Seven steps to computer aided design education
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1 Introduction

The Superior School of Industrial Design (ESDI), CEU San Pablo in Valencia, offers a three year period of studies that leads to an official degree in Technical Engineering of Industrial Design. Students who wish so, may further complete their studies during a two year period of specialization in graphic and industrial design.

Education in computer graphics is offered throughout several required and optional courses that any student will take during their second, third and fourth year of studies. Two required courses, CAD I (9 credits) and CAD II (9 credits) introduce the student to Computer Aided Design in its role of simulation in two and three geometric dimensions. We are working to expand this sequence introducing CAD III, an optional design studio that would teach the specifics of solid modeling systems, with an emphasis on parametric design.

This paper presents a very short description of the different lessons and underlying structures of thought we use in our CAD II course to impart education in 3D modeling.
2 Methodology

Design is seen as a process that could be aided by the use of computer systems through modeling (representation), and rendering (static or dynamic visualization) of a digital model.

We approach CAD education from a tool using point of view. We teach students how to use some commercial software in their design tasks. We currently use StudioPRO from Strata, Inc., a surface modeler that runs on the Apple Power Macintosh platform, as our main tool for three dimensional modeling and rendering of scenes. We concentrate our efforts on both teaching the specifics of the software and its particular grammar of use, while relating these steps to an overall conceptual structure of design knowledge.

We emphasize a general structure of thought over terminology, describing the steps taken and guiding the user which many times gets confused and does not understand what he is really doing, just designing and manipulating three dimensional objects and spaces. We hope that the student understands he is using computer graphics as a design media that will eventually transform his/her own process, far from being a transparent media without influence.

The information and knowledge involved when learning and applying these techniques is explained along seven different categories that will help us analyze the relationship between industrial design and digital modeling technology.

2.1 Geometry
We reduce design to a pure expression of geometry, which is at the base of any other property of design. A digital model is, before anything else, a data structure that allows mathematical expression and manipulation of geometry, and therefore makes the simulation of form and space possible. A vocabulary of geometric elements is introduced together with the notion of operators for transforming and manipulating these elements.
2.2 Composition
We analyze design as an issue of composition or relationship amongst geometric elements. Laws for design composition will guide formal and spatial development of any design project. Digital modeling is founded upon explicit definition of structural and hierarchical relationships amongst the elements that compose a design.

2.3 Texture
We introduce the concept of superficial appearance in design. Texture is understood as a code of expression to a certain level of formal and spatial abstraction, as a vocabulary of superficial properties we will be able to manipulate. These properties will allow the simulation of a specific visual behavior of a surface when it is illuminated.

2.4 Light
There is no visual perception without light. We see design as a play of light and shade. A digital model will let us control the lighting conditions of a design through a vocabulary of light sources that will illuminate a scene and will reveal through shading its form and space (contained or radiated).

2.5 Projection
Projection of three dimensional scenes into two dimensions makes possible physical presentation (mainly visual), of form and space. Digital modeling systems will let us observe a three dimensional scene through two dimensional views of it projected on a flat surface, such as a computer screen. The possibility of observing this space sustains the metaphor of manipulation within a model.

2.6 Animation
A digital model allows us to simulate the passing of time which adds a new dimension to the three geometric dimensions so far considered. We will be able to generate animations of it, sequences of pictures that if projected at a fast enough rate, will result in an appearance of smooth movement.
2.7 Rendering

Rendering is the end or conclusion of the digital modeling process. This is possible through several programmed mechanisms that will allow a computer to calculate and produce a graphic image that communicates to us form and space, to a certain degree of realism.

Classes rely on lectures and slide presentations, required readings that highlight relevant points of view towards computing in design, and extensive individual use of computers. Recommended readings are mostly from Daniel H. Herbert, Bryan R. Lawson and William J. Mitchell.

3 Exercises

Students follow a sequence of three exercises that will promote understanding of the potential CAD has as a modeling tool in design conception, development and presentation. During the first exercise students are asked to design a chess game. Simple shapes will reflect issues of geometry and hierarchy in design. Textures are introduced as different alternatives of the same geometry. Light is considered as it reveals geometry. (See figs. 1, 2, 3, 4).

The second exercise is the analysis and presentation of some industrial design already produced, or a design by the student. It introduces complexity in the modeling process. Formal composition and assembly conditions are considered. Texture as material. Lighting conditions are more complicated. (See figs. 5, 6, 7, 8, 9).

The first two exercises are explorations of shape worlds, space is radiated from and around objects. The third and last exercise is an exploration of interior and architectural space, of the space within, around us. Students are asked to design a pavilion space for the exhibition of some small objects or any other architectural composition. (See figs. 10, 11, 12, 13, 14, 15, 16, 17).

The excellent results that we have witnessed are certainly due to the enthusiasm and dedication that both our students and ESDI, CEU San Pablo, have shown for this discipline.
It has been difficult to select particular projects for publication amongst the many ones that show a high conceptual and plastic quality. The illustrations that you may see reproduced here are samples of student work that we would like to credit. Eva Martínez N. (fig. 1), Carolina Galindo P. (fig. 2), Mariola Moreno B. (fig. 3), Lucía Cordón C. (fig. 4), Alejandro Catalá R. (figs. 5, 12, 13), Rafael Blat L. (fig. 6), José Martínez F. (fig. 7), Arturo del Saz S. (fig. 8), Roberto Celada R. (fig. 9), Pilar Casabán R. (figs. 10, 11), Paco Mora G. and Alejandro Catalá R. (figs. 14, 15, 16, 17). Design work modeled by students is by Roy Fleetwood (fig. 5), Jaume Tresserra (fig. 6), Eduardo Albors (fig. 7), and Daniel Nebot (fig. 8).

4 Recommended Readings


Figs 1, 2, 3, 4. Chess Game.
Figs 5, 6, 7, 8, 9. Industrial Design.
Figs 10, 11, 12, 13. Exhibition Space.
Figs 14, 15, 16, 17. Architectural Composition.