop in one week in cooperation with Thomas Fischer whom developed customized programs (TOFU/BUBBLE embedded with 3DS/MAX) based on top-down and bottom-up processes.

2. Parametric design: 4 tutorial lessons were given by FormZ to rationalize geometric modeling.
3. Tectonic design: It is given by four lectures of invited architects for sharing their expertise knowledge and project experience.
4. Collaborative design: The design consists of individual and team works, and both require collaborative design for sharing experience and skills.

Exercises and Issues Focused

In Phase-I, exercises were given for enhancing the concept and skill learning, Table 1. 10 graduate students are participated in the studio, Exercise 1-3 were undertaken individually, while Exercise 4 was undertaken by a group of 3 students.

Ex1. Thread and Needle - Students' design conception was derived from two openings in a vertical wall, and alternatives for changing openings and the linkage contribute a flow of space, Figure 3 (1 week)

Ex2. Higher and Higher - Design generation was started from defining the spatial elements and applying the generative rules to study the form composition, Figure 4 (1 week)

Ex3. Paths and Scenes – Design adaptation is situated by environmental factors for studying different alternatives and variations, Figure 4 (1 week)

Ex4. 9-cell Box Prototype - Finally, a basic unit of a single house is exemplified for form synthesis based on the learning from Ex.1-3, Figure 5 (2 weeks)

In the process, the studio was able to assimilate design knowledge, offer skills, and define issues for design exploration. The studio is aimed to consolidate the knowledge and skills via a single house design as an example for validating the methodology and form synthesis. The process and partial works were demonstrated in an exhibition in collaboration with another school.

Digital Realization and Exhibition

The exercise in Phase-II is to translate the learning experience in virtual design into a physical operation, i.e. the above exercise in Phase-I is consolidated by the prototype development and implemented in an exhibition "Generation and Variation" in May 2006 in the TADA Center in Taichung, Figure 6. For instance, 3 box prototypes were constructed by 3 groups of students to demonstrate their capability to fabricate manually and integrate various components based on their digital modeling and scale models. Meanwhile, more level of details and advanced skilled are explored. The roof design, "Kite" shown in Figure 7, illustrates the steps of surface modeling and subdivision of components for fabrication and assembly. In the process, "the making" create problems as well as create possibility for "the thinking." The dialogue with the materials (virtual and physical ones) is reflected naturally with the "reflection-in-action" as Schön (1983) described.

Table 1
List of Design Exercises.

No.	Theme	Goals	Assignment	Demonstration
Ex 1	Thread and Needle	Design conception	Components and connections	Timber components with fixed metal joint
Ex 2	Higher and Higher	Design generation	3D composition and rules	Timber frame building envelope
Ex 3	Paths and Scenes	Design synthesis	Linkages and constraints	Adaptive frame in respond to conditions
Ex 4	Box prototype	Design evaluation	Prototype	Scale model and mockups

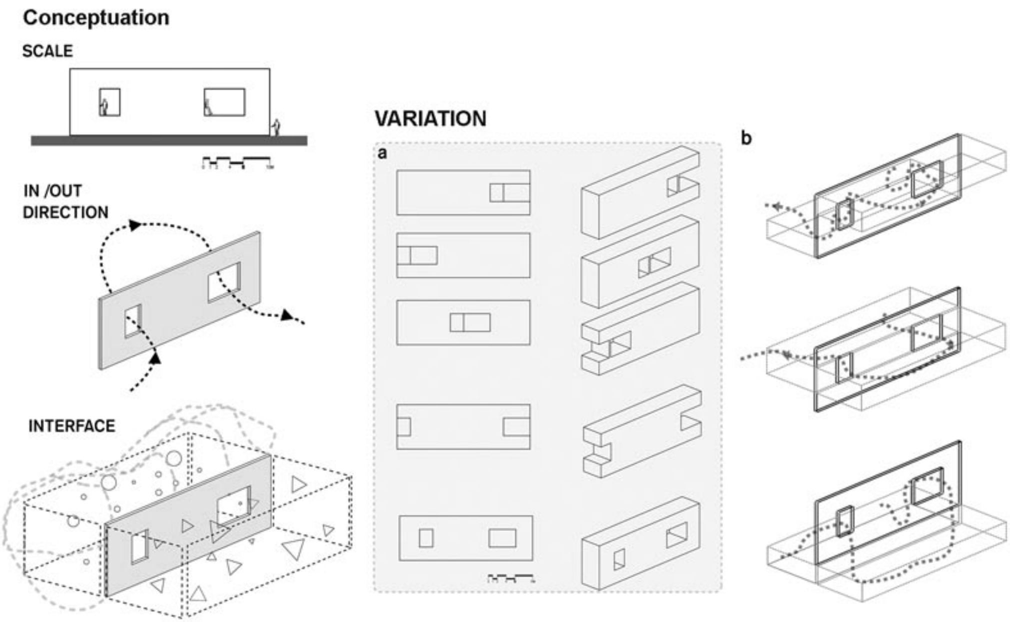


Figure 3
Process of Form Conception
(Drawing by B.S. Lee)

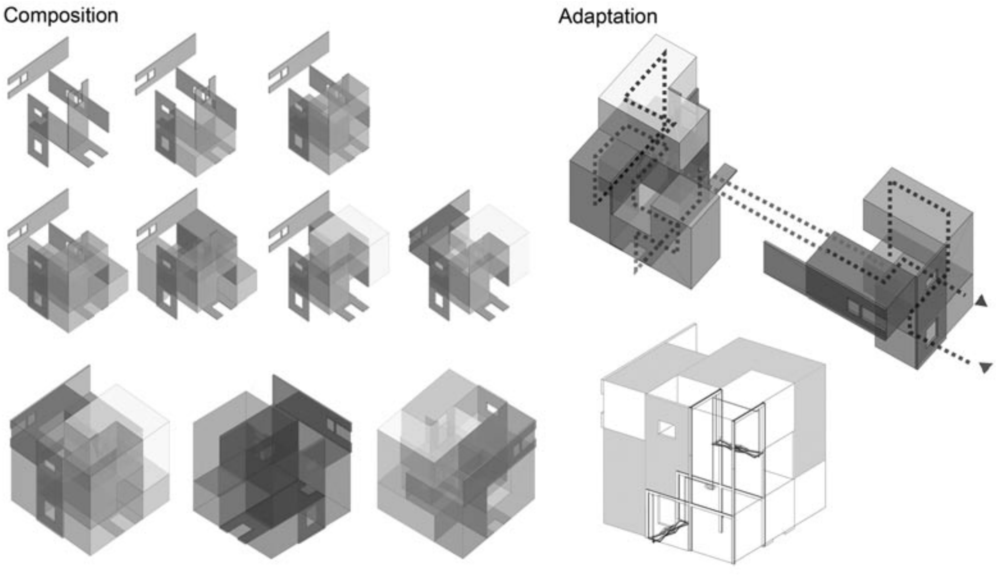


Figure 4
Process of Form Generation
(Drawing by B.S. Lee)

Figure 5
Process of Tectonic Design

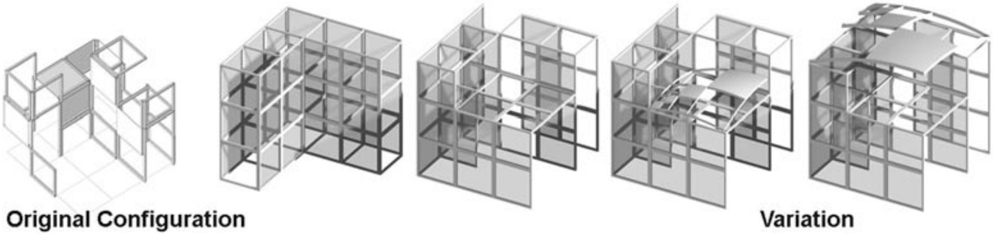


Figure 6
Tectonic design demonstrated in Exhibition 2006

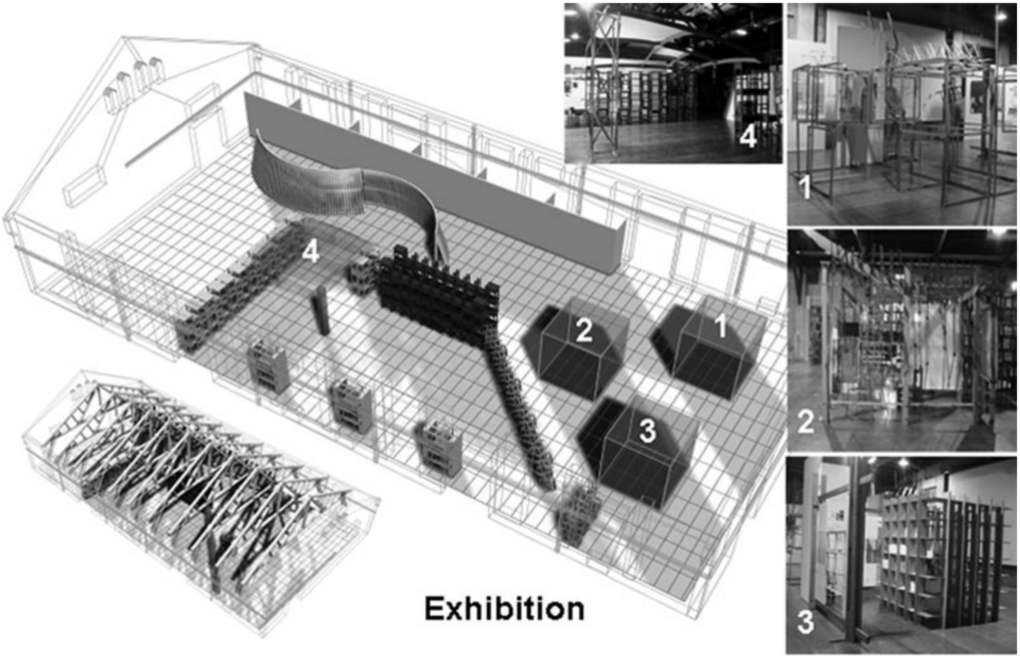
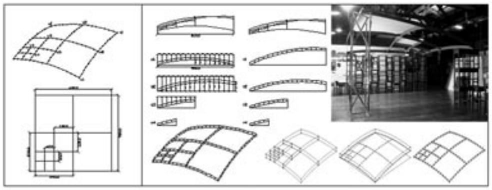


Figure 7
Process of Tectonic Design – Roof design as an example



Observations and Issues Revealed

As observed, the design process from exploration, translation, to operation is reshaping the conventional way of studio teaching as well as CAAD education. Tectonic design requests students responding to the uniqueness in design content as well as the choice of digital technologies. Individual exercise will translate their experience to practice and get a new vision of digital design. The value of this experience is to accumulate the multi-disciplinary views and form a new design program for educating future designers, from define the issue and solutions with the aids of digital technologies. The above exercises provide concrete ground for observations and discussion.

Dialogue with the "material"

A tectonic is an art between materials and how-to. The growing issues and subjects in digital design as witnessed by practice, research and education, we need to foster the dialogue with the "materials" that is suitable to the formation of digital design thinking. While the designers can be inspired from the richness of materials (physical and virtual), but the assistance from instructors, teaching assistant, and technicians contribute to the formulation of how-to. Design teaching requires students conduct exercises to formulate "how-to" and translate their observation into their own views and methodology of tectonic design.

Computer-supported Tectonic Design

We believe the tectonic design combine two factors, one is construction logic and the other is material, and includes the concept of composition. It is beginning from design and the essence of design structure. It's not from practice and just choose the material and construction methods. The issue-concept-form approach provides the uniqueness for learning and exploration. On one hand, students have to better equip with computational skills, and on the other hand they need to enhance knowledge about tectonic design and hand-on experience. Therefore, computer-supported design becomes the critical for the outcomes.

Preliminary Evaluation and Feedbacks

Given the conditions of generative design (virtual design) and tectonic design (physical design), students were learning both and fill the gap between both. We had pre-defined several check-points to review the improvement of students' capability such as the application of digital technologies (2D/3D Modeling, Macro editing for form generation), tectonic design (including materials and assembly), the process (Bottom-up vs. Top-down), and collaborative design. These are closely related to each other. The preliminary evaluation as shown in Figure 8 demonstrates the materials learned in Phase-I and Phase-II. And more importantly, the logic generates the new teaching method and evaluation that are needed.

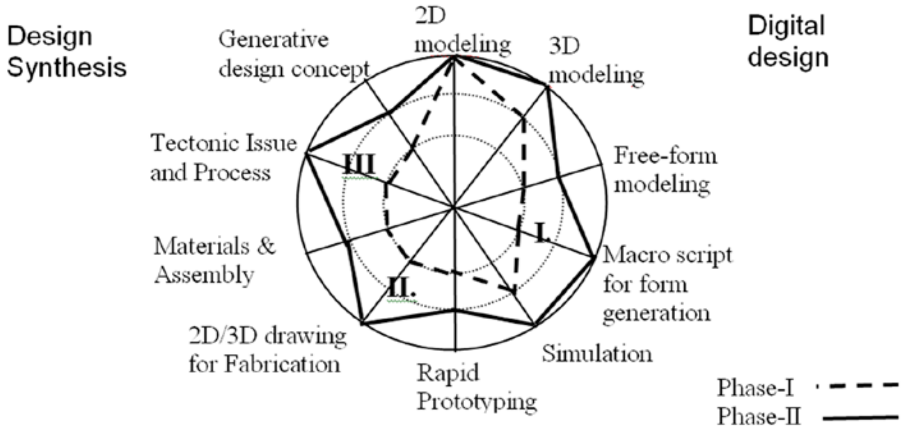
The feedbacks from students are useful for balancing computer skills and design performance. We had found three areas (I, II, III) require the extra efforts for enhancing the design performance, namely, digital design thinking with formal knowledge, rapid prototyping capability, and hands-on experience for tectonic design. While there are still rooms for improve the learning and exploration, the studio requires workshops and lectures in parallel.

Conclusions

Nowadays, teaching digital technologies and tools is not enough for digital design studios that require different kind of design thinking for integrating the process with appropriate issues. In this paper, tectonic design with digital design re-emphasize the arts of "making" as well as "thinking." Dialogues with the materials help to structure the process either in top-down or bottom-up manner. Apparently, it is subjective to say that a systematic approach to pedagogy of architecture will ensure the excellence of design performance. The evidence from the result observed and reflections from the participants demonstrate the feasibility of the approach. The findings from this paper provide the promising direction and challenges for the field.

In conclusion, the needs for responding to the technological advancement and design issues are never ended. How digital design can be organized and integrated naturally with the architectural design studio to pursue the right approach will be important. With the evidence of digital design projects, both the professions and the academics can foresee the continuous development and challenges in this domain. Digital fabrication may become convenient and personal (Genshenfeld, 2005). The future emphasis in digital design education should be the novel digital design thinking to inspire "how to" (choose, make, produce, or integrate) and the integration of the design process digitally, including design infor-

Figure 8
Preliminary Evaluation of the Materials Learned in Phase I and II



mation and knowledge management, collaborative design, CAD/CAM, and resource management.

Acknowledgements

The authors are grateful for the students participating in the studio, TA (Han-Yuan Tseng) and the collaborator (Ms. Pei-Yu Chen) for organizing the exhibition.

References

Achten, H.H.: 2003, New Design Methods for Computer Aided Architectural Design Methodology Teaching, International Journal of Architectural Computing, Issue 1, Vol.1, pp. 72-91

Chiu, M.L.: 2006, The Jump of Digital Design Thinking - Overviews of Digital Architectural Design Education, proceedings of CAADRIA 2006, Kumamoto, Japan

Chiu, M.L., C.J. Liao, R.L. Wu, J.C. Peng, and C.C. Huang: 2003, Educating Digital Designers: A Process-Oriented Approach, proceedings of eCAADe 2003, Graz, Austria, pp. 583-586

Chiu, Y.C. and M.L. Chiu: 2003, Right Tools for Designing Free-form Geometry: More than Representation and Manipulation, in Chiu, et. al. (eds.), Digital Design – Research and Practice, Kluwer Academic Publishers, pp. 433-444

Frampton, K.: 2001, Studies in Tectonic Culture – The Poetics of Construction in Nineteenth and Twentieth Century Architecture, MIT Press

Gershenfeld, N.: 2005, Fab: The Coming Revolution on Your Desktop – from Personal Computers to Personal Fabrication, Basic Books

McCullough, M, W. Mitchell, and P. Purcell (eds.): 1990, The Electronic Design Studio – Architectural Knowledge and Media in the Computer Era, The MIT Press

Oxman, R.: 2006, Digital Design Thinking: In The New Design Is The New Pedagogy, proceedings of CAADRIA 2006, Japan, pp. 37-46

Oxman, R.: 1994, Precedents in Design: a Computational Model for the Organization of Precedent Knowledge, Design Studies, Vol. 15, No.2, pp. 141-157

Sazlapaj, P.: 2005, Contemporary Architecture and the Digital Design Process, Architectural Press

Schön, D.: 1983, The Reflective Practitioner, Basic Books, New York

Schmitt, G.: 2003, Architects of the 21st Century - Cultural dimensions of CAAD, in Chiu (ed.), CAAD Talks 3 – Digital Design Education, pp. 1-24