ENGINEERING AND PRODUCT DESIGN EDUCATION CONFERENCE
7-8 SEPTEMBER 2006, SALZBURG UNIVERSITY OF APPLIED SCIENCES, SALZBURG, AUSTRIA

VIRTUAL PRODUCT DESIGN STUDIO

James Arnold

ABSTRACT
This paper examines 3D virtual product design opportunities, limitations, currently needed skills, and what should be emphasized during the educational process of future product designers. Virtual space serves as a product development environment for thousands of companies around the world. Product design in virtual space has opportunities and limitations; likewise, product design conducted in physical space has opportunities and limitations as well. Balance is needed in design education.
Through analysis of want-ads and 2 case studies, this paper reveals that Solids/Parametric and surface/NURBS modeling are roughly equal in popularity at product design organizations and that design in virtual space has certain advantages.
This paper is of interest to product design educators and practitioners concerned with all phases of the product design process. The conclusion describes how design education can better provide adequate training in virtual product design studios. New designers need this training to be effective and global industries demand it.

Keywords: Product Design, Computer Aided Design, Design Software, Co-Design

1 INTRODUCTION

In the field of product design today, how important is 3D CAD knowledge? What are the challenges and benefits of working in a 3D CAD environment? How should designers be educated and what should they know as they enter the workforce? These questions are important as educators plan curriculum. A content analysis of want-ads covering three months out of the last three years (2003-2005) for industrial designers found in *Design Perspectives*, the monthly newsletter of the Industrial Designers Society of America, suggests that almost three quarters of design jobs in the US demand some kind of 3D CAD skill.

Table 1. 3D CAD skills required for industrial designers

	Ads for Designers	3D CAD Required
Total	121	86 (71%)

This study did not reveal companies that do require CAD skills and do not advertise for them. It is safe to assume that the percentage of companies that actually require CAD skills in new designers is significantly higher than 71%. This is because CAD skills are now the standard among many practitioners [1] and there is a cost per word in want-ads. Mentioning CAD skills in a want-ad may be viewed as unnecessary.
3D CAD skills enable design team members to collaborate in a virtual studio space that has advantages and disadvantages over design in a physical studio space. Knowledge of 3D CAD, or virtual design space, is obviously needed in education. A discussion of: the

importance of virtual space, 3D CAD myths, current popularity of various design software, 2 case studies, and how to integrate 3D CAD into the curriculum follows.

2 THE VIRTUES OF VIRTUAL

In the world of fast paced product development there is no room for time spent waiting for others to finish their work before you begin yours. The old process of passing a design in development to the next group in the product development chain by “throwing it over the wall” is a dying approach to product design. Concurrent design’s effectiveness lies in the fact that problems can be solved earlier in the design process and synergistic solutions can be more easily incorporated into the design without having to make drastic changes to a concept later in the design process.

While never a replacement for a designer’s creativity, knowledge, and traditional analogue skills, design in virtual space, using 3D CAD software, makes this collaborative approach to design work more efficient and effective. It provides a common space (in parallel with physical space) where distinct parts of a design may be worked on by separate individuals or groups. This virtual design space, which exists on the computers and servers of design organizations, also houses various tools – not unlike tools found in physical spaces. Virtual tools have counterparts that are not unlike their physical counterparts such as saws, drills, measuring devices, sheet metal benders, mills, and sanders. Some virtual tools also have capacities that are far beyond the realm of physical possibility that can provide information and help the design team change directions rapidly. These capacities are not always possible with physical material and prototypes.

2.1 Myths about 3D CAD

Designers of an award winning automobile said, “The math-based tools allowed us to get to a full-size, 3D sketch very quickly so everyone could interact with it and understand very easily how it could translate into an actual production vehicle,” [2]. This statement suggests that 3D CAD tools in general can be thought of as distinct items within a virtual space that can be used to facilitate activities or help us manipulate things as one goes through the design process. A computer in a design studio represents not only a tool, but a kind of portal into a parallel studio space where various tools are used and design is facilitated. Simply describing the computer as a “tool” fails to recognize the vital roll it plays in the current and future process of product deign. In the world of fast passed product design 3D virtual space is a necessary place for designers to be intimately familiar with in order to be successful.

NURBS (Non Uniform Rational B Spline) program users often encounter a misconception that NURBS programs, such as Alias Studio and Rhino, are less effective when it comes to rapid prototyping or for producing data files that can be used for tooling. This misconception probably stems from the fact that NURBS modeling software allows for extreme modeling flexibility and allows inconsistencies not typically found in solids/parametric modeling programs. For example, one can create a 3D NURBS model with gaps between surfaces which appear continuous when viewed on screen but present problems when transferred to rapid prototyping or parametric/solids modeling programs. When a NURBS program user employs proper techniques, usable surfaces can be created that have little or no difficulty transferring to other programs or technologies. Problems that arise are usually the fault of the program user, not the software. Solids modeling programs such as Pro-E or Solid Works

typically do not have the capabilities or inherent flexibility of NURBS programs and the resulting myth can be that solids modeling programs are “better.”
Cost of some 3D CAD programs sometimes means more efficient tools – not higher quality. For example, an Alias Studio user might think that because it was purchased for $25,000.00, a higher quality model can be achieved than if Rhino was used. Again, quality in this situation might depend heavily on the software user and not the software being used. Efficiency and model quality are not the same and should not be confused. It may be true that Alias Studio has some very effective tools that can aid in the modeling process, but that does not necessarily mean that the Rhino user will have a more difficult time creating tooling ready surfaces, getting concepts to production, or solving highly complex modeling challenges using Rhino priced at under $1,000.00.
There are myths about the popularity of certain leading design software as well. For example, a designer might assume that Pro Engineer is the leading design software used and that solids/parametric modeling is the dominant trend in 3D CAD. Table 2 and 3 suggests that the most popular 3D CAD programs, and NURBS vs. Solids programs, are almost evenly used by industrial designers at companies looking for new employees. The other combined category represents programs such as IDEAS, Unigraphics, and Catia.

Table 2. Programs used at hiring companies

	Alias	Rhino	ProE	SW	Other
Total	26	21	24	27	15

Table 3. NURBS vs. solids at hiring companies

Issue/Year	NURBS	Solids	NURBS&Solids	Unknown
Total	23	23	21	25

2.2 Design Facilitator

While never a replacement for a designer’s physical space and tools, virtual space can facilitate more effective and efficient product design. In the case of the Motorola RAZR “…a 3D digital model created in CAD software was used to mold the shape around the internal components to define the design and reduce the volume even further.” [3]. The RAZR design team used virtual studio space to optimize the concept through an integration of different functional and aesthetic aspects in one design environment. This product won an IDEA Gold award in 2005 and is one of the most popular cell phones today.
Virtual design space also facilitated the design of the Chevrolet SSR. “The latest product development processes were used, engaging state-of-the-art computer design tools. This enabled a concept-to-reality phase of two years without visual compromise, demonstrating that Chevrolet could respond quickly to market demand.” [2]. The SSR’s visual appeal was optimized through collaboration in virtual space – winning an IDEA Gold award in 2004.

2.3 Case Study 1

As an industrial designer, the author worked at and observed a recreational boat manufacturer in the United States, from May 1997 to July 1999. This company developed new products at a design and engineering facility – from initial scope and specifications to final prototypes and produced the associated tooling. 3D software was used for concept development, engineering, and for the production of tooling through the use of CNC milling technology.

At this facility, industrial designers and engineers worked simultaneously after the industrial designers created a preliminary model of an approved concept. The aim was to develop production ready prototypes quickly (within 4 months). Typically, the industrial design component of the development team produced a 3D virtual mock-up of the entire boat that was evaluated “on screen” and through cutting a scale model using the CNC mill. When an overall concept was approved, the industrial designer involved would further develop and refine the more visible and user-interactive areas of the boat such as the deck interior, exterior, and cockpit areas. The engineer would focus on the performance parts of the hull, such as the running surface, and mechanical workings of the boat.

Throughout this collaborative process the industrial designer and engineer would create files (i.e. iges files) that could be shared to communicate intent and for reference. These files could be understood and translated by either the designer’s or engineer’s software. The industrial designer used Alias Studio which creates surface geometry that is particularly easy to manipulate and sculpt. The engineer used Unigraphics which is a surface and solids modeling program particularly suited to engineering needs.

Important decisions and changes could be made at an early stage in product development without investing large amounts of time and money in physical mock-ups and prototypes. Human factors simulations and photorealistic images were used to communicate with non designers in company.

2.4 Case Study 2

As an industrial designer, the author worked at and observed a company that manufactures electrically powered wheel chairs and scooters for people with personal mobility needs (i.e. elderly and physically disabled) from 1999 to 2003. This company developed new products at a design and engineering facility – from initial scope and specifications to final prototypes. The documentation and computer files used to create tooling were sent to various manufacturing facilities in the United States, Korea, and China for production. Computer software was also used for concept development, engineering, for the creation of rapid-prototype (i.e. SLA, SLS, and FDM) parts used in the evaluation and marketing phases of product development.

Industrial designers and engineers worked simultaneously on distinct but highly integrated parts of vehicles after a preliminary scope and specification was produced. The aim was to develop concepts quickly into final prototypes – within 2-3 months. The computer played a key role at integrating the work of the designer and engineer who worked as a collaborative team. Additionally, upper level management had a working knowledge of modeling software, so their ability to participate in the design process was enhanced. Together, designers and engineers worked on configurations and refinement of concepts through to the final stages of product development. Key to this process was the creation of full sized working prototypes for testing. Physical and rapid prototyped parts were produced in order to check fit, evaluate, test, and begin the marketing process. Throughout this collaborative process the industrial designer and engineer used the same software (i.e. Solid Works) as a common design space.

Important decisions and changes could be made at an early stage without wasting large amounts of time and money to rework prototypes. Mechanical configurations and movement could be simulated and photo realistic images could be sent to non designers in the company for evaluation.

3 FOR THE CIRRICULUM

Balance of the physical and virtual in education is necessary; but how can this be done when there is a need for more CAD instruction and the curriculum is already filled to capacity with other necessary courses? Following are three ways this can be achieved: integrated studio courses, elimination of outdated courses, and offering web based courses.

Design studio courses can integrate 3D CAD as part of a design project even if the students are unfamiliar with the 3D software. For example, the author has found that many design students can learn the basics of geometric modeling and become proficient enough to create forms that are, in many cases, as complex as hand made appearance models in the space of a few weeks rather than the space of a typical semester or quarter. In this example, it is helpful when the instructor knows the software and can lead the student through exercises beyond simple tutorials included in software documentation.

Courses that were once thought to be necessary may actually be eliminated from the curriculum. For example one may find that manual drafting or specialized drafting software instruction may be eliminated or absorbed into 3D CAD courses because in professional practice 3D digital models often completely replace the need for 2D drawings formerly use to create tooling or to otherwise communicate design intent. Many 3D CAD packages also contain drawing functionality that allows the 3D model to be imported into a drawing mode for 2D printing purposes [4].

If there is simply a lack of classroom space or funding to support computers, software, and desk space in an educational facility, internet based tools can provide a solution. Web based leaning is becoming mainstream in many programs of higher education. *WebDeGrator* [5] is one example of an online 3D interface that can help students learn principles of 3D CAD in an interactive way.

4 CONCLUSION

In the hands of designers and engineers, 3D CAD tools can be used to facilitate a more effective and streamlined design process through the following:

- Collaboration with others can be enhanced in two ways: visual based systems (e.g. visualizing, inspecting, and annotating design models in a Web or CAD space) or co-design systems in a CAD space (e.g. "interactive co-modeling and co-modification") [6].
- Better integration between designers and engineers "…data can be transferred into engineering design (3D solid modeling) systems, allowing the entire development process to be more easily integrated." [1]; this is true whether it be through NURBS model transference or through use of a common solids modeling program between engineers and designers. Engineers and industrial designers can both use solids modeling programs to co-create in the same virtual environment. While using the same programs, they can increase their collaborative capacity because common knowledge about how to manipulate parts and assemblies in 3D virtual space is shared.

As mentioned in tables and case studies above, there is a need for knowledge of NURBS technology (especially for industrial designers) and Solids/Parametric technology. Industrial designers usually work with both NURBS and Solids modeling technology in roughly equal amounts. For industrial designers, a balanced education in NURBS and Solids modeling is of benefit. Solid Works and Pro-Engineer are most frequently used in industry, unless one considers specialized industries such as the automotive industry where programs like Catia and Unigraphics are more frequently used.

The potential for curriculum enhancement and research opportunities exist in the area of 3D CAD collaborative technologies that enable design team members to co-design with each other remotely (e.g. using the internet for collaboration with those in other countries) [7], and with potential end-users through participatory design methods found in user-centered/human-centered/co-design approaches [8]. The need for research in this area will be of growing importance – considering the global nature of product development. The virtual design studio of the future will extend beyond the walls of one facility. For example, production efficiencies may be optimal in one country, skilled design team members in another, and those with design research input in yet another.

REFERENCES

[1] Ulrich K.T., and Eppinger S.D., *Product Design and Development 3rd Edition.* Tara McGraw-Hill, New York, 2004.

[2] Durmisevich G. and Witzenburg G., Truck or Roadster? *Innovation*, Vol. 23, No. 3, 2004, pp.220-224.

[3] Wicks J. and Caruso F., Thin is In. *Innovation*, Vol. 24, No. 3, 2005, pp.69-73.

[4] Branoff T.J., Hartman N.W., and Wiebe E.N., Constraint-Based Three Dimensional Solid Modeling in an Introductory Engineering Graphics Course: Re-examining the Curriculum. *Engineering Design Graphics Journal*, Vol. 66, No. 1, 2002, pp.5-10.

[5] Sung W.T. and Ou S.C., Web-Based Learning in the Computer Aided Design Curriculum. *Journal of Computer Assisted Learning,* Vol. 18, 2002, pp.175-187.

[6] Li W.D., Lu W.F., Fuh J.Y.H. and Wong Y.S., Collaborative computer-aided design-research and development. *Computer-Aided Design,* Vol. 37, No. 9, 2005, pp.932.

[7] Shyamsundar N. and Gadh R., Internet-based collaborative product design with assembly features and virtual design spaces. *Computer-Aided Design,* Vol. 33, No. 9, 2001, pp.637-651.

[8] Sanders E.B.-N., Harnessing People's Creativity: Ideation and Expression through Visual Communication. In *Focus Groups: Supporting Effective Product Development*. Langford J. and McDonagh-Philip D. (Eds.), Taylor and Francis, 2001.

Contact info

James W. Arnold, Assistant Professor
The Ohio State University
380 Hopkins Hall, 128 N. Oval Mall
Columbus, Ohio 43210-1318 USA
Telephone: 614-292-1766
Email: arnold.650@osu.edu