tion.

b. (Rapid prototyping & CNC) 3D digital model à 3D CAM physical model. It is able to facilitate the design thinking of form.

6. **Digital accuracy**:
   The "zooming" operation in CAD modeling can aid the design thinking of detail. The output of CAM physical model aids the design thinking of scale.

A preliminary framework for the *"e-basic design studio"*

Based on the previous analysis of traditional and digital basic design studio, this study conducts a four modules teaching framework which emphasize the four design stages: conceptual design, preliminary design, detail design and manufacture. In the early stage, especially conceptual and preliminary design, apply the training of traditional design media. In addition, the training of using digital CAD/CAM media applies to the model making, detail considering, and manufacturing modules. A preliminary framework for the *"e-basic design studio"* which integrates the using of traditional 2D/3D design media and digital CAD/CAM media is concluded as Figure 1.

Participant observations

The *"e-basic design studio"* framework integrated in Step 1 was applied to a real design studio (second year undergraduate) at Department of Art and Design, YuanZe University, which have 17 students in the studio. By using participant observations, we obtained the data we needed for analysis from two different design projects during a semester (18 weeks). We determined the teaching effectiveness and noted some aspects of design in the students' design outcomes. The teaching framework was modified according to the analysis and applied again in the second design project to validate its feasibility. This study chooses 5 students' results for analyze according to the completeness and evaluation from teacher. The following describes the design process and results.

Design Project 1:Transformer furniture design

1. **Aim:** Training students to transform 2D graphic to 3D thinking. Meanwhile, teaching the integration of using traditional design media and digital CAD/CAM media (laser cutter).

2. **Design topic:** Find the natural pattern from nature, develop three kinds of continuous 2D pattern, and then transform to 3D design of deformable multi-functional furniture. Complete the design in 1:1 physical model using acrylic and wood materials.

3. **Design media:** Traditional design media(sketch, handcrafted paper model); digital CAD/CAM media (AutoCAD 2D, laser cutter)

4. **Design outcomes:**
   Module1 (1 week): Conceptual design

Module	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 12
A modified preliminary teaching framework of "e-basic design studio".

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

resentation. In this project, students are more familiar in using CAD/CAM media; they fabricated their study models (CAM models) in Module 2 with the aid of Styrofoam cutter a lot. As they can easily modify their design in 3D model, they rely on digital tools in Module 3 to prepare the drawings for fabrication. Based on these aspects, the framework was modified again as following: *Modify 3:* The use of traditional design media in Module 3 become optional.

Results

From the analysis of design outcomes, it is clear that after applied the *"e-basic design studio"* teaching in the two design projects, the students (design novices) were trained well 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 suitable for the "e-basic design studio" (Figure 12). We propose a new teaching method for design novices in the design studio that integrates both traditional design media and digital CAD/CAM media in the design process. In addition, this research draws some conclusions regarding the design outcomes and processes for the "e-basic design studio":

1. Design novices are more focused on their design concept development when using traditional

media but more attentive to the scale, material, structure and construction procedure when using CAD/CAM media.

2. Design novices are able to think about the construction procedure during the assembly process.

3. Design novices are more familiar with the conversion of 2D/3D design thinking in the process of integration of traditional and digital media.

4. The design outcomes can be more precise in any scale models; and can even produce works at a scale of 1:1.

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