Many years ago, when computers became the standard tool in the industrial design studio and employers began looking for competent, computer-savvy designers, many design schools were eager to begin teaching with them. However, due to class-time limitations, teaching the new computerized systems was favored over the old (manual) techniques. With time, this meant that students became more and more competent computer users but were not equipped with the hand drawing techniques so important in rapid communication of ideas. Some of these basic drawing skills were replaced by sophisticated digital rendering whose realism and accuracy remain a necessary part of the design process but can be detrimental in the early stages of creation and exploration.

As more and more students entering the field of design have extensive computer knowledge and ability, many of them feel increasingly confident using that technology to express their designs than hand-drawing and rendering techniques. This can be problematic, however, as we begin to see the effects of computer driven design as opposed to designer driven work where students feel confident with the tool but lack the ability to realize their concepts due to their limited knowledge of the newly introduced software packages. Increasing the students' ability and confidence using hand drawing, therefore, leads to enhanced creative freedom. By teaching students manual techniques in accordance with a particular scale or unit, they are better equipped to visualize objects within a three-dimensional grid system and are more easily able to translate their ideas into 3D modeling software later.

There is no doubt that computer technology has improved and enhanced the abilities of the modern designer. In teaching creative drawing techniques, my aim is not to surpass or even match the capabilities of these modern machines, but to reintroduce an invaluable design tool that many of today's young designers have lost: quick, cheap, accurate, and efficient communication.

**The Basics: Units, Grids and Linear Perspective**

Computer-aided industrial design (CAID) software is based on the conventions of manual drawing techniques. Once we begin to understand this, the commonalities between these two seemingly autonomous techniques become increasingly evident. By finding a balance between teaching the "old" techniques of manual drawing and the "new" computer software, we can create more well-rounded students and better-equipped design professionals in the future.

The course in which I teach these methodologies is in the first semester of the students' second year of design education. The students are not permitted to use any image manipulation or 3D modeling software in any of their industrial design classes until the final project of this term. The second term is devoted to applying these concepts to a newly introduced 3D modeling CAD program.

At the beginning of this course, I introduce one-, two- and three-point perspective drawing to the class. As these students have at least one year of art or design training, I am typically faced with disappointment from the students saying that they already know all there is to know about perspective. What they don’t yet realize, however, is that designers and artists have different needs concerning the use of perspective. As an artist, I can look at a still life or a live model and interpret the gesture of the model or the essence of the still life using perspective techniques. As an industrial designer, however, I have to take whatever I have in my mind and then translate that back to a sheet of paper in the most accurate and descriptive possible way. To illustrate this fundamental difference, as a first project, I ask my students to draw a perfect cube. This seemingly simple challenge underlines for them the fundamental difference between artistic drawing and descriptive design drawing.

After I have introduced basic linear perspective, I talk about its history beginning with its creator, Filippo Brunelleschi, in the Italian Renaissance. The main technique that I use to teach perspective drawing for industrial design comes from the methodology of Jay Doblin, from his book, first published in 1956, *Perspective: A New System for Designers*, in which he talks about 45-degree perspective
and 30-60 degree perspective that sets out a system for students to start drawing perfect shapes, perfect cubes.

In my experience teaching industrial design, I have also found that the students have some difficulty understanding units and scale as well as their relationship to each other. In the real world, it's not difficult to see the difference between a centimeter and an inch; however, in the virtual world of CAID software the units that we see on a computer screen indicating millimeters, feet or kilometers look identical and to add to the confusion, they are described or displayed with pixels. By creating a parallel of these virtual units to the actual world, we can achieve a good understanding of scale. The best way to attain this understanding is to first teach students about units and grid systems using hand drawing techniques by dividing a square with diagonal and straight lines to indicate units (inches) and their relationship to the division of these inches into halves, quarters, sixteenths, and so on. (Figure 1.)

![Figure 1.](image1)

The next step is to relate that information to a three-dimensional cube. This is accomplished with help of platonic solids, namely hexahedron, octahedron and tetrahedron and their geometric unity with each other. As the octahedron and tetrahedron can fit perfectly within the cube (hexahedron), they allow for complex three-dimensional division of a cube that is the basis for this drawing technique. I teach the students how to use the division of simple squares and cubes to draw anything that they can imagine, in perfect perspective and scale.

![Figure 2.](image2)
By handing out printouts of these unfolded shapes I ask students to make multiple copies and assemble these objects into 3D solids from the flat surface. (Figure 2.) This seemingly simple process once again has a relationship between the real world and the computer world, allowing me to introduce the relationship between curves, surfaces, and solid objects, where the edges of the shapes represent the curves, the faces are the surfaces, and the assembled, 3D shapes become the solid objects. These physical, 3D objects also allow me to start introducing the idea of building with units by stacking the cubes next to each other and on top of each other. (Figure 3.) Anchoring creative drawing on the box system allows me to relate the importance of proportion in drawing to the physical world, and gives students the basic skills to draw the allusive perfect cube.

Information Gathering: Orthographics, Contours, and Cross Sections

Orthographic views are all about looking at the different aspects of the object: top, front, and sides. Having assembled the platonic solids, the students easily visualize and comprehend the relationship of each view to another. I then ask them to unfold these objects in their minds’ eye, and it is in this unfolded state that the objects describe the basis for orthographic projection.

Figure 3.

The next step in my approach is to use orthographic drawing as a tool for gathering information from a real object that can be used for creating perspective drawings based on particular size and unit. At first, I ask them to gather information from an existing object, such as a small electronic device, and to create basic orthographic drawings from the object at 1:1 scale. As these drawings will later be the only source of information used to create a perspective drawing of the product, they are asked to include as much detail as they feel that they will require. By asking the students to rely on orthographic information alone to create a 3D drawing, the skills required to draw an invented, nonexisting object are established.

Critique sessions are invaluable tools that accelerate this complex learning process. Through building critique time into almost every class, the students can receive constructive criticism about their work from their classmates and myself, quickly preparing them to move on to the next assignment. This open dialogue also helps them to be able to present their own work, expands the student’s ability for critical analysis and opens up the collegial lines of communication.

By giving the students confidence to ideate their ideas on paper before turning to the computer, students become more creative with their concepts, and instruction tends toward design problems rather than computer problems. These newly acquired skills will also be beneficial later, in creating objects in computer space where orthographic sketches on paper and quick perspective sketches are extremely helpful in modeling new designs.

Teaching cross sections and contour lines in perspective drawing is also very important to the students’ understanding of 3D representations of objects. Using these curves in drawing allows for a
clearer representation of complex forms. This particular ability is introduced through the creation of a model of an existing small product, wherein the students create a 1:1 scale model using only contours cut out of flat cardboard. This ability has a further application in CAID where contour lines are used for lofting, revolving, sweeping, and many other essential software commands.

**Photography and Stylized Hand Rendering**

Now that the students understand how to create objects within the box system, I am able to take this technique a step further and introduce them to more stylized rendering using distortion. At this stage, I introduce them to perspective based on a 35 mm camera using various types of lenses. By exploring these different types of equipment, students become much more aware of the distorted differences between wide angle, telephoto and other focal length of lenses. To illustrate this, I have created simple line drawings of boxes simulating these focal lengths and allow the students to place a piece of tracing paper on top of these boxes and then create their drawings within them. (Figure 4.)

![Figure 4.](image)

Coming back to the paper boxes that we created in the first project, I use them in this module to illustrate linear perspective using photography. By arranging the cubes into a row and photographing them, students are able to easily understand and visualize the way that each of these objects relate to one another in perspective. (Figure 3.) In these photographs for instance, the circles that are printed on the side of the boxes become ellipses when viewed in perspective. It also becomes very evident how these ellipses evolve and multiply as they move towards the vanishing point. (Figure 5.) This understanding is essential to drawing any object based on a circular or organic shape in perspective.
Another thing that I do throughout this class is to draw in front of the students using a camera–
projector system. I will explain these concepts or methodologies to the students while illustrating
these on the large projection screen in real time. I find that this technique is also extremely helpful in
answering any questions that the students might have.

**Real Life Experimentation: Light and Shadow in Rendering**

In today’s world, computer-generated renderings will often act as photographic representations of real
objects. Early in the design process, the expressiveness of hand drawing and rendering, including line
weight, white space and shading, are advantageous to the communication and ideation stages. Later,
these unique features of hand drawing can also be used in more detailed or stylized ways to
communicate not just the form, but also the personality of a designed object. For these types of
drawings, or even just to ground a simple sketch, a good understanding of light and shadow is
necessary. Direction, height, and angle of the light are simple and yet allusive topics that I introduce
through the use of worksheets and by continuing to sketch in front of the class responding to related
questions.

Using only black, three shades of gray markers and the white of the paper, we look at the relationship
of real world light and shadow to the simple cube. The students’ first introduction to shadows and
renderings takes place in a dark room with one light shining onto a small cube. This stark light source
gives a clear visual indication of the shading differences on the sides of the cube and the direction,
height and angle of the light as it relates to the shadow casted by the cube. Light intensity variations
and color are introduced at later date. Using these four markers, students are asked to go through
many short exercises to help them to understand these newly introduced concepts. This is a quick
exercise that allows for multiple drawings to take place during one individual session. Slowly, the
objects I ask them to shade get more complex and the exercises more challenging, taking the
students one step closer to the ability to expertly use creative shadow techniques. Once again, the
information acquired in this exercise can be directly applied CAID for the lighting set-up in computer
rendering, making this later process quicker and more effective.

Once we have covered all of these various aspects of creative hand drawing, the students are finally
asked to use these new techniques in conjunction with an image manipulation software program.
Using the line drawings and gray-scale renderings that they have created in class, the students are
asked to scan these images and then manipulate them in computer space. At this point all elements
of drawing are brought together: scale, units, orthographic drawing, linear perspective, grid systems,
and shadows are all required to accurately transport their drawings into the photographic environment as a way of realistically representing their ideas in situ.

Conclusion

Drawing is not something that can be learned if not practiced. The skills acquired in this class have to be nurtured and tested throughout in order to keep the students’ momentum and to increase their skill level until drawing becomes something that they enjoy doing. By teaching this methodology to the students, hand drawing becomes an integral part of their personal design process, and re-enforces the need for continuous practice and use.

In the second semester of this class, the students are finally introduced to the 3D modeling computer program. Through founding the students’ approach to the design process in drawing and supplying them with the tools necessary to apply these techniques to computer modeling, the students have a much easier time comprehending the capabilities of this new tool. They also continuously practice their drawing skills, going back and forth between paper and software throughout every project.

In past years, before I began teaching this methodology, many students lacked confidence in drawing and treated it as an unwanted or unnecessary task standing in the way of the “cool” stuff as opposed to a natural and vital step before one gets there. This combined approach to design education has resulted in improved design concepts, a quicker and more comprehensive understanding of the software and more accurate communication between students and instructors at all stages of the design process.

References


