A Teaching Framework of an "E-basic Design Studio"

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ABSTRACT

The objective of this research is to illustrate the teaching of CAD/CAM media in basic design studios for 1st and 2nd year under-graduate students. The research consequently establishes a framework for an "e-basic design studio" based on design studio observations and analysis of academic literature, which include the new thoughts on tectonics and the operation of traditional 2D/3D design media and CAD/CAM digital tools.

KEYWORDS: design education, basic design studio, CAD/CAM media, digital thinking.

Since 2000, researchers have been discussing how to include CAD/CAM media into the content of design studio and cours-es, particularly those of MIT, Harvard, AA, Columbia, ETH, etc. (Campbell, 2006; Schoch, 2006). Through hands-on op-eration in CAD/CAM design studios and experimental studies of courses, researchers have proposed teaching frameworks which apply CAD/CAM media-aided design and manufactur-ing process. In addition, Iordanova (2007) indicated that the design studios in which CAD/CAM media have been applied must contain two stages of teaching: basic skill training and advanced digital design.

These CAD/CAM courses were usually planned for advanced design students (4th and 5th year undergraduate students and graduate students) because of their highly-technical content. However, some researchers have started to study how to apply digital tools to basic design studios. In 1996, Naai-Jung Shih (1996) already started to discuss how to use CAD in basic de-sign studios, and offered suggestions for CABD (computer-aid-ed basic design) studios. Through case studies and teaching experiments, Sheng-Fen Chien and colleagues (2007) planned a series of applied CAD media-aided design studios divided into to various levels.

Problem and Objective

The insight gained from the research and class observations showed that the role of CAD/CAM media in the digital age was becoming more popular and that the learning threshold in such design applications has gradually decreased. Conse-quently, it has become critical to include CAD/CAM media and digital thinking into the planning of basic design studios.

The objective of this research is to apply the teaching of CAD/CAM media to basic design studios for 1st and 2nd year un-dergraduate students. First, the authors will observe some aspects of design thinking and processes using CAD/CAM media by novices. Then, the research will be placed within a framework of an "e-basic design studio" that is based on ear-lier observations, including the new thinking on tectonics and the operation of traditional 2D/3D design media and CAD/CAM digital tools.

Methodology and Steps

The first step taken in the research process was a review of the pertinent academic literature. We first integrated "*teach-ing objectives*", "*the training of media operations*" and "*de-*

sign thinking" for the traditional basic design studio. Then, we integrated the digital media operation and digital tectonics thinking based on the research of Iwamoto (2009) and Liu and Lim (2006). Based on these analyses, we defined "*the training of media operations*" and "*design thinking*" in both the traditional and digital design studios, in order to establish a preliminary framework for the "*e-basic design studio*".

In the second phase of the research we observed studio participants. It applies the preliminary teaching framework of "*e-basic design studio*" to a real course (second year undergraduate basic design studio at Department of Art and Design, YuanZe University) for two design projects. We obtained the data for analysis through video recordings and photographs. The teaching framework was modified according to the analysis and applied again in the second design project to validate its feasibility. Finally, we integrated an executable preliminary teaching framework for an "*e-basic design studio*" for design novices, which included the new tectonics thinking and the operation of traditional 2D/3D design media and CAD/CAM digital media.

Analysis of Step One: A Preliminary Framework for the "E-basic Design Studio"

Traditional Basic Design Studios

· Teaching objectives: current design education, which offers introductory level "basic design studios", originates from the design education founded by Walter Gropius in Bauhaus. At that time, six-month "elementary courses" were offered. They mainly contained "fundamental studies on form", "fundamental studies on materials", and "studies on composition" (Wang, 2003). And the teaching goal in these courses focused on concept and operation, development of students' creative thinking, as well as on all kinds of preliminary stages of professional training (Ni, 2009). This paper will focus on the teaching objectives of traditional basic design studios in the following three areas: design concepts and operation training, development of creative potential, and preliminary stages of professional design training.

· The training of media operations: design media used in traditional basic design studios are mainly sketches, handcrafted models, and photography. The tools for sketches include pencil, watercolor, etc. Naomi Asakura (1992) summarized the main materials used in 3D composition as paper board, clay, wood, metal, plastic, ceramics, and light. It is also very common to see students present their design ideas with photography or pictures. This research concludes that media application training found in traditional basic design studios can be divided into the following three items: sketches, handcrafted models, and photography.

· Design thinking: Shun-Chen Ni (2009) integrates several important operational practices in traditional basic design studios including simplification, 2D composition, 3D composition, and material studies. In these operational processes, "form" design thinking training is mainly to transform abstract conceptual thinking into 2D drawings, and then further transform it into 3D models. Students are trained to recognize and study the characteristics of different materials. In the process of 3D composition, construction methods of materials and structural relationships are taken into consideration. This research concludes that the training of design thinking found in traditional basic design studios can be identified in the following: form, materials, composition, structure, and construction.

Basic Digital Design Studios

· Teaching objectives: this study attempts to train design novices familiar with digital design processes, so it is essential to teach the operation of digital tools in basic design studios. At the same time, design novices are trained to be familiar with the integration of traditional and digital design media in their design process. The digital basic design studio will extend the teaching objectives of traditional basic design studios; it will also add digital media training associated with computer courses or workshops. It contains the following two teaching objectives: digital design concepts and operation training, and integration of traditional and digital design media.

· Digital media operation: in digital design processes there are software and hardware being used as design media such as 2D image processing software like Photoshop and Illustrator, CAD software such as AutoCAD, Sketchup, 3dMax, Rhino, Maya, and CATIA, CAM machines such as laser cutters, rapid prototyping (RP), CNC, and 3D scanners. The applications of CAD/CAM design media enable the fabrication of physical models from complicated 3D model data precisely. Iwamoto (2009) concludes that there are 5 types of digital fabrication techniques: sectioning, tessellating, folding, contouring, and forming. This research concludes the media application training of digital basic design studios can be divided into the following three items: digital 2D drawings, digital 3D models, 3D CAM physical models such as laser-cut models using fabrication techniques like sectioning and folding, RP models using fabrication technique such as tessellating, and CNC models that use fabrication techniques such as contouring and forming.

· Thoughts on digital tectonics: using different design media will change the way we think about the design process (Lim, 2003). In order to explore the tectonic thinking of using CAD/CAM media, Liu and Lim (2006) integrated a preliminary framework of new tectonics involving classic and digital thinking. It includes 5 traditional tectonics factors (joint, detail, material, structure, construction) and 4 digital tectonics factors (animation, generation, information, fabrication). Furthermore, through a cognitive experiment the author concluded that design thinking differed when using CAD/CAM media (laser cutter and RP) (Lim,

2006). It is understand that the accuracy of digital tools enables designers to consider different aspects of detail, dimension and scale. Therefore, this research concludes that the thinking on digital tectonics can be divided into the following three items: digital form, where abstract concepts lead to different modeling methods, which leads to a new 3D model, which leads to a 3D CAM physical model (RP); digital tectonics which use laser cutters that are able to facilitate the design considerations of the material, structure and construction, as well as RP and CNC that are able to facilitate the design thinking of form; digital accuracy in which the "zooming" operation in CAD modeling can aid design thinking on detail and where the output of CAM physical model aids the design thinking of scale.

A Preliminary Framework for the "E-basic Design Studio"

Following from the above analysis, this study presents a four module teaching framework that is divided into conceptual design, preliminary design, detail design and manufacture. In the early stages, especially the conceptual and preliminary design stages, we train students in the use of traditional design media. In addition, we teach the use of digital CAD/CAM media applied to model making, detail consideration, and module manufacture. In figure 1 we present a preliminary framework for the "e-basic design studio", which integrates the use of traditional 2D/3D design media with the use of digital CAD/CAM media (Fig. 1).

Analysis of Step Two: Participant Observations

The "e-basic design studio" framework integrated in Step 1 was applied to a second year undergraduate design studio, which had 17 students. By video recording, photographing and collecting data, we obtained data from two design projects carried out during a semester (18 weeks). The teaching framework was modified according to the analysis and applied again in the second design project to evaluate the feasibility of its use. This study chose 5 students' results for analysis. The following describes the design processes and their results.

Design Project 1: Transformer Furniture Design

The design topic was to find natural patterns in nature, and then transform them into 3D designs of deformable multifunctional furniture, and to complete the design in a 1:1 physical model using acrylic and wood materials. The design media used were traditional design media (sketch, handcrafted model) and digital CAD/CAM media (AutoCAD 2D, laser cutter). The design outcomes are outlined in the following:

· Module 1 (1 week): Conceptual design
Figure 2a shows the designs presented by hand drawings, photographs, and Photoshop drawings.

	Traditional 2D/3D media		Digital CAD/CAM media	
	Media operation	Design thinking	Media operation	Design thinking
Module1 (Conceptual Design)	• Photography • Sketch	• Design concept		
Module2 (Preliminary Design)	• Sketch • Handcrafted model	• Form • Material • Composition	• CAD model	• Digital Form • Accuracy (detail, scale)
Module3 (Detail Design)	• Sketch • Handcrafted model	• Form • Material • Structure • Construction	• CAD drawing • CAD model • CAM physical model	• Accuracy (detail, scale) • Digital Form • Digital tectonics
Module4 (Manufacture)			• CAM physical model	• Digital tectonics

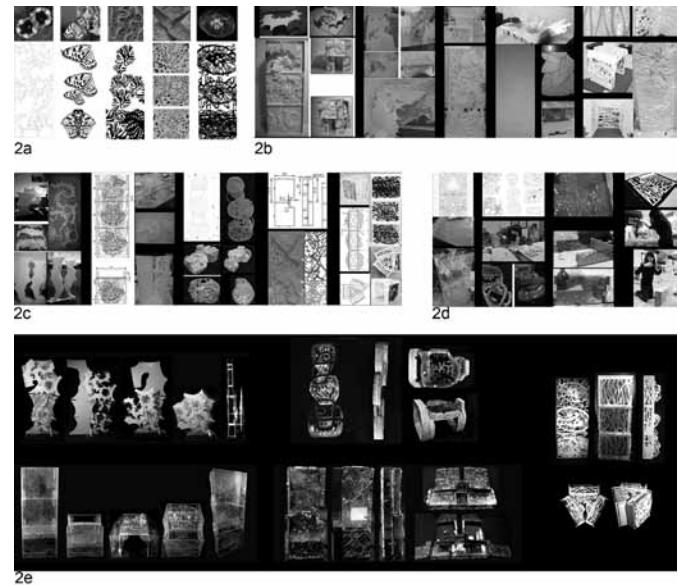Figure 1. A preliminary teaching framework of "e-basic design studio"

Figure 2. Design Project 1: transformer furniture design

· Module 2 (4 weeks): Preliminary design
Figure 2b shows the designs presented by hand drawings and handcrafted model.
· Module 3 (2 weeks): Detail design
Figure 2c shows the designs presented by CAD drawings and handcrafted model.
· Module 4 (2 week): Manufacture
Figure 2d shows the manufacture process. Students used laser cutter to cut the design components and assemble. Figure 2e shows the final 1:1 acrylic and wood model.

Based on the design outcomes, it can be seen that some students used a digitaltool (Photoshop) in module 1 to transform (copy, rotate, scale) the patterns. Becausethe students are just beginning to be trained in using CAD/CAM media, they stillused many handcrafted models in module 3 instead of making CAM models. As a result, we

modified the framework by adding "digital 2D drawing" in module 1, and adding a "3D CAM physical model" in module 2 to train the using of CAD/CAM media ahead.

Design Project 2: Personal Reading Space Design

The design topic for this project was to interpret 1D text into 3D space design by reading short essays, develop a 3D personal reading space design based on body posture and text strokes,

and complete the design in a 1:1 physical model using Styrofoam materials. The design media used were traditional design media (sketch, handcrafted model), and digital CAD/CAM media (AutoCAD 3D, Styrofoam cutter). The design outcomes are illustrated by the following:

· Module 1 (1 week): Conceptual design
  Figure 3a shows the designs as presented in hand drawings, photographs, Photoshop drawings and CAD dimension drawing.
· Module 2 (3weeks): Preliminary design
  Figure 3b shows the designs presented by CAD drawings, handcrafted models, 3D models, CAM physical study models (Styrofoam cutter).
· Module 3 (2 weeks): Detail design
  Figure 3c shows the designs presented by 3D simulations, 3D models and CAD drawings.
· Module 4 (3 week): Manufacture
  Figure 3d shows the manufacture process. Students used Styrofoam cutter to cut the design components and assemble them. Figure 3e shows the final 1:1 Styrofoam model.

The design outcomes showed that students were more familiar with using CAD/CAM media in this project; they frequently fabricated their study models (CAM models) in module 2 with the aid of Styrofoam cutter, and because they could easily modify their design in 3D model, they relied on digital tools in module 3 to prepare the drawings for fabrication. Based on these aspects, the framework was again modified; the use of traditional design media in module 3 become optional.
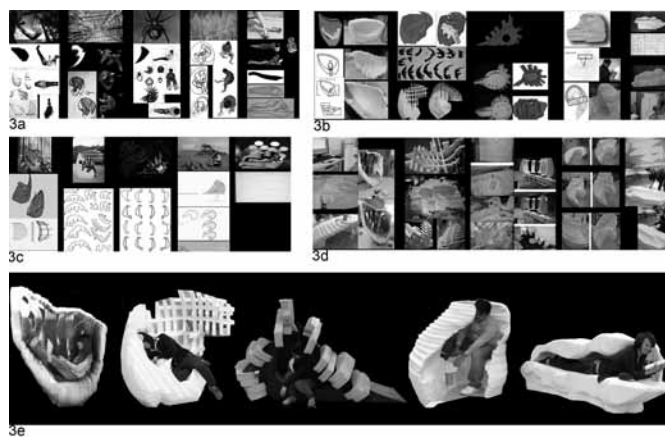

Figure 3. Design Project 2: personal reading space design

Figure 4. A modified teaching framework for an "e-basic design studio"

Conclusions

After analyzing these design outcomes, it is clear that the application of the "e-basic design studio" teaching in the two design projects effectively trained the novice students to be familiar with the implementation of both traditional 2D/3D media and digital CAD/CAM media in their design projects.

This research produced an executable teaching framework for an "e-basic design studio" (Fig. 4). In addition, this research offers some insights regarding the design outcomes and processes for the "e-basic design studio" such as: (1) novice designers are more focused on their design concept development when using traditional media but are more attentive to the scale, material, structure and construction procedure when using CAD/CAM media, (2) novice designers are more familiar with the conversion of 2D/3D design thinking in the process of integration of traditional and digital media, (3) novice designers' outcomes can be more precise in any scale models; and can even produce works at a scale of 1:1.

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