AUTOMOTIVE DESIGN EDUCATION: INTEGRATING COMPUTER BASED TOOLS WITH TRADITIONAL TECHNIQUES

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AUTOMOTIVE DESIGN EDUCATION: INTEGRATING COMPUTER BASED TOOLS WITH TRADITIONAL TECHNIQUES

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To my family, my teachers, my students, and especially Tracey who have all inspired me.

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LIST OF ABBREVIATIONS

AAU	Academy of Art University
ACCD	Art Center College of Design
AIP	Art Institute of Pittsburgh
ASC	American Specialty Car, Inc.
BA	Bachelor of Arts
BFA	Bachelor of Fine Arts
BID	Bachelor of Industrial Design
BS	Bachelor of Science
BYU	Brigham Young University
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CAID	Computer Aided Industrial Design
CAM	Computer Aided Manufacturing
CCS	College for Creative Studies
CDN	Car Design News
CFD	Computational Fluid Dynamics
CG	Computer Graphics
CIA	Cleveland Institute of Art
CNC	Computer Numeric Control
DAAP	Design, Art, Architecture, and Planning
DIAS	Detroit Institute of Automotive Styling
FEA	Finite Element Analysis

GM	General Motors
GPA	Grade Point Average
HCD	Human Centered Design
HCI	Human Computer Interaction
MIT	Massachusetts Institute of Technology
NASAD	National Association of Schools of Art and Design
PACE	Partners for the Advancement of Collaborative Engineering Education
PLM	Product Lifecycle Management
RP	Rapid Prototyping
SCAD	Savannah College of Art and Design
UC	University of Cincinnati
VR	Virtual Reality

SUMMARY

This paper begins by showing the need and motivation for an examination of automotive design education. Following that is an overview of the current state of the art in the field as exemplified by the programs of Art Center College of Design, College for Creative Studies, Academy of Art University and other institutions offering undergraduate transportation design programs in the United States. Particular attention is given to the integration of new technology into the design curriculum. Once the baseline has been established and the range of current practice revealed, possibilities for the future are explored through the insight of leading educators, software developers, and professional design studios. Not to be overlooked but slightly tangential to the thrust of this paper is the great importance of the student population and educational theory.

Ultimately this paper will grapple with the opportunities presented by the introduction of computer based design tools into the traditional industrial design education process. Proposals will be made with regard to new curricula that better serve the students, the academic institutions that prepare them, and the industry to which the graduates matriculate.

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CHAPTER 1

INTRODUCTION

The field of automotive design has relied heavily on oral tradition to pass its foundations from one generation to the next. Like the coach building craft of pre–industrial Europe that passed its knowledge from master to apprentice, the tools and skills of automotive design have been taught by experienced practitioners to eager students primarily via demonstration and word of mouth. This has preserved and nurtured a rich heritage but perhaps at the expense of innovation and understanding of the field outside of its circle of practitioners. Perhaps ironically, the acknowledged father of automotive design education, Andrew F. Johnson, did the majority of his teaching via correspondence. Arguably, the Internet has made such an educational process once again viable.

With the advent and proliferation of the computer in society, traditional methods in innumerable fields are being challenged and questioned. Automotive design, and specifically automotive design education, faces this conflict. The evolution if not resolution of the conflict between traditional automotive design methods and the developing tools based on the computer (three-dimensional modeling, simulation, digital rendering, electronic presentation and review…) in the educational setting is a central focus of this paper.

Given that the dissemination of automotive design skills is so dependent on a personal and oral tradition it is not surprising that relatively little is written for or about that educational process. Most of the available literature is written for a popular audience from an artistic point of view. There are books that offer instruction in the use of traditional tools in the design process but these focus on the use of the tools in a narrow context (Hoadley, 1999; Krist, 1989; Taylor, 1996; Turner, 1999). Indeed, there are books -- and DVDs -- that teach the use of digital tools to create automotive images (Holland, 2005; Krumweide, 2003). The concentration, regardless of the media (traditional or digital) is on “how to draw” cars or how to make models (clay, foam, or math) not how to design cars. Only when the focus is broadened to include multiple tools and process can the issue of design begin to be addressed. Certainly there are numerous books that detail general industrial design practice, methods and tools (Baxter, 1995; Cagan & Vogel, 2002; Coates, 2003). Those books that do pertain to the overall process of automotive design are very heavily weighted towards the design engineering side of the equation and tend to diminish the contribution of industrial design (Korff, 1980; Norbye, 1984). Too frequently, any aspects of the automobile that require attention to appearance are belittled with the sometimes pejorative label ‘styling.’

There is a great deal of literature available that chronicles the results of the automotive design process. Some of these take the form of general design histories (Armi, 1988; Lamm & Holls, 1996; Nesbitt, 1985; Sparkle, 2002). Others take the form of beautiful coffee table books concerned with design prototypes (Bellu & Vann, 1989; Kuah, 1989; Piccard, 1981; Rees, 1999; Wood, 1998), single marques (DeLorenzo, 2000; Rogliatti, 1990), or company profiles (Marshall, 2000). Still others are case studies concerning particular models (Lamm, 1979; Ludvigsen, 1978; Schefter, 1996; Witzenburg, 1986). Like all industrial designers, automotive designers are, to a great degree, generalists. For the most part, the textbooks that are used are borrowed, metaphorically speaking, from engineers (Hucho, 1990), artists (Dalley, 1981; Kemnitzer, 1983), psychologists (Bayley, 1986) and sociologists (Gartman, 1994) to name just a few. Only when all these types of books are taken collectively does a clear picture of the automotive design process begin to appear.

The lack of available literature on automotive design education is also attributable to the fact that it comes from a small group in the relatively small field of industrial design that chooses to focus on the automobile or slightly more broadly, transportation. According to Bureau of Labor Statistics data from 2002, there are 52,000 industrial design professionals in the U.S. (Bureau of Labor Statistics, 2002). A reliable count of professional automotive designers does not exist but a liberal educated guess puts the number at 1,000. Add to that number approximately 600 automotive design students in recognized programs in the U.S. and the small handful of full-time automotive design educators. David Gartman has argued that the lack of scholarly literature in the field is partly attributable to academic snobbery (Gartman, 2004). One might simply assert that those most intimately involved in automotive design are prone to drawing rather than writing. Although the number of practitioners is small, the influence is great. Over 60 million cars a year are built (McElroy, 2005). In 2005 there were 850 million automobiles in the world; by 2020 it is estimated that there will be 1.1 billion (Duchene, 2006).

The field of automotive design currently enjoys unprecedented influence within the automotive industry. Design has been widely recognized as an efficient means to distinguish one vehicle from another (both within a single manufacturer’s offerings and as compared to the competition) and increase market share via the superior design of otherwise very similar competing products. No longer can manufacturers count on a few models being sold by the hundreds of thousands. The market is now subdivided into dozens of niches and manufacturers seek to become dominant within these niches. Market analysts AutoPacific Inc. estimate that by 2009 there will be 277 distinct models of cars and light trucks offered in the U.S. (Vlasic, 2006). Competing in numerous niche markets requires a greater number of vehicle models, each tailored for a specific market and each requiring its own design. As competitive economic forces require companies to run leaner even in the face of the proliferation of models, the training and hiring of the best young designers becomes increasingly critical to the industry as a whole and to individual manufacturers. Industry is demanding graduates who are ready to perform fresh out of school and is no longer in a position to take time to train new hires. This responsibility is falling ever more heavily upon the design programs of the country.

The motivation and justification for this thesis may be summed by the following: the dearth of extant literature on the topic and the need to document current practice, the introduction of new technology and the associated opportunities, the growing influence of automotive design on the industry, and the desire to stimulate further exploration of the topic. Perhaps most importantly, the intent is to suggest possibilities that may improve the educational process thereby benefiting the students, their academic institutions, the industry, and hopefully society in general.

Scope

The scope of this investigation is limited to undergraduate design programs in the United States with an established concentration in automotive (or transportation) design. This is not intended to be an exhaustive review of design school curricula nor is every program scrutinized. Not every institution contacted was willing to participate in the research and participation varied from program to program. Likewise, professional designers' and major manufacturers' participation has been limited to those who voluntarily responded to research inquiries. The same is true of technology venders and developers contacted in the course of this research. The observations, comments, and theories herein are neither to be construed as endorsements nor indictments of any particular program, educator, company, designer, or product.

The intent of this paper is not to be a definitive work but rather to point in the direction of promising possibilities and spark a continuing inquiry and dialogue in the automotive design community. To borrow from Mazda's recent concept car, the Kabura, this paper, like the name of the car, is the first arrow released starting the battle (Mitani, 2006).

Method

The primary method of inquiry employed in this research has been personal interviews of expert practitioners in the pertinent fields. This approach provides the most accurate, first hand information. In a field that does not have a tradition of scholarly research or the associated library of documentation, primary sources are frequently not only the best sources but also the only sources. That said other methods have been used in addition to interviews. Just as good design usually comes from the skilled use of complementary tools, sound research must draw from multiple methods.

A ‘classical’ automotive design education at Art Center College of Design (1990 graduate of the Transportation Design program) twelve years of first hand observation and experience in the automotive design profession (primarily in racing), and three years of teaching automotive and industrial design provide significant first-hand understanding of the topic. Additional observational research was completed during brief visits to Art Center College of Design in Pasadena, California and Art Academy University in San Francisco in 2003.

In addition to the customary literature review, careful examination of the program curricula and educational philosophy as posted on the schools’ websites and in other materials published by the institutions provided much valuable information. Finally, a series of targeted surveys were distributed to the relevant populations: educators, students, design professionals, and technology providers.

Thesis

I think it is appropriate that just as industrial designers (and automotive designers) are almost by definition generalists, so too must be the philosophy of their education. There is little debate as to the considerable merits of both traditional industrial design tools and techniques and those afforded by computer technology. They are symbiotic and at this time it would seem almost nonsensical to declare one superior to the other. The great challenge is the integration of both sets of tools in a practical academic setting. Industry demands designers who have a profound understanding of design and communication fundamentals. At present those core aspects of automotive design are still best taught using pen and paper, foam and clay. Industry also demands designers who are fully prepared to work in a digital environment, maximizing the efficiency of the design process. This requires extensive training and experience at the academic level. The successful design program must integrate both the old and the new into both the curriculum and the design process. Rapid evolution of new technology and a fluid environment in industry must be embraced and accommodated by any program that aspires to have continuing success and health.

CHAPTER 2

STATE OF THE ART: UNDERGRADUATE TRANSPORTATION DESIGN PROGRAMS IN THE US

A Brief Early History

At the close of the nineteenth century, as the invention of the automobile was unfolding and evolving much of the engineering was borrowed from steam locomotives, bicycles, and the general technological fruits of the industrial revolution. Automotive design as we might understand it in today's context was predominantly *ad hoc* or simply non-existent. In the earliest days, if the vehicle was indeed auto-mobile then, in many respects, the design could be judged a success. Form did not simply follow function but was the mere residue of it.

Soon the functional aspects of this new form of transportation were well enough understood and executed that those involved in the field looked to improve these products beyond elementary function. Design gained its inevitable foothold as engineers and inventors refined their machines. Horseless carriage enthusiasts turned to the art, craft, and technology of the traditional carriage trade and that of the shipwright. [Part of the carriage builders' legacy survives in the marketing nomenclature, if not the actual shapes, of today's body styles. Break, brougham, cab, cabriolet, coupe, landau, phaeton, spider, tonneau, and Victoria are but a few of the descriptions of carriages, carts, or wagons that were initially pulled by horses and were adapted into early automotive forms (Haajanen, 2002).]

From the shipbuilders early automotive designers and their precursor, brethren the carriage builders adopted the practice of modeling and lofting to envision and build bodies. This was one of the primary skills that Andrew Johnson learned at the Technical School for Carriage Draftsmen and Mechanics, New York, in 1885 and subsequently taught his students at the appropriately renamed Technical School for Carriage and Automobile Body Designers and Draftsmen (Lamm & Holls, 1996). So central to the understanding of automotive form, volume, scaling, and craft has been lofting that it has been a fundamental lesson in some curricula virtually to the present day.

Arguably, Mr. Johnson educated the modern day equivalent of manufacturing and design engineers much more so than the J Mays and Bryan Nesbitt types of the early twentieth century like Ray Dietrich or Frank Hershey. Just the same it was upon this foundation that specialized coachbuilders began to be a part of the automotive landscape. The elite chassis of the day were clothed for a discriminating, wealthy clientele by renowned craftsmen and artists in very small numbers but their influence soon reached the masters of mass production. The shrewd appreciation for marketing (product differentiation, hierarchies, planned obsolescence…) of Alfred P. Sloan at General Motors (GM) and other industry executives paved the way for Harley Earl and the “art and colour” departments of major manufacturers. GM was very much at the forefront of this movement along with some of the smaller companies. Ford and later Chrysler joined in as competitive pressure from GM made it a necessity. Eventually these new divisions evolved into the design (and styling) functions that we recognize today.

The culture and commerce of the U.S. in the 1920s began to embrace the fruits of the young field of industrial design. Industrial design curricula and more vocationally oriented relatives arose out of established art schools, and colleges while some were created from whole cloth. The automotive industry beckoned yet for many years there were no established automotive design schools in spite of several attempts. Manufacturers took things into there own hands. Chrysler offered a course in body design at the Chrysler Institute beginning in 1932. By the mid to late 1930s, under the direction of Harley Earl, GM in particular was developing close relationships with many art and design schools, helping to establish or strengthen industrial design departments in order to train and hire the best new talents. Detroit was calling to aspiring automotive designers from Pratt Institute in New York to Art Center School in Los Angeles.

GM was looking at illustrators, advertisers, artists, and product designers to find the group that would become the core of American automotive design. Earl went so far as to set up a sort of school for these recruits from the far flung corners of the country. In 1938 the Detroit Institute of Automotive Styling (DIAS) was founded. This was part finishing school and part tryout. The students were paid a very modest salary and at regular three month intervals the aspiring designers were either ‘thrown out’ of the program or given a modest, some might say token, raise (Crippen, 1984-1989). Upon completing Mr. Earl’s program of about one year the reward was a professional job at GM. With the exception of a hiatus for World War II, the program carried on in some fashion until 1948.

Just as the Technical School for Carriage and Automobile Body Designers and Draftsmen spawned a generation of designers, so too did the DIAS. DIAS ‘graduates’ held prominent positions in the industry up to the end of the 20th century. Perhaps none of the DIAS alumni have proven to be more influential than Homer LaGassey. A student at Pratt and DIAS, he worked for each of the big three (General Motors, Ford, and Chrysler) between 1942 and 1980 but his greatest influence was as an educator. In 1959 he founded the transportation design program at the Art School of the Detroit Society of Arts and Crafts and guided that school, known today as the College for Creative Studies, until 1987 (Lamm & Holls, 1996). Designers educated by LaGassey rose to the top of the industry and have themselves educated a new generation of car designers.

Starting with Harley Earl and GM, the automotive industry has been intimately involved with the educational process of automotive designers. Indeed this sort of relationship can be traced back to the Technical School for Carriage Draftsmen and Mechanics which was founded by the Carriage Builders National Association in reaction to a shortage of appropriately skilled labor (Lamm & Holls, 1996). Indeed, generally speaking new technologies and attendant, associated consumer demand regularly produce opportunities in academia. One might say that the industry has been responsible for educating the academic institutions. When existing programs have not been producing the personnel required by the manufacturers, those companies have initiated their own training programs or partnered with existing academic programs, usually in the realm of industrial design, to generate the desired pool of applicants.

Specific Programs in Focus

Several of the leading undergraduate transportation design programs are reviewed over the following pages. Information about the programs has been taken from the schools' published materials (web and print), personal interviews and correspondence with program chairs, faculty, and administrators and in some cases direct observation on site. This is not a point by point comparison of the programs. The intent is to reveal some distinguishing characteristics of each program and show the range of practice found today to be further discussed in the next chapter. As the preeminent programs in the field, the more detailed descriptions of Art Center College of Design and the College for Creative Studies serve to illustrate many of the common features of most, if not all, programs in transportation design.

Art Center College of Design

Foundation and History

Art Center School, founded in 1930 by former advertising man Edward 'Tink' Adams, started with 8 students 12 teachers and a philosophy that differed from the prevailing norm in several significant ways. As an advertising professional, Adams understood the commercial side of creative, artistic endeavor and its place in relation to modern business and industry, indeed, its place in society (ACCD, 2005).

Drawing on his own artistic educational experience and the many flaws he perceived, his philosophy called for instructors who were working professionals in their fields of expertise, not professional educators, steeped in academic tradition. Likewise, the students at this new school were not to be those looking to ‘find themselves’ at an art school but rather serious individuals bent on learning a chosen profession. The Art Center School would be no ivory tower but perhaps rather like a Bauhaus factory. At this distance it would appear that Adams’ vision for the school also drew more from the distant past of dedicated apprentices learning a trade from vital masters than from the university model of higher education. The enduring success of the school (accredited as a four-year college in 1949) is one of many testimonies to the viability of Adams’ vision.

Philosophically, Art Center College of Design (the name was changed in 1965) has remained true to the original vision while expanding and evolving to serve the changing needs of industry. Art Center’s reputation has always relied on extreme professionalism and close ties with industry. Those ties are maintained and strengthened by using employees of the major manufacturers and consulting designers as the school’s studio instructors and by allowing car companies from around the world to sponsor studio projects in the upper terms. By cultivating strong relationships with numerous manufacturers, the school is beholden to no one company and graduates find doors opening to them all over the globe.

Art Center’s international reputation was built largely on the foundation of a six week visit to Japan by Adams and the chairs of the transportation and product design programs in 1955. At the invitation of the Japanese government, struggling to revive the post-war economy, the Art Center contingent toured the country lecturing on industrial design and observing. This trip forged a bond between the Japanese manufacturers and Art Center that began a steady flow of the country's brightest designers back and forth to the school and was a significant step toward making Southern California the automotive design center that it is today. Without this relationship it is doubtful that Toyota would have opened their CALTY design center in 1978 sparking the proliferation of major manufacturers' design studios in the area (Ito, 2005). With so many studios in the area Art Center College of Design (ACCD) had, through mostly altruistic motives, assured itself of a deep pool of local industry professionals to instruct the students, continued strong ties to industry … and a number of potential local employers for the graduates.

Character and Academic Environment

Today, Art Center has about 1300 students enrolled in a total of ten undergraduate degree programs (advertising, environmental design, film, fine art media, graphic design, illustration, photography and imaging, product design, and transportation design) plus about 100 graduate students. The school has a co operative enrollment agreement with nearby Occidental College and the California Institute of Technology (Cal Tech), greatly expanding the range of classes offered to the student body. In the transportation design program there are approximately 120 students currently with a possible expansion of up to 192 (24 students per semester) in the near future (Lim, 2005).

The current challenge of the administration seems to be pulling the students' noses off of the *traditional* grindstone long enough to get a bigger picture of the world around them. This is not to say that there is any less material to be mastered. Quite the opposite is true. Now there are multiple grindstones. In addition to the traditional industrial design skills there is now the requirement to be fluent in CAID softwares and more conversant with engineering, well grounded in business and entrepreneurial practices, and pay greater attention to the humanities in order to better understand the automobile in context.

As has always been the case at Art Center, the student body is intensely focused on learning the skills and landing a job. Ironically it seems that in order to give students the big picture and engage them in the bigger problem solving quests of the modern world they must be taken up into the 'ivory tower' that Art Center has forever eschewed long enough to get a glimpse of what lies out before them. Students must be given the opportunity to see that there is more than mastering the process and the skill that *could* earn them a job at the car company of their choice.

Curriculum

A total of 144 units are required to earn the Bachelor of Science from Art Center College of Design. Studio courses account for 99 units. (Please note: the terms units, credits, and hours are used synonymously by various institutions to represent the academic 'value' ascribed to a particular class or program. For the purposes of this paper the term units will be used throughout.) The school is accredited by the Western Association of Schools and Colleges (WASC) and the National Association of Schools of Art and Design (NASAD).

The first four semesters are dedicated to learning the fundamentals: concept sketching, rendering, three-dimensional model making, presentation techniques, computer-aided design tools, emerging technologies and energy sources, and the principles of ergonomics, mechanical engineering, and materials technology. Of course one must not forget the required courses of the Liberal Arts and Sciences Department which are sprinkled throughout a student's eight terms. The final four terms are focused on putting the skills learned in the early terms into practice, refining skills, and finding appropriate specialties. Greater emphasis is placed on digital design techniques and presentation during the second half of the curriculum.

At the top level the school has recognized the importance of higher level education in liberal arts and sciences (BusinessWeek, 2001). Its academic courses are tailored to relevant, contemporary topics within the given subject and the relationship to design is brought to the fore. When possible, academic courses are dovetailed into concurrent studio courses so that, for example, what a student studies in a psychology course can be directly applied in a studio project. That said, there are only a given number of required units that can be devoted to this sort of more general education (45) and a number of those courses are quite specifically geared toward automotive or industrial design (History of Auto Design, Automotive Engineering, Human Factors & Design Psychology, Art of Research, Materials & Methods). Also required are one math course and one English course. That leaves 18 units (approximately six courses) for liberal arts and science electives. Another requirement that sometimes fits within the liberal arts and sciences realm is that of the Trans-Disciplinary Studio. This is another vehicle that the program is using to expand the horizons and broaden the perspectives of transportation designers.

The curriculum devotes ten classes to traditional design fundamentals. This includes a basic design class, six visual communication courses (teaching specific traditional media techniques), industrial design graphics, and perspective. As one might expect these classes are placed predominantly in the first three terms. Traditional three-dimensional modeling is the focus of four classes. Three classes are dedicated to teaching digital media.

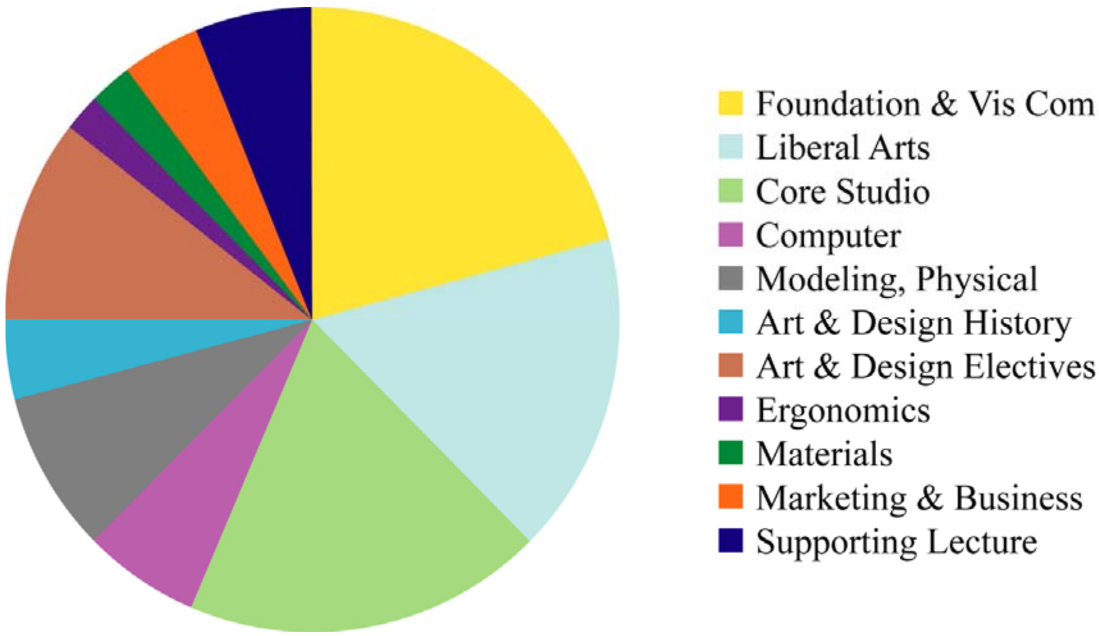

Figure 2.1 Art Center College of Design curriculum by topic

The heart of the transportation design curriculum consists of eight transportation or mobility design studios. Supporting these studios in addition to the topics already mentioned (such as automotive engineering, human factors, history of automotive design, traditional and digital modeling…) are Vehicle Architecture, Design Management, and Automotive Product Planning. These three classes are testimony to the efforts that the administration is making to produce design leaders who can easily step into management positions. The final two transportation design studios are projects sponsored by major automotive manufacturers. Over the course of these two projects, each student is given the opportunity to pull all his or her accumulated skills together to communicate an advanced design satisfying a 'real world' design brief created by the sponsoring company.

Faculty

Founder 'Tink' Adams' philosophy of using working professionals to teach studio classes remains a cornerstone of the program; to quote Adams, "a faculty of professionals rather than a professional faculty." At the time that the school was founded this was a radical idea but today this approach is the norm in leading industrial design programs. Art Center's location in the Los Angeles suburbs is ideal to draw in professionals from the many Southern California design studios, 15 from major manufacturers, and the entertainment industry (Edsall, 2003). Such a rich talent pool allows the school to choose and rotate its instructors, keeping the instruction fresh and engaging while giving the program and its faculty great flexibility. Members of the current faculty are employed by Honda, Volvo, GM, Volkswagen / Audi, and CALTY (Toyota) among others. The relatively few full-time faculty members have distinguished themselves in the industry prior to accepting full-time positions including administrative and staff duties at Art Center. In 2005, 16 faculty members taught transportation design out of over 400 total faculty members for the school. Not surprisingly, many members of the faculty are graduates of the school who have taken a position at one of the local studios or in local private practice and returned to the school to teach part-time. This further strengthens the program's connection with industry.

Facilities

Physically, the school is made up of two campuses in Pasadena, California. The Hillside Campus has been home to Art Center since 1976 when it moved from the city of Los Angeles. In 2004 the South Campus facility was opened. President Richard Koshalek has been spearheading an ambitious building campaign that will, when complete, see the construction or renovation of several buildings on both the Hillside and South Campuses vastly increasing the space and facilities of the school. The plans are as blue sky as the advanced transportation proposals found in the senior studios and may take as much as 25 years to realize if the plans are indeed pursued to completion (Ouroussoff, 2003).

The commitment to technology is evident in the implementation of ‘smart classrooms’ with integrated computing facilities and advanced audio / visual capability. The campus infrastructure is continually adapting to provide ubiquitous computing to the students and faculty. Every classroom, lab and studio is linked (hardwire and / or wireless) to the campus network and the Internet. In keeping with Art Center’s commitment to professionalism, it has been at the forefront of CAID since computers were first brought into use on the campus in the early 1980s.

What might traditionally be called the shop goes by the name of the Technical Skill Center. In addition to the tools, machines, and spaces required for fabrication, woodworking, vacuum – thermoforming, mold making and composite lay up, painting and other processes common in the creation of design models and prototypes, the center features a variety of rapid prototyping machines and associated software. Also taking advantage of the computing capability in the shop are five axis CNC mills, three axis

CNC routers (manual mills and lathes also available) and laser cutters. A well stocked tool crib also carries a variety of commonly used materials.

Upper level studio courses have dedicated studios that allow students plenty of personal work space and presentation areas. Other facilities worth noting include a library, copy centers, gallery spaces, and a student store stocked with art supplies, textbooks and other student necessities. The school cafeteria is open throughout the day for breakfast, lunch, and dinner.

Multiple computer facilities, including one in close proximity to the computer driven machines in the Technical Skill Center and the library, and connectivity for laptops help make ubiquitous computing possible on campus. Over 250 Apple and 100 PC work stations are available for student use. An array of printers (color and black and white) and scanners and other input devices (tablets) are accessible to students. As needs evolve new software is made available as appropriate. Currently the available and commonly used CAID software includes the products of Adobe (Illustrator, Photoshop, ImageReady), Autodesk (CAD and Alias including Maya and AutoDesign Studio), Bunkspeed, and Solidworks (Lim, 2005).

Students

Central to the success of any academic program is the ability to attract, enroll, and graduate good students. This has certainly been one of the reasons for Art Center's enduring success and reputation. Applying to the school is not entirely unlike submitting a job application: fill out the forms, list your credentials, perhaps have a personal interview. Just like a design job, these activities are usually mere formalities when compared to the portfolio. If the portfolio is solid then you have the job offer, or the acceptance to the program.

From the start, Art Center has attracted serious, professional-minded students who are self motivated, eager to work and to learn. There are many factors that create that situation. At first it was the economic climate of the 1930s. With the whole country in a deep economic depression even most of those who could afford the 'luxury' of a post-secondary education understood that education was a serious matter of economic if not physical survival. This attitude set the precedent for hard work that is followed to this day. The end of World War II saw a flood of veterans entering schools all over the country. Art Center was no exception. The veterans were older and more mature than typical college students, with a focus on putting the depression and the war behind them. They were ready to get an education that would propel them into a career and the promise of the post war era. It was also during this time that the school began offering classes year round, accelerating the minimum time required to earn a degree. Then as now, this is an attractive proposition for a student who clearly recognizes the benefits of exchanging a tuition for a salary.

Tuition and other costs associated with earning a degree at Art Center are significant. Tuition alone for a *single* semester in 2006 is $13,155. If this cost were fixed at this rate for the duration of a student's eight terms of instruction, the total expense for tuition alone would be over $105,000. The administration recognizes that this amount will increase annually, going so far as to declaring the following on the school website. "Students should plan on tuition increases in the range of 4.5 to 6.5 percent per year." (ACCD, 2005) Adding conservative amounts for room and board ($5,000 / term), transportation ($1,000 / term), supplies ($1,175 / term), and personal expenses ($1,000 / term), the eight term total rises to over $175,000. It should be noted that generally speaking the Los Angeles area has a relatively high cost of living. While this may at first glance seem to be an outrageous sum, Art Center is a private, non-profit institution and this number is not out of line with other such educational organizations. Comparisons notwithstanding, this is still an amount that insures a large degree of motivation within the student body to succeed or to choose another educational or career path.

Attrition at many design schools is legendary if not mythology. 'Medical school without the blood,' is one of the many common clichés used to describe the situation. Perhaps medical school should be called design school without the markers. The survival of the fittest begins with the admissions process and the entrance portfolio. College-wide, 74% of applicants are admitted. Students must declare a major as part of the application process and are then considered for acceptance into a particular program. This is another factor that tends to attract applicants who are more focused and motivated than the average, college-bound high school graduate. Students who wish to change their major may submit a portfolio to the department they wish to enter but there is no guarantee of acceptance. Shopping for a major is a very rare occurrence at Art Center. A more likely scenario is shopping for a different institution.

Publicly available data for graduation rates is limited. By 2001 the graduation rate of students who entered the school in fall of 1995 with no previous college experience was 59%. The same rate for all students entering at that time was 78%. There is no data available for specific majors. Art Center admits and graduates three classes each year corresponding to their trimester division of the year. For all Art Center students graduating in spring 2005, the average number of terms from entering to graduating was between ten and eleven (Roames, 2006). This number may include academic terms, un-enrolled terms, and internship terms. Without significant advanced standing the minimum number of terms required to graduate is eight.

The program requires a review of each student's portfolio in both the third and sixth semester. The intent of the review is to insure satisfactory progress by identifying any need for remedial instruction and adjusting the student's program of study appropriately. This is also an important gateway in the academic development of a student. Frequently this is the point at which a student will decide to change major or even leave the school to pursue other academic and / or career opportunities. This is an occasion for soul searching and self-selection. The portfolio review provides the venue for a frank discussion and critique between the student and the program for the equal and mutual benefit of both parties. Failure of a student to participate in the review process in good faith is grounds for removal from the school.

As an illustration of the rigor of the program, dismissal of a student may occur at any time the determination of unsatisfactory academic progress is made. Such a determination may be triggered by a third consecutive semester with a cumulative grade point average (GPA) below 2.50 (corresponding to a C+) or failure to complete at least 40% of graduation requirements by the end of the fourth semester of enrollment. As mentioned previously, dismissal may also result from the student's failure to fully participate in the portfolio review process. A probationary period is implemented whenever a student's cumulative GPA falls below 2.50 or when a student's term GPA falls below 2.50 for two consecutive terms. A minimum GPA of 2.50 is required in order to graduate.

Art Center's studio environment fosters an atmosphere of both competition and collaboration amongst its students. This serves to maintain very high standards. Each student strives to perform at the highest level, naturally promoting a metaphorical game of leapfrog. At the same time there is an understanding that the better the studio as a whole performs, the better each student looks individually. This is the element that encourages cooperation among students in the studio, sharing strengths, techniques, new technologies, supplies and such. Working in a common studio space minimizes the secrets and maximizes the creative synergy. Upper level studios have dedicated space so students may make themselves 'at home' and share the space with each other throughout the week, not just on days that the class meets.

Not to be overlooked is the simple passion of the students for the subject matter. This is not a discussion of the psychology that generates such strong affections for the automobile in American society and culture but that relationship is undeniable. In some percentage of the population that passion is especially acute and those individuals pursue careers in the automobile industry with zeal. Those who are particularly enamored with the design aspects of the automobile are likely to be drawn to ACCD or rival institutions -- no school has a monopoly on automotive passion -- where they apply themselves with the earnestness and intensity of a missionary.

Logistically speaking, most studios are conducted once a week, all day. Normally critiques are conducted in the morning and the afternoon is comprised of demonstrations, lectures, and individual meetings. Studio size is about 15 students.

Art Center has no dormitories or other student housing. Other than general information and a weekly listing of appropriate, local rental availabilities from the Office of Student Life, students are on their own with regard to finding accommodations. This places a small logistical burden on the student and usually requires that the student have access to an automobile or other private transportation for trips to and from the campus. On the positive side, the generally older student body has already had its fill of dorm life and welcomes a refuge away from campus. A short walk across an idyllic campus from dorm to studio might be pleasant but it would surely shelter students from an appreciation for the average consumer's commute and so many other experiences that support this education. Living independently in the Los Angeles suburbs immerses the student in a cultural, contextual environment that is in itself a learning experience for a young designer. One need only look out to the smog-obscured, horizon to see one of the realities that transportation designers face today. Art Center lies in the foothills of a mountain range that usually cannot be seen from the campus or the city of Pasadena.

Demographically, the population of the whole school is 60% male; average age of entering freshmen is 24; 55% are from California; 25% are international students; 20% are from the US outside of California. ACCD has no part-time students. This information is not available exclusively for the transportation design program.

Internships and Post Graduate Employment

During the fourth through seventh terms students with satisfactory GPA (2.5 or higher) are encouraged to apply for professional internships. Competition for these internships is another vehicle that serves to maintain, if not further elevate, the high standards that the school and the students set for themselves. Many opportunities are organized through the Office of Career Services. In 2006 transportation design internships have been offered by Audi, BMW (Germany), BMW (Designworks), Fisker Coachbuild, General Motors, Johnson Controls, Mazda, Volkswagen, and Volvo. Stewart Reed, Transportation Design Chair at Art Center estimates that 50 to 60% of recent graduates have had at least one internship experience (Reed, 2006).

Internships serve many purposes. Foremost, working and learning in a professional environment as a professional gives the student a perspective that cannot be found in an academic setting. Both the company and the intern get to try the other on; in some respects it can be an extended interview. Provided that the company has a positive experience, the bond between the school and the company is strengthened. Perhaps most important to the school is the effect that the internship can have on the program once the intern returns to school. The experience gained by the intern in industry and then shared with peers in the academic studio is an essential element of the competition and collaboration that makes the studio such a fertile educational environment.

Part of the school's symbiotic relationship with industry entails regular on campus recruitment visits from major manufacturers, tier one suppliers, design consultancies and other automotive design employers. In 2006 BMW, CALTY (Toyota), DaimlerChrysler, Ford, General Motors, Harley Davidson, Honda, Johnson Controls, Mazda, Nissan, Renault, Audi, Volkswagen, and Volvo are among the numerous companies who will visit campus to interview potential employees. Because Art Center has rolling admissions and classes enter and graduate each of the three semesters every year, many of these companies make a habit of visiting campus to recruit, for full-time employees and / or interns, at least once a semester.

From an economic perspective, a good return on investment is a major selling point for any academic institution. The prospect of a lucrative career softens the sticker shock generated by the cost of higher education. Art Center has recently completed a survey of its 2000 and 2004 graduates to determine employment rates and average salaries one year and five years after graduation. Note that the survey results are dependent upon response rates and graduates with good news may be more likely to share that news. 'Working in the field' is defined as full-time, part-time, or self-employed in the discipline in which one is degreed. Results for year 2000 graduates of the entire school show 99 percent working in their field (based on a 37% response) and an average salary of $62,597 (based on 35% response). 2004 graduates report 88% employment in their field (52% response) and an average salary of $42,189 (48% response). Among Transportation Design graduates of 2000, 100% (31% responding) are working in the field and the average salary is $73,409 (31% responding). Transportation graduates of 2004 also report 100% (34% responding) working in the field with an average salary of $66,136 (38% responding) (Mitsunaga, 2006).

Not surprisingly, most of these factors, policies, and traditions appeal to the sort of student whose academic performance tends to more deeply entrench and solidify the attitudes and values that attracted them to Art Center in the first place. Seventy-five years of reinforcing an ethic of professionalism and hard work have given the school and its graduates a definite character, reputation, and standing in the industry.

College for Creative Studies

Foundation and History

In a very real sense the College for Creative Studies (CCS) was born out of the industrial revolution, not as a part of it but as a reaction to it. The arts and crafts movement started in Europe as a counter-balance to the industrial revolution came to America near the close of the nineteenth century. By 1906 it had traveled to the Midwest and inspired a group of civic-minded Detroit citizens to found the Society of Arts and Crafts (CCS, 2005). In 1911 the Society began offering informal instruction covering topics of drawing, woodcarving and general design. In Detroit and other cities across the country arts and crafts societies sought to soften and humanize the utilitarian objects of mass production. It was in these organizations dedicated to beauty and attention to detail in common, functional products that the previously oxymoronic pairing 'industrial design' was nurtured if not born. While Art Center was born out of the need for practical vocational training, CCS has its roots in more cerebral and philosophical ground.

The informal course offerings of the Detroit Society of Arts and Crafts became a full-fledged educational arts program in 1926. The program gained nationwide attention in 1933 when the Society declared the automobile to be an art form. By this time Detroit, and the surrounding area, had already distinguished itself as the major center of automobile manufacturing in America. It is easy to imagine that any business-minded Michigander would be promoting the automobile in whatever manner possible, including recognizing it as art. From there it was a small but significant step to add industrial design to the Art School of the Detroit Society of Arts and Crafts' (as it was then known) educational curriculum. As mentioned previously, 1959 saw the inclusion of a transportation design curriculum headed by Homer LaGassey within the industrial design program (Lamm & Holls, 1996). It was not until the Michigan Department of Education allowed the school to grant the Bachelor of Fine Arts degree in Industrial Design in 1962 that the school became recognized as a college. In 1975 the college changed its name to the Center for Creative Studies-College of Art and Design in order to better express the academic status it had achieved. The current name, College for Creative Studies, was adopted in 2001.

Academic Environment

CCS now has approximately 1300 undergraduate students. The industrial design program is the largest in the college accounting for 28% of the student body. There are no graduate programs in the college but some are under consideration. The Bachelor of Fine Arts degree may be earned in eleven majors: Advertising Design, Animation and Digital Media, Art Education, Crafts, Fine Arts, Graphic Design, Illustration, Interior Design, Photography, Product Design, and Transportation Design. Like some other institutions, CCS places the transportation design curriculum within the industrial design program. The program has about 360 students of which approximately 65 are concentrating on automotive design. The typical studio enrollment is 20 students and each Spring the program graduates about 20 automotive designers (Fitzpatrick, 2005). The academic year is divided into two 15 week semesters. Accreditation of CCS comes from NASAD and the Higher Learning Commission of the North Central Association.

Being located in Detroit, the heart of the American automobile industry, it is no surprise that CCS is closely linked to the major manufacturers headquartered in the area (DaimlerChrysler, Ford, and General Motors). There are ties to European and Asian companies and a small number of foreign students but the hometown influence is clear. The city takes pride in CCS and CCS returns the favor. At the recent 2006 North American International Auto Show in Detroit it was announced that upon her death last June, Josephine F. Ford, granddaughter of Henry Ford, left $50 million to the college. This gift was the largest ever to a private arts college in the U.S. and has boosted the CCS endowment to over $62 million (Howes, 2006).

CCS is currently the only art and design school that has been accepted into General Motor's Partners for the Advancement of Collaborative Engineering Education (PACE) program. The program brings together resources from GM, EDS, Sun Microsystems and UGS along with several other manufacturers of hardware (Hewlett Packard) and software (Alias, Fluent, and MSC among others) to support carefully selected academic institutions throughout the world in order to educate design and engineering students in product life cycle management (PLM) and the parametric, inter-disciplinary, and distance collaboration that PLM requires and facilitates (PACE, 2005).

Curriculum

The CCS BFA requires 126 units, 84 of which are earned in the studio. In addition to the courses in automotive design, students have requirements in the Foundation Department studying basic design, color theory, and drawing and the Liberal Arts Department. "Foundation classes are an intense program in drawing, design, and color created purposely to give students a work ethic," states Robert Schefman, Foundation Department Chair. This foundation is comprised of about nine courses concentrated in the first year of the program but continuing through the fourth term (when including the visual communication courses) with a focus on understanding basic design principles and visual communication techniques. A Digital Fundamentals course gets students grounded in the use of computers. This class is designed to impart the basics, promote confidence, and reveal a broad range of computer applications: word processing, scheduling, communications, research, and graphics (both pixel and vector software such as Adobe Photoshop & Illustrator).

Beyond the fourth term much of the time previously spent in foundation courses is absorbed by the liberal arts requirements: English, social and natural sciences, history, philosophy…. There are ten required classes of this ilk and they are heavily concentrated in the final terms of the curriculum. There are 120 different liberal arts courses offered. The core of industrial and transportation design studios runs through the eight term schedule, one studio per term. Seventh and eighth term transportation design studios are sponsored industry projects. There is one course devoted to traditional three-dimensional model building. Neither perspective nor graphics are the exclusive focus of any of the foundation courses. In addition to the basic Digital Fundamentals course, there are four classes that are dedicated to digital three-dimensional modeling and rendering. This series culminates in an advanced Alias class in the seventh term. Four art or design history classes are required. Human Factors, Business Practices, Vehicle Packaging, Design Strategies – Transportation, and Science and Technology (materials and methods) are required courses designed to support the studios. There is one elective studio requirement.

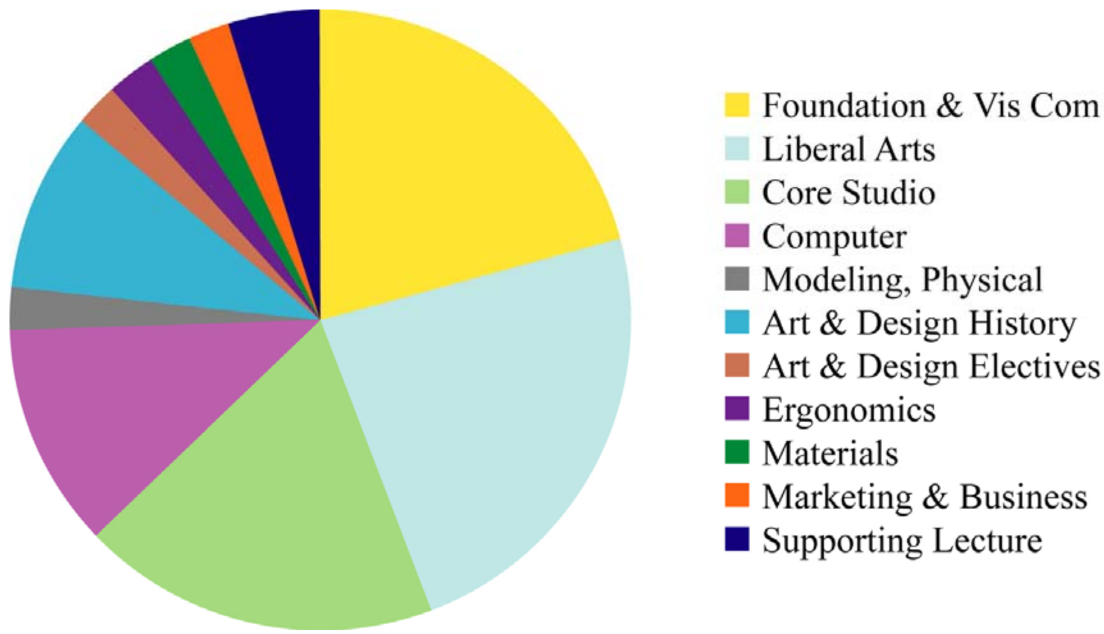

Figure 2.2 College for Creative Studies curriculum by topic

The CCS catalog advises students to expect to do at least one hour of work outside studio for every two hours in studio. For lecture classes this ratio is reversed. A typical week for a full-time student is comprised of 24 hours in studio and 6 hours in lecture based courses. Experience suggests that this workload is underestimated for those studying industrial design.

<u>Faculty</u>

The transportation design faculty at CCS is drawn primarily from the local design studios of the big three. Numbering about 17, many of the instructors spend their days in the studios of GM, Ford, or Chrysler and then teach transportation design in the evening or on Saturday in the CCS studios. Transportation design studios meet once a week. The Industrial Design department (including both the product and transportation design programs) employs nine full-time faculty members including the two program chairs and

35 part-time adjuncts. Only two full-time faculty members teach transportation design (Molnar, 2006). The College as a whole employs over 200 practicing professionals as part-time faculty members.

A distinguishing characteristic of CCS is the practice of assigning a faculty mentor to each student upon entry into the program. Mentor and student meet at least twice a term, affording the student the opportunity for portfolio feedback and guidance with respect to career, academic and professional.

Facilities

The CCS campus is located in downtown Detroit surrounded by many of the city's cultural institutions. The five main buildings of the campus surround the Josephine F. Ford Sculpture Garden which serves as the focal point of the campus and offers a park-like retreat in the midst of the urban environment.

The Walter B. Ford II Building, so named for the husband of college benefactor Josephine Ford, is home to six departments including product and transportation design. Also located in the Ford Building are the Digital Imaging and the Audiovisual Checkout Centers. The imaging center provides timely, discount graphic output to members of the CCS community. The center also loans digital cameras, drawing tablets, and recorders. The Checkout Center loans various types of projectors for use on campus.

The extensive shop facilities are located primarily in the Kresge-Ford Building (as well the bookstore, cafeteria, and several departments including Foundation and Liberal Arts). Automotive design students spend a great deal of time in the well-equipped wood and metal shops but the facilities also include ceramic, fiber, and glass studios, a blacksmith shop and a foundry. There are facilities for anodizing, electroplating, tube notching, and welding (TIG, MIG, and oxy / acetylene). Brakes, lathes, mills, shears, presses, pipe bender, blast media cabinet, roll formers, sanders and grinders, along with an extensive selection of hand a power tools provide everything to keep any fabricator happy. This equipment is testimony to CCS student's reputation for being 'hands-on' and also indicative of the fact that Detroit remains a manufacturing center.

Spread out among classrooms, studios, dedicated project rooms, the library, and ten computer labs are 415 computer workstations (Macintosh G5s and Dell Pentium 4s). Ashar Vellum is used to teach two-dimensional computer drafting and orthographic projections. 3D Studio Max, Form Z, and Pro-design are all taught as stepping stones to Alias. Students also have access to software suites from Adobe, Autodesk (CAD and Alias including Maya and AutoDesign Studio), Macromedia, and Microsoft among others.

The 13.5 acre campus also includes the Yamasaki Building, the Academic Resource Center (ARC), and the Art Centre Building (ACB). The ARC houses two galleries and the library. The ACB is home to 263 students living in apartment-style suites with full kitchens. College housing is also available in the nearby Palmer Court Townhomes. 23% of the students live in school housing.

Students

The CCS transportation design program is in the enviable position of attracting many more qualified applicants than it can accept. This is one factor that leads Imre Molnar, Dean of the College, to characterize his students as, "VERY motivated" and "very competitive." The standardized test scores of entering freshmen are virtually identical to the national average. The distinction comes from the required entrance portfolio.

The majority of students attending CCS come from the region. 83% are from Michigan. A number of the students are from families who have worked in the automobile industry for generations. Many can be fairly characterized as 'gearheads' and Molnar also points out that CCS, and Detroit, is more 'blue collar' than Art Center. (As one of the author's instructors at Art Center, it is natural for him to make comparisons between the two preeminent automotive design programs.) The average age of the CCS student is 23; 59% are male; 83% are full-time students. International students account for 4% of the student body.

The annual cost to attend CCS, a private, non-profit institution, is about $34,000. This number includes tuition and fees, and estimates for room & board, supplies, transportation, and personal expenses. Based on this estimate the total eight term (summers not included) cost is over $135,000. Interestingly, 95% of the students are receiving some form of financial aid from the school. This accounts for a significant part ($4.5 million) of the school's budget (Molnar, 2006). This cost must also be recognized as a factor insuring the students' motivation.

The whole college accepts 60% of applicants. Students may be accepted without declaring a major but must choose one before the end of the first term of attendance. In the Transportation Design program only one student out of every five freshmen will graduate (Molnar, 2006). College-wide the graduation rate is 54% which is the same as the national average for private colleges.

This attrition is partly the result of academic rigor and policies that ensure satisfactory progress and adherence to a high standard. A cumulative GPA of 2.0 or lower will cause a student to be put on academic probation. Failure to raise the GPA over 2.0 by the end of the probationary term will result in suspension. Likewise a student must successfully complete a minimum of two-thirds of the credit hours attempted. Falling below this threshold will trigger a probationary term at the end of which suspension may result if the two-thirds standard has not been met. Suspended students may apply for readmission after a minimum of 12 units have been completed with at least a C in each course at another accredited institution. Departmental reviews are required of each student at least once a year. Failure to attend such a review will prevent a student from registering for the next semester. A student must also have departmental permission to graduate based on a review of his or her portfolio and a minimum GPA of 2.0 is required at the time of graduation.

While the attrition may be high, CCS offers a significant degree of support to promote each student's success. In addition to traditional academic advising and the departmental mentor program, the Student Success Center offers individual tutoring for every class offered by the college including studios. Much of the tutoring is done by upper level students who are willing and able to share with their peers. The competition is serious but so too is the support among peers. The Center also offers group tutorials, workshops on topics such as time management, and facilitates the creation and meeting of study groups.

Internships and Post Graduate Employment

Juniors and first semester seniors are encouraged to apply for internships. Before applying for an internship students must meet academic criteria and the potential intern's portfolio must be screened by a member of the faculty. CCS allows students to receive academic credit for internship experience provided that a minimum number of hours are worked. DaimlerChrysler, Ford, General Motors, Honda, Renault, and Polaris have recently employed CCS interns.

Many of the world's leading automobile manufacturers and suppliers also come to CCS to recruit for full-time positions. Recent visitors include BMW, Bombardier, Collins & Aikman, DaimlerChrysler, Daihatsu, Volkswagen, Ford, GM, Honda, Johnson Controls, Mercedes Benz, and Nissan. Top graduates can earn a starting salary of $60,000 to $80,000 a year (Molnar, 2006). Such a salary can considerably soften the hardships of the expense of the education.

Academy of Art University

Foundation and History

The Academy of Art University (AAU) in San Francisco, California is a relatively recent addition (about 1998) to the group of institutions offering a transportation design program but the school itself dates from 1929. Founded as the Academy of Art College by artist Richard S. Stephens, initially the curriculum focused solely on advertising art. Philosophically Mr. Stephens was on the same page as Mr. Adams, founder of Art Center. Both believed in hiring experienced and talented professionals to teach aspiring professionals their craft and this practice continues at both institutions today. By 1936 Fashion Illustration and Fine Art had been added to the curriculum (AAU, 2005).

Leadership of the college was assumed by Richard A. Stephens, son of the founder, in 1951. Ambitious expansion led to incorporation in 1966 and the authorization from the state of California to grant a BFA in Fine Art. Dr. Elisa Stephens then followed her father at the helm of the private, proprietary institution in 1992.

Academic Environment

AAU is the largest private art and design school in the country with over 8,000 students. The school offers Associates, Bachelors, and Masters degrees. Over 6,600 undergraduates are enrolled in the schools of Advertising, Animation & Visual Effects, Architecture, Computer Arts / New Media, Fashion, Fine Art, Graphic Design, Illustration, Industrial Design, Interior Architecture & Design, Motion Pictures & Television, and Photography. The School of Industrial Design offers concentrations in product, toy, and transportation design and has an enrollment of approximately 400. About 70 students are pursuing the transportation concentration. The program produces about six transportation graduates a year.

Part of the AAU philosophy is accessibility. There are no undergraduate admissions requirements save a high school diploma or the equivalent. There is no portfolio review for acceptance. Also unique to AAU among the institutions examined in this paper is the ability to earn a degree online. Thirty-five percent of the university's instruction is done online. As a proprietary institution, AAU also advertises regularly in popular magazines such as *Motor Trend* as well as more specialized design oriented periodicals. Even more so than the other schools, AAU sees education as a business and this is clearly one tool used to gain market share. The transportation design program could be seen as the ambitious new kid on the block. The school website states that the mission of the School of Industrial Design is to be the "preeminent design program" in the country.

Curriculum

132 units are required to earn the Bachelor of Fine Arts degree from AAU. Studio courses account for 60 of those units. Eighteen may be considered foundation and 45 are derived from liberal arts. AAU is accredited by the Accrediting Council for Independent Colleges and Schools and NASAD.

Nine classes focused on design fundamentals and visual communication serve as the foundation for the program. Six of these courses are scheduled during the first three semesters of the curriculum. The balance is ordered one per term through the sixth. The first semester also includes the first model making class in a series of three and computer drafting, the first of four consecutive semesters that include one course of digital instruction. On top of that there are several core studios and visual communication classes that make significant use of the computer. A total of seven courses designed to teach computer skill sets includes three classes of three-dimensional sketching and modeling (Rhino and similar software), two on two-dimensional images (Illustrator and Photoshop), one for drafting and one Alias. Numerous digitally oriented electives allow a student to focus even more deeply on computer modeling and graphic skills. These tools are put to use in most studios starting with the sophomore year.

One liberal arts course is scheduled in each of the first three semesters. The remaining six liberal arts courses are equally distributed in the sixth through eighth terms. Four art or design history classes are required. Beginning with the third semester, one transportation design studio per term forms the core of the concentration. While interiors may be a part of several studios there is one transportation studio that is always devoted to interior design. This is a fairly common practice in transportation design curricula.

Traditionally the emphasis, and the bulk of the instruction, has been on exteriors. Many professional automotive interior designers come from the ranks of product design majors. This appears to be changing somewhat as the influence and prestige of interior design is on the rise. In support of the core is Materials & Processes, Intro to Ergonomics, and Trend Analysis & Consumer Psychology. Completing the curriculum in the final two semesters are four art electives.

Transportation studios vary in size, attrition usually accounting for larger numbers earlier in the sequences. Senior studios generally have six to eight students. AAU follows the rather standard practice of weekly studio meetings of about six hour duration.

In addition to or as part of the model making coursework, students create at least four clay models during the course of their studies. This is another example of the AAU commitment to traditional model building and the lessons of craft, volume, and form that it teaches. While digital models are frequently translated into physical models, one exercise at AAU takes a clay model and imports it into the digital realm by taking points right from the clay (Matano, 2005). This procedure demonstrates the skill of the modeler when the form is examined on the computer. It also fosters an appreciation of both the subtle and complex forms that sometimes are still achieved more easily by hand than by computer. Perhaps most importantly such an approach reveals the complimentary nature of design tools that are too often set in opposition to each other.

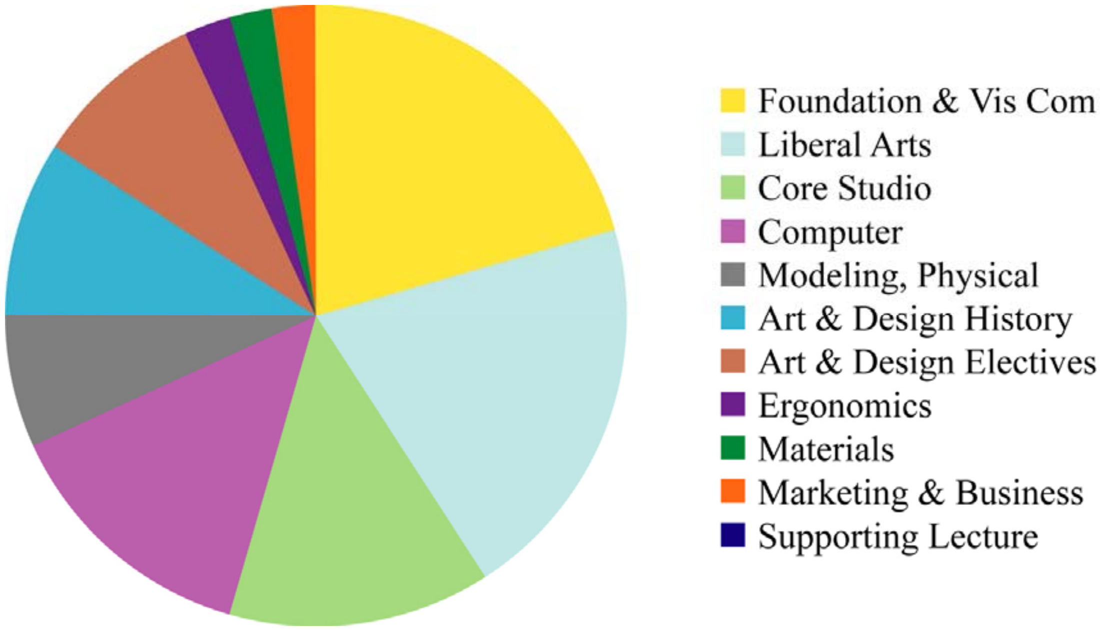

Figure 2.3 Academy of Art University curriculum by topic

Sponsored projects are a regular if not standard part of upper term studios that help to motivate students providing them with a more professional context and challenge. According to Director Tom Matano, AAU does not charge as much as other schools to sponsor a project. Perhaps this is a function of supply and demand, a desire of the program to build relationships with manufacturers, or simply a way to position the school in a competitive market against the established 'brands' called Art Center and CCS.

<u>Faculty</u>

The program currently has three full-time faculty members. It is worth noting that the Director, Matano, and the Assistant Director, Hideki Masuda are Art Center graduates. Like Tink Adams, these educators are fashioning a program in part as a reaction to the deficiencies that they have identified in their own formal educations and more general gaps observed at other programs (Masuda, 2006; Treece & Rechtin, 2002).

As a practical and philosophical matter, AAU follows the instruction-by-practicing-professionals model and employs a cadre of part-time faculty. While San Francisco is not as rich in automotive designers as Los Angeles or Detroit, the bay area does have a thriving industrial design community and the program has been known to fly in car designers from Southern California and other regions to teach transportation design classes.

<u>Facilities</u>

AAU occupies over twenty buildings including dorms and other student housing scattered through downtown San Francisco. The School of Industrial Design shops, studios, classrooms, labs, and offices are all located in a building know as ‘the warehouse.’ This location also houses a student lounge, foundation classrooms, gallery space, and a design office that can serve as a temporary satellite studio for professional firms. (When the author visited AAU, Nissan was in residence.) Having a professional design office on site can present serious logistical difficulties for the tenet but there is significant value to the students from such close proximity to an operating studio and occasionally affords an opportunity for on site internships.

The industrial design curriculum at AAU places significant emphasis on traditional, three-dimensional model building. In support of that philosophy the program maintains extensive shop facilities. Five separate areas are dedicated to individual fabrication media: metal, paint, plastic, wood, and computer / rapid prototyping. The metal shop is primarily used to make aluminum tools for the production of plastic parts. It features lathes, milling machines, grinders, brakes, shears, a media-blast cabinet, and an appropriate array of hand tools. The paint shop includes three spray booths, one of which is large enough to paint an automobile. Both of the other booths house nine individual work stations. A computer database is used to facilitate student access to 150,000 colors of automotive paint that can be mixed on site for the students to spray on their models. The plastics shop focuses on the fabrication of sheet plastic and simple molded plastics. The facility also houses a vacuum-forming machine. Composite lay-up is also a part of the fabrication education.

The wood shop is the primary model fabrication area and houses a variety of machine saws, drill presses, shapers, wood lathes, a jointer, and a planer. The shop also features a sophisticated dust collection system. Adjacent to the primary wood shop area are separate sanding rooms with spindle and disc sanders. The ‘3D Computer Lab’ is the clean home to laser cutters, rapid prototyping machines, CNC mills, digitizing probes and the computers used to control them.

There are over 700 computer workstations for student use scattered across the campus in labs, studios, classrooms, and even in some dormitories. The most commonly used software in the industrial design program includes Graphite (primarily for two-dimensional drafting), Adobe Illustrator and Photoshop (for graphics and two dimensional rendering), Rhino and Alias (for three-dimensional sketching and digital modeling), Bunkspeed and ImageStudio (for three-dimensional, digital rendering) (Masuda, 2006). Wacom tablets can be found at most computers in the School of Industrial Design. A Mini Scribe hand digitizer is available to translate physical models into digital models (Matano, 2005).

Students

Although AAU students do not need a portfolio to be accepted, the program is rigorous. Not surprisingly, students are expected to attend all classes arriving promptly and submitting assignments in a timely manner. Failure on any of these counts has significant negative impact on grades. Students whose GPA drops below 2.0 are subject to a one term probationary period followed by dismissal or a remedial program if the GPA is not raised sufficiently during the probation. Satisfactory progress standards must also be met. A minimum GPA of 2.0 is required to graduate.

Applicants are not required to declare a major during the admissions process but must select a major before the end of the second semester.

As is the case with most non-public college educations, the price is a motivational factor. Annual cost (two semesters) for a full-time, undergraduate student is estimated at $35,500. This places the four year estimate at $142,000. Consistent with the cost estimates for the other institutions in this paper, this number includes tuition and fees, room and board, transportation, supplies, and personal expenses.

Demographically, 40% of the undergraduate student body is from California; 52% are female; 25% attend part-time. Housing is guaranteed for all full-time students but only 9% choose to live in the ten school housing facilities (dorms and apartments) scattered around the city. Several meal plans are also available. Taking advantage of student housing can offer significant savings over the course of a four-year education and perhaps more importantly AAU sees student housing as an academic and social support network.

University of Cincinnati School of Design

The University of Cincinnati (UC) is perhaps best known in academic circles for its co-op programs. The transportation track in the Industrial Design Program, School of Design, College of Design, Art, Architecture, and Planning is no exception. Graduates must complete six quarters of professional practice in the co-op program (DAAP, 2005). Co-op experience prepares students for work in industry and fills in whatever necessary skills the student may not have sufficiently grasped from the campus elements of the curriculum. The UC industrial design program is one of the largest in the U.S. with over 230 students. Unlike most highly regarded industrial design programs UC students can take advantage of being a part of a large public university. This provides great diversity in educational opportunity, trans-disciplinary collaboration, and (for residents of Ohio) a relatively low cost alternative to the design programs of private institutions.

University enrollment includes about 19,000 undergraduates and 7,400 graduate students. Only 8% of the student body is from out of state. Estimated total cost (some of which may be defrayed by the required co-op participation) is about $85,000 for state residents. That total climbs to $140,000 for students from outside Ohio. The university as a whole accepts 76% of applicants. It is accredited by The North Central Association of Colleges and Schools (NCACS), The Higher Learning Commission, and NASAD among others.

UC operates on the quarter system, four to a year. This allows a bit more flexibility in the breadth of the industrial design curriculum. Since the quarters are 10 weeks in duration as opposed to semesters or trimester that are usually 15 or 16 weeks long, more topics can be covered with dedicated, if shorter, courses. One notable example of this is the Figure Drawing for ID course. Of course this also means that many necessarily in depth topics frequently covered in one semester must be spread out over two or more quarters. It also makes some comparisons with other programs difficult. The Industrial Design Bachelor of Science degree at UC requires 190 units, significantly more than the other programs considered, but since quarter (10 week) units are being compared to semester (15 or 16) units, some rudimentary algebra is necessary. Simply multiplying 190 by two-thirds provides a reasonable approximation of 127 units which is very much in line with the other programs.

There is no portfolio required for acceptance into the School. UC strives to attract the best students academically, those with 3.9 and higher high school GPAs. Then challenges them to learn the creative and communicative tools spread around them. The required co-ops infuse the program with a great deal of energy and facilitate peer mentoring and studio synergy. Collaboration in the studio and across the university, and indeed with industry, is a significant element of the education (O'Kane, 2005). Sponsored projects are another link between the school and the profession working in conjunction with co-ops. They serve as advertisements if not inducements for each other.

UC has applied to become part of the PACE program to further facilitate joint projects with other elements of the university. Transportation students have recently collaborated with a number of other disciplines including engineering, marketing, and even anthropology. It seems particularly natural to model the relationship between design and engineering in industry in an academic setting in order to better prepare the students for employment. Indicative of the gravitational pull between transportation design and engineering, and the UC technological bias, students also learn Solidworks and Unigraphics (UGS) CAD software.

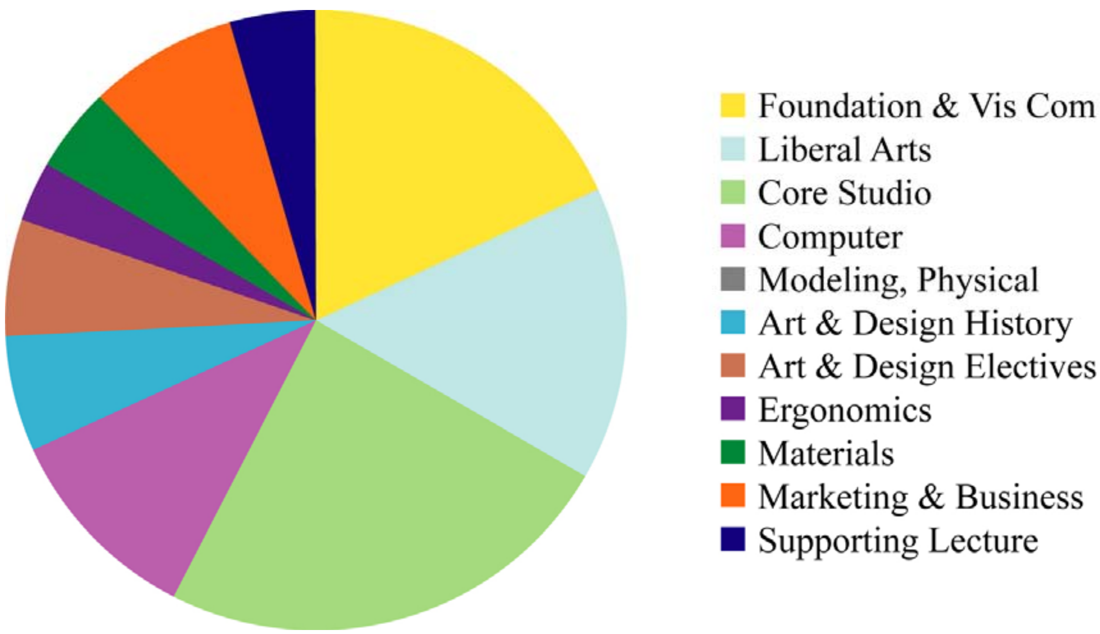

Figure 2.4 University of Cincinnati curriculum by topic

The UC program is heavily weighted towards the use of CAID. As testimony to that fact, industrial design students are required to purchase a specific brand and model laptop computer. To further illustrate the thrust of the program, Professor Brigid O'Kane, Lead Coordinator for the Transportation Track, asserts that as a medium, pastels "are gone. The way we were taught is obsolete. [Professor O'Kane graduated from CCS in 1990, the same year the author graduated from Art Center.] We still use 'normal' sketching for ideation but marker sketches are as far as it goes before it goes digital…if it even gets to the marker stage." Computers are introduced and used in the common School of Design foundation year and then continually throughout the student's career at

UC. The philosophy here is that design fundamentals can be taught, and learned, using digital tools. Photoshop, Illustrator, Painter, and Alias are all used even at the sophomore level.

A student's first four quarters are filled mostly with foundation and liberal arts courses. There are no less than seven computer courses scattered in the schedule. In addition to the required professional practice quarters away from studio, there are five business / professional practice course requirements. Courses specifically dedicated to physical model building are conspicuously absent although there is some shop instruction in each of the three Materials and Processes classes.

In addition to co-ops, collaboration, and CAID, the Senior Capstone project is a hallmark of the UC program. Officially consuming two quarters, it is the culmination of the student's education divided roughly into three equal segments: research and analysis, concept generation and synthesis, and communication and presentation. (Kanawari, 2005)

Cleveland Institute of Art

The Cleveland Institute of Art (CIA) was founded in 1882, three years before Andrew Johnson completed his studies at the Technical School for Carriage Draftsmen and Mechanics. Today CIA is home to about 600 undergraduates studying Ceramics, Enameling, Fiber & Material Studies, Glass, Jewelry and Metals, Industrial Design, Interior Design, Painting, Photography, Sculpture, Drawing, Communication Design, illustration, Printmaking, Scientific/pre-med Illustration, and TIME Digital Arts. The programs are accredited by NCACS and NASAD (CIA, 2005).

The industrial design program is in the midst of a significant change in its curriculum. Previously the program had been one of ten semesters (five years). Now it will consist of only the traditional eight semesters. Clearly this seems to fly in the face of most current thinking. While many programs are searching for more time to teach new technology without neglecting traditional techniques and foundations, CIA is truncating their schedule. In truth CIA is responding to market demands and turning what many would perceive as a problem into an opportunity – just like any good industrial designer.

The decision to implement a four year program was largely driven by economics. All told, using estimates consistent with those applied to the other institutions, the five year, 153 unit BFA cost in the neighborhood of $180,000. It was determined that this was a major factor in declining enrollment (Cuffaro, 2006). The four year, 126 unit BFA saves a student (or a parent) about $30,000 and is in line with other institutions both with regard to units and cost. It should be noted that all examination and comparison of curricula for this paper was completed before the change was known and as such is based on the five year program.

In the past the program entailed two years of foundation followed by three years of focused industrial design. The change will basically eliminate one year of foundation studies that have tended toward the less disciplined, fine art end of the scale. Daniel Cuffaro, Chair of the Industrial Design Program, is optimistic about the change but sees both sides of the issue. Less artistically oriented instruction prior to a serious introduction of industrial design methodology could produce a smoother transition to better defined parameters, criteria, and goals. The negative impact may be less creativity in the solutions but Cuffaro is confident should that occur appropriate adjustments to the industrial design curriculum can be made.

A second ace up the chair's sleeve is the idea that the four year program could be augmented by a one year introductory or portfolio development program for high school students or recent graduates and / or a Masters or other post-baccalaureate program. The programs would complement the four year BFA while being economically profitable and possibly allowing more industrial design instruction than the defunct five year program. Moreover, it would allow anyone with an interest to gain an understanding of the all too often misunderstood field of industrial design including high school students who might be interested in applying to CIA upon graduation.

The department has about 55 students, each with a dedicated studio space that becomes a home away from home. Two industrial design computer labs have Macs used primarily to create presentations and PCs running Alias. About half of the computers also feature Wacom tablets. CIA as a whole has over 303 computer workstations. Physical modeling, with the exception of automotive clay models, is usually done at the level of a sketch model. Finished models, again with the exception of the clays, are being supplanted by digital models.

Two full-time faculty members handle 40% of the course load. Seven adjunct faculty are responsible for the remaining 60%. The professional automotive designers who teach the automotive studio are not considered to be adjunct faculty but rather visiting artists. Transportation and product designers follow the same general course of study. The elective transportation path has class on Saturday with all levels in the same studio. This 'one room schoolhouse' is taught by DaimlerChrysler designers in the fall term and GM designers in the spring. The thrust of these studios is skill development and visual communication. During the week industrial design studios are taught by product designers with the concentration placed on design principles.

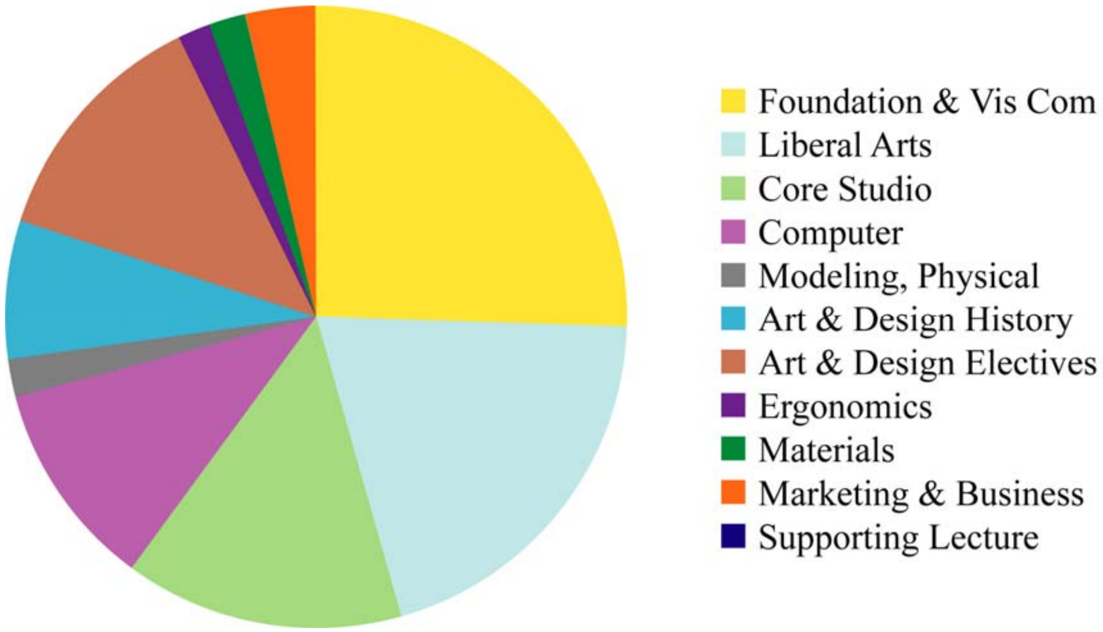

Figure 2.5 Cleveland Institute of Art curriculum by topic

Internships play a significant part in the education of most CIA automotive design students. It is not uncommon for a student to have completed two or more summer internships before graduation. Since CIA is not in full operation year-round students have the time for an internship once a year without delaying their studies. According to Mr. Cuffaro, "In 2003 55% of [CIA industrial design] students had internships, in 2004 65% had internships, and in 2005 86% had internships." Among the automotive design students six out of seven fourth year students had automotive internships.

CIA has a small program in comparison to its more widely known rivals. This has been turned into an advantage. The smaller classes that move through the program together in close contact with each other and the instructors cultivate competitive but team oriented designers who can thrive in a professional environment (Cuffaro, 2006). To mitigate some disadvantages of its size the institute participates in a cross-registration agreement with the 13 other colleges and universities that comprise the Northeast Ohio Council on Higher Education. CIA students and visiting artists also have the advantage of only being a short drive from Detroit.

Pratt Institute

Pratt was founded in 1887. The industrial design ID curriculum was added in 1936 (Pratt, 2005). Based on the percentage of applicants accepted, Pratt is the most exclusive of the programs considered in this paper. Only 49% of those who apply are accepted. Although Pratt does not have a transportation design program *per se*, it does offer studios in transportation design and students could choose to focus on that segment of industrial design. There are six possible industrial design studio paths: product, furniture, transportation, table top, and general (including some of all of the preceding). Some authorities still recognize Pratt as a viable venue from which to recruit automotive designers. It has also been included because of its historical significance in the early days of automotive design as previously mentioned and to further demonstrate the range of instruction that is available.

In addition to over 3,000 undergraduate students studying in 11 fields, the campus supports over 1,600 graduate students. There are approximately 200 industrial design students working toward the 134 units required to earn the Bachelor of Industrial Design degree. Cost for the eight semesters necessary for the degree is approximately

$160,000. Pratt offers a broad education with liberal arts and foundation courses dominant.

After a freshman year filled with the fundamentals, students must be reviewed before being allowed to enter the core of the industrial design program. Traditional fundamentals are paramount throughout the curriculum. The focus is on basic skills, critical thinking and process. In the junior transportation studio the cars are simply the objects with which the subject matter -- general principles and skill building – is taught. The vehicles themselves are merely three-dimensional abstractions (Goodwin, 2005).

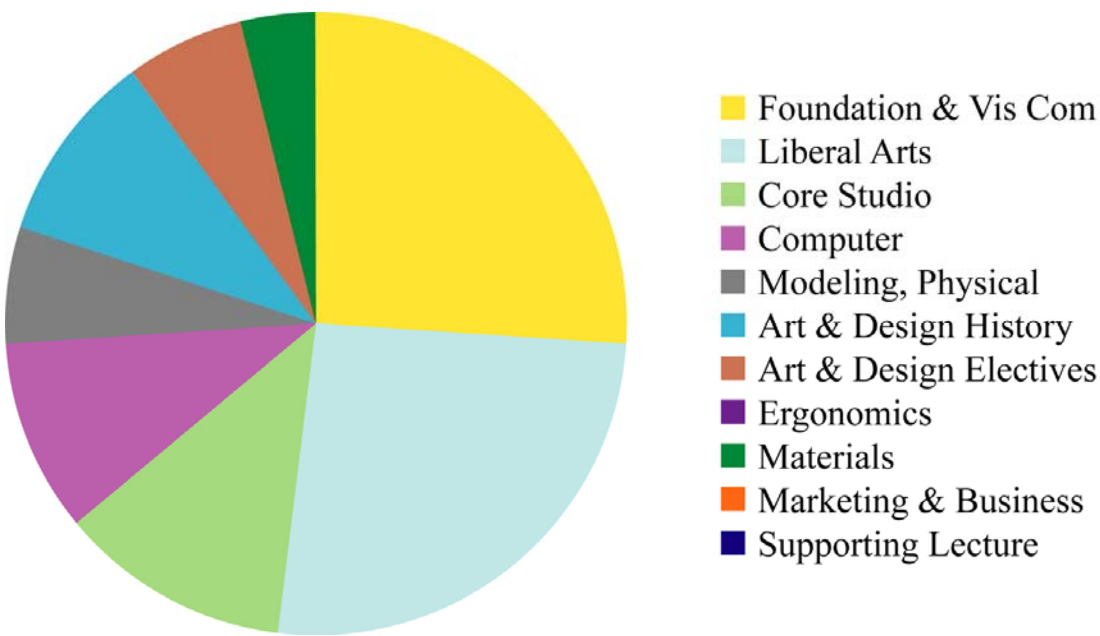

Figure 2.6 Pratt Institute curriculum by topic

Computers are introduced in the context of drafting in the third semester. The fourth and fifth terms feature a CAD class (CadKey or Solidworks) and seventh and eighth terms call for Alias classes. That is the extent of the dedicated computer instruction. Digital media is used primarily in the upper terms and to generate presentation materials as opposed to as a design tool.

Traditional model making is a very important part of the program with no less than nine courses concerned with model making or three-dimensional forms and sketch models. The design process evolves in both two and three dimensional sketches concurrently. As the two dimensional work advances from thumbnail to rendering, the dimensional development moves from elementary sketch models to the final appearance model.

Pratt is a very traditional institution that seems to be making a concerted effort to provide an education as opposed to a vocational training.

Savannah College of Art and Design

Savannah College of Art and Design (SCAD) is the youngest institution considered by this paper. Founded in 1978, the school now has over 7,000 students studying 25 undergraduate majors (SCAD, 2005). In addition to the primary campus in Savannah, Georgia there are satellite campuses in Atlanta, Georgia and Lacoste France. The BFA degree requires 180 units and is customarily earned over a period of 12, ten-week quarters. Estimated total cost is $147,000. Approximately 68% of applicants are accepted. Industrial Design Department Chair Victor Ermoli reports 278 students in the program.

Like Pratt, SCAD does not have a complete transportation design program. SCAD offers four transportation design classes, three of which are taken in sequence, nine marine design classes that allow students to receive a minor in marine design, and one dedicated automotive design class. The transportation design classes may or may not focus on automobiles. The sequential transportation design classes are normally used to design and build a working prototype or at least a full scale model (Ermoli, 2005). [When visiting the program in 2000 the author had the pleasure of riding in a Fiero-based prototype with SCAD designed body and interior.]

SCAD has a very firm teaching philosophy in the industrial design program based on five principles as expressed by Professor Ermoli: human centered, mass consumption, innovation, solves a real problem, and profitable (meets organizational objectives). SCAD's focus is on process and creative problem solving. The curriculum strives to include a sponsored project each term.

Like many programs SCAD is struggling with the integration of computers into the curriculum even as they embrace the new technologies. One of the stumbling blocks seems to be educating the students with regard to the choice of tools: when is it most efficient to work with traditional media; when are digital tools more appropriate. Moreover, how can the different tools be used concurrently to make the greatest contribution to the design process?

Industrial design students have access to three computer labs each equipped with 20 workstations. The computers are loaded with the latest versions of Alias, Rhino, Solidworks, and Cobalt. Increasingly, final presentation models are being created with 3D printers. While the final models are turning away from traditional techniques the program continues to emphasize the merits of sketch modeling during concept development. Sketches can be done in two or three dimensions and should be equally effective in the development process.

Moving forward the program is looking to add more business and entrepreneurial instruction, sustainable design, and more minor concentrations including one in transportation design.

The Art Institute of Pittsburgh

Yet another variation on the theme of automotive design education is provided by the Art Institute of Pittsburgh (AIP). Founded in 1921, it is now the flagship school of the Art Institutes, 30 educational institutions scattered across North America offering a multitude of degrees. Seven of these schools offer industrial design programs but Pittsburgh is the only one with a transportation track The Art Institutes are proprietary institutions owned by Education Management Corporation (AIP, 2005).

AIP operates year-round on the quarter system serving 5,892 undergraduates. The BS degree requires 180 units corresponding to 12 quarters: 36 months as a full-time student. Estimated cost for that course of study is slightly over $100,000. The school is accredited by the Accrediting Council for Independent Colleges and Schools. The industrial design program employs 11 faculty members.

The curriculum is dominated by liberal arts courses and design studios. While this program is clearly not able to take advantage of the resources of a major university or the reputation of one of the elite private institutions in the field, the curriculum is peppered with appropriate courses that some of the more prestigious programs appear to neglect. AIP requires at least one class in drafting, perspective, graphics and principles of mechanical engineering. Three model making and six computer courses complement the core design studios and design courses in photography and exhibit design afford a broader, design perspective.

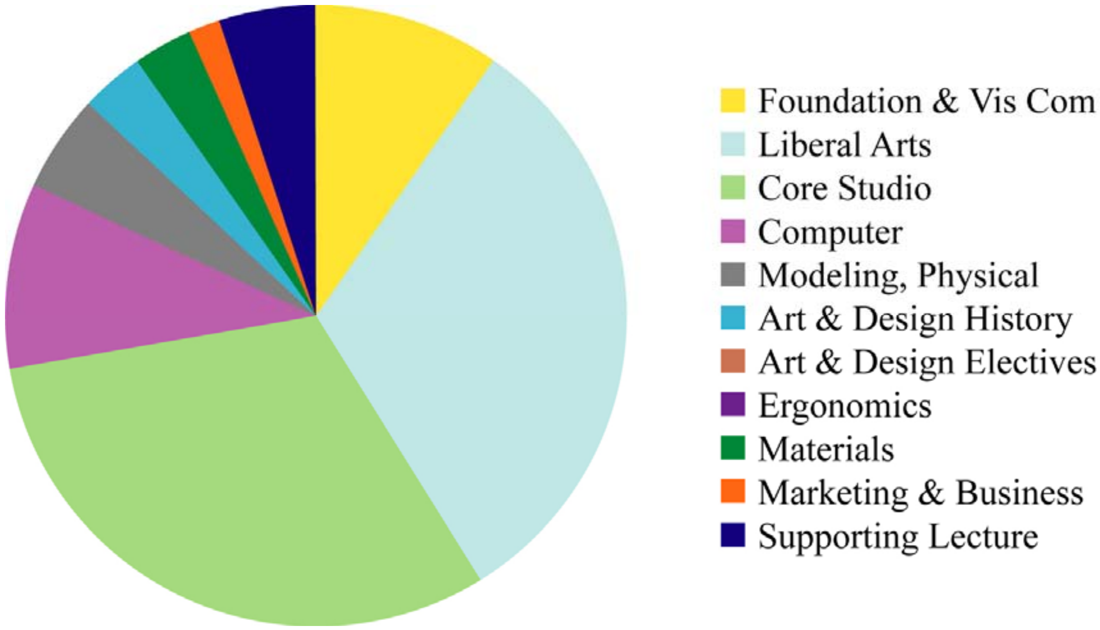

Figure 2.7 Art Institute of Pittsburgh curriculum by topic

Other Programs

One additional program that should be mentioned by name is that of Brigham Young University (BYU). The industrial design program started in 1968 as part of the School of Fine Arts and Communication. In 1997 it was decided that it would be more appropriate and better serve students to locate the program within the new School of Technology, itself a part of the Ira A. Fulton College of Engineering and Technology. Also part of the School of Technology are the Facilities Management, Information Technology, Manufacturing Engineering Technology, and Technology Teacher Education programs (BYU, 2006). BYU is a large university with nearly 27,000 full-time undergraduate students and is accredited by The Northwest Association of Schools and Colleges and NASAD among others. It is a member of the PACE program and is one of the schools that GM recruits from regularly (Shuster, 2005).

Surprisingly, these eight schools nearly complete the ranks of U.S. schools that have some significant automotive design offerings. Other industrial design programs may offer one or two automotive design courses or may sporadically list such courses when appropriate faculty is available. Certainly there are a number of well respected design schools (both large state universities and small art and design schools) that graduate industrial designers who move into the automotive design field, many in the realm of interior automotive design.

It is worth noting that at the graduate level there are currently no schools in this country with specific, ongoing curricula for transportation design students. On occasion an industrial design Masters program will be tailored to transportation design for individual students. Looking abroad, there are approximately 12 significant programs in Europe, some of which feature or are exclusively graduate programs, and three more in Asia (CDN, 2005).

CHAPTER 3

SUMMARY ANALYSIS OF PROGRAMS

Given the common subject matter and demands of industry, it is not surprising that these programs share many similarities in both curricula and philosophy. The fact that many of the programs are accredited by NASAD leads to some degree of similarity. Also, as is the case with virtually all products and services competing in an open marketplace, there is some element of follow-the-leader. Programs that are recognized as the leaders in the discipline will be emulated to some extent by those who aspire to challenge for the leadership positions. Of course the challengers may also develop characteristics that are intended to offer something unique that will distinguish the program beyond the standard or appeal to a particular segment of the market. This chapter examines the distinctions and commonalities of the offerings in part though the philosophy and opinion expressed by the educators who drive the programs.

In general most if not all of the schools considered have the same philosophical concerns and didactic goals at the core of their program (creativity, problem solving, process, intellectual growth of both the individual student and the school, aesthetic and functional understanding, preparation for industry, profitability …). The balance between these concerns at the various institutions is one of the primary factors that differentiate them. It is a matter of priority and relative emphasis within a broad range of criteria. It should also be noted that the approach of a particular school is not like a die at a stamping plant. Each student will inevitably wear the institutional philosophy differently unlike the sheet metal stamped in a given die.

Some programs, Pratt for example, aim for a broad, traditionally enriching post secondary education (albeit with the particular focus of industrial design), that appears to make a concerted effort *not* to simply provide a training to perform competently in a relatively narrow field of endeavor. The goal here is lofty but the danger is that graduates will require additional, practical training, in spite of a good education, upon graduation in order to meet the needs of industry.

The other end of the spectrum is perhaps best exemplified by CCS. At CCS the focus is on servicing the industry, providing the specific sort of graduates requested by the manufacturers (and perhaps more specifically those in Detroit), and traveling wherever the industry directs (Fitzpatrick, 2005). For some students this approach insures lucrative employment immediately after graduation. On the other hand, for those graduates who are not chosen by the manufacturers, major suppliers, or consulting firms, the education may be too narrow to adequately prepare students for tangential or alternate career paths. Educators recognize that on the whole, and at many individual institutions, the number of qualified graduates is still significantly larger than the demands of the automotive industry. One need only look at the size of the profession versus the number of students engaged in its study to recognize this. It should also be noted that the pool of qualified applicants to some if not most transportation design programs is greater than the capacity. This is a happy circumstance for both the schools and the industry allowing very high standards and fierce competition among students (Molnar, 2006).

Another possible liability of a particularly focused, industry-driven course of study is the somewhat understandable, possibly necessary, short-sightedness of the industry. In a quest to produce good entry level designers, does the requisite training leave room for the educational aspects that will perhaps one day allow these designers to climb the corporate ladders becoming good managers and champions of design within the corporate structures? This is a question that has in part led Art Center to invigorate its liberal arts courses and emphasize design in the societal context. The conflict then becomes one of broadening the curriculum to more closely resemble a traditional liberal arts education versus continuing to provide the sort of focused instruction that has made Art Center world-renown for superior visual communication and creativity.

The continuum between practicality and blue-sky creativity provides another measure of distinction from one program to another. A number of programs might describe themselves as ‘more practical than Art Center.’ Of course this presumes an understanding of Art Center that in some cases may be more perceived than real. “We tend to be more practical than Art Center with emphasis on human factors, ingress/egress, package drawings, eye ellipses, cut lines, and real design briefs that we stick to,” asserts Bryon Fitzpatrick of CCS. Having taught at Art Center prior to taking his position at CCS Fitzpatrick is better qualified than most to make such an assessment. The friendly rivalry and respect between the programs is clear and while no one is suggesting that Art Center ignores human factors, ingress/egress, package drawings design briefs and such, these are the practical considerations that CCS holds as priorities. Art Center has different priorities. By the same token it would be foolish to suggest that CCS eschews creativity or visual communications but programs develop priorities and strengths that become their hallmarks. Once established these are the qualities that distinguish the programs from each other and are, perhaps ironically, supported and advanced by rival institutions. When Fitzpatrick declares CCS to be more practical than

Art Center he pays homage to the creative blue-sky reputation that Art Center has gained. Likewise when Art Center touts its visionary concepts, it tips its institutional hat to the reputation of practicality that CCS, UC and other programs have earned. Finally, it must be recognized that within the marketplace it is often foolish to assail a rival's strength. In so doing, one trumpets the strength of the rival while diminishing one's own distinctions that may be highly attractive.

Each program has distinctive features that are both the strength and liability of the school. Those qualities must be recognized and accepted as such. At the heart of the Cincinnati philosophy is the professional co-op experience. It is understood that whatever the campus curriculum may lack with regard to preparation for industry, the co-op will provide (O'Kane, 2005). This is a strength of the program and helps to insure employable graduates. It is also a weakness in so far as the education is relying on the less controlled commercial environment to nurture students and a certain degree of intellectual inbreeding is inevitable. Economically the co-op can have the advantage of defraying a significant degree of the cost of the education. On the other hand it also protracts the duration of the educational process.

The attitude towards the use of computers and digital media within a program is also indicative of the philosophy and priorities of an institution. While every program recognizes the merits of a traditional foundation as well as the value of using contemporary technology, each program strikes a different balance between the two. Arguably, those that lean toward modern technology are aligning their curriculum with engineering and pressing, immediate economic considerations, while those who tip the balance toward traditional media reveal a stronger alliance with psychology, marketing, fashion, and …dare one say…art? Any program that allows either extreme to become clearly predominant imperils the success of the school and its graduates.

Curricula

Academics

A bachelor's degree (of arts, fine arts, science, or industrial design) requires and insures a certain level of rigor in well recognized academic subject matter (English, math, history, social and physical sciences). Consequently, the basic academic requirements of each program are quite similar. There is some variation in the methods used to achieve those requirements and some programs elect to add greater emphasis to the liberal arts element of the education.

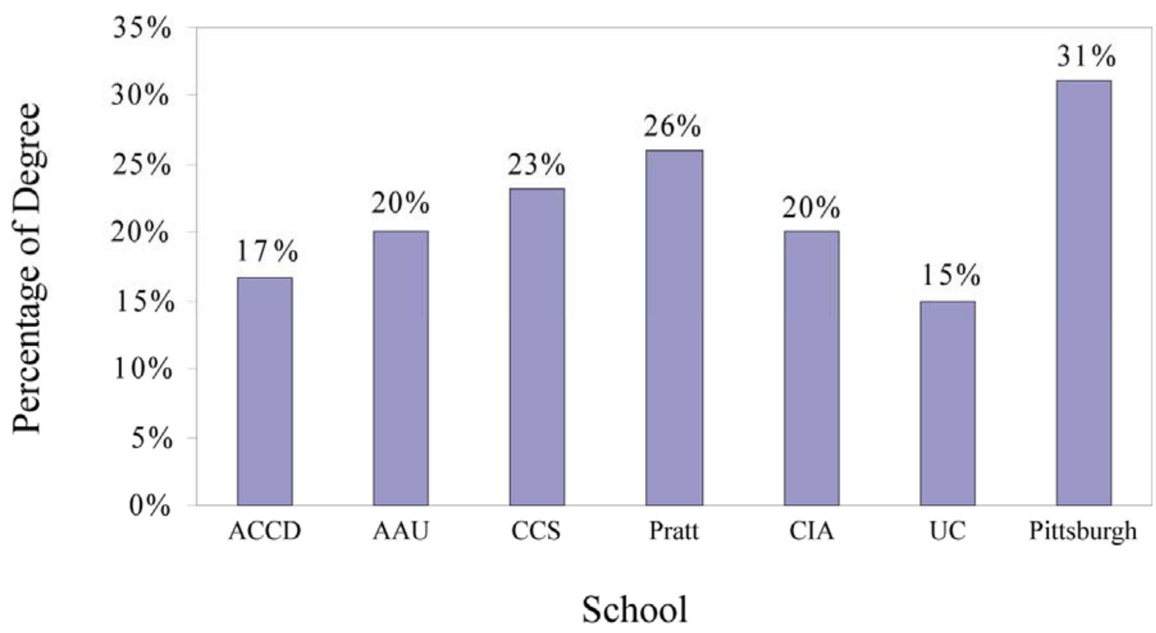

Figure 3.1 Academic requirements as measured by required courses in English, math, history (not including art history), and social and physical sciences as a percentage of the degree at each school

A university setting such as that provided by Cincinnati offers a wider variety of academic choices than is possible at art and design centered institutions. Arguably the university environment also affords better instruction in these fields if only based on the size of the infrastructure and available resources with regard to research opportunities, laboratories, libraries, other facilities, and faculty. Several of the smaller schools address this inequity through cross-registration agreements with other local colleges or universities. As mentioned previously, Art Center students may take classes at Cal Tech or Occidental. CIA students can choose from a wide variety of sister institutions including Case Western Reserve University.

Frequently design students do not enter these programs directly after high school. Previous college or advanced placement credit often relieves some of the academic burden from the schedules of both the student and the administrator. It is not an uncommon strategy to fulfill academic requirements prior to enrolling in one of these design programs so that a student may focus more completely on studio assignments. A little time in between high school and design school also allows students the opportunity to tune up an entrance portfolio for the programs that have such a requirement.

While it may be tempting to look at the preceding graph and draw conclusions, it would be unwise to look at any one such graph in isolation. Jumping to any conclusions before examining the overall balance of a program will not provide a useful picture. That said it is difficult not to speculate as to why Pittsburgh seems to place such a great priority on academics while Art Center and UC are apparently on the cusp of making the academic element a token gesture. Be aware that the division of the curricula into categories is not an exact science and was completed by the author based on published course descriptions and schedules.

Programs based on the quarter system are afforded a bit more flexibility by the shorter duration (ten weeks) of the terms. A program using quarters is more likely to devote an entire course to a particular topic than to combine it with one or more broadly similar topics in a course with a more general title. Some programs are more likely than others to teach particular skills within the confines of a particular studio as opposed to presenting the material in a separate course, model making or visual communications for example.

When specific skills (for instance, marker sketching, clay modeling, Photoshop rendering…) are taught in the context of a design project there is a risk that the design will be dictated not by a student's imagination, vision, or research but by the student's developing ability to utilize a particular tool or technique (a marker, a steel, or a tablet). This may artificially inhibit and frustrate the student and ultimately serve neither to expand the student's understanding of design principles and processes nor to build competency with a particular communication skill. Conversely, when tools and techniques are taught in dedicated classes outside of the primary studios they run the risk of losing the context of a project that facilitates understanding of not only the tool itself but also its appropriateness and relationship to the overall design process. Additionally, dedicated courses require space (academic units) in a crowded schedule. That said, it should be recognized that if a program appears light with regard to foundation and visual communication courses (for example), it is likely that many of the topics that might be covered by such classes are being addressed in studios or even supporting lecture classes.

Design Foundation and Visual Communications

These courses in conjunction with digital media offerings constitute the very language of design. The term foundation is more than just a name; it is what the rest of the education rests and relies upon. Most programs use foundation courses to teach basic design fundamentals: proportion, scale, color, theory, process, creative thinking…. Visual communications courses build on those basics and focus on particular tools and methods to express different materials, environments, experiences…. Without a certain level of mastery in visual communications the design process becomes untenable in studio courses. A student's concepts cannot be sufficiently expressed nor adequately understood. Imagine reading a term paper for an English class written by a student with no understanding of the rules of grammar or composition. Likewise, how might one complete a thermodynamics or physics course without a mastery of algebra?

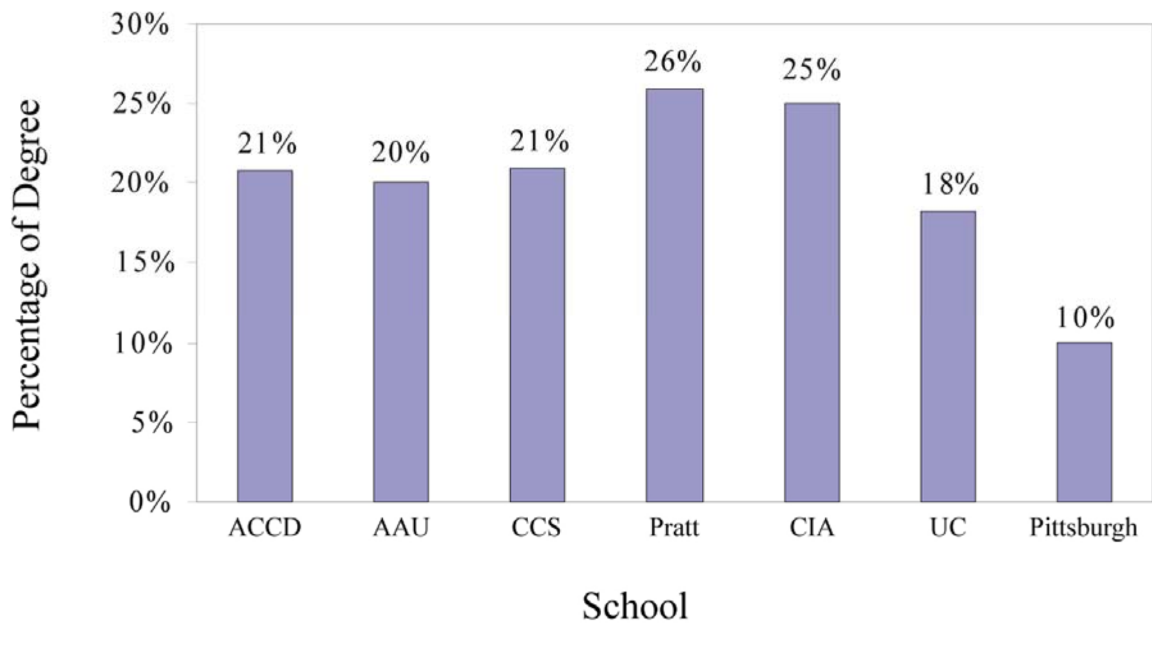

Figure 3.2 Design foundation and visual communication required courses (not including model making or computer courses) measured as a percentage of the degree for each school.

Once the fundamentals are learned they must always be maintained. This is another function of visual communication courses. New skill sets are added as older ones are maintained and strengthened. No substitutions are made. Education is a process of accretion. Educators must be ever-vigilant to insure that students retain the skills acquired in one course and apply them in studio and other courses, concurrently to be sure but perhaps more importantly, moving forward into subsequent terms and years.

Core and Concentration Studios

These studios are the focus of a student's academic career. The projects completed in these offerings will form the backbone of the portfolio that graduates will rely upon to land a job. These projects also offer the student the opportunity to apply the tools and techniques that have been accumulated in other parts of the curriculum. One of the unique elements of a design education is the intimate relationship between learning a skill, using that skill and being accessed with regard to that skill. In a design education these things happen almost simultaneously much like an apprentice learning a craft under an acknowledged master. Understanding cannot be achieved without application. Unlike more traditional academic disciplines, design is much more concerned with techniques and processes as opposed to facts. Techniques and processes are learned by the very practice of them, not simply the intellectual understanding and identification of them.

Based on the importance of these studios one might be surprised at the relatively low percentages that are reflected in the graph below. It should be understood that these graphs do not take into account the number of units associated with a given class, rather they more simply reflect that such a class is a required element of the program. The graph also does not reveal the number of hours required by such a class to meet the expected standards. Greater percentages of studio classes could indeed represent an excessive workload that will ultimately burn out even the most talented and dedicated student. To borrow an analogy from sport, most of the classes are like practices. At practice you work on specific situations and develop particular skills: the throw in, the corner kick, dribbling, passing, and the header. These are analogous to ergonomics, research, story-boarding, perspective, marker sketches, and modeling. Practice should be fun but it is always in preparation for the game: the studio. The studio project, particularly the sponsored studio project, is the field of competition where all the skills developed in practice are put to the test and the game is raised to a new level.

Competition in the studio is a tremendous motivational and educational tool. Many programs rely on the interaction between students in studio to advance the educational process. While each student desires to be recognized as standing above his or her peers, students recognize that the strength of the studio as a whole is also a reflection on the individual members of the group. That collaborative environment is fostered with that in mind. Moreover, the student who is able to teach more firmly grasps the topic with each lesson provided and is also more likely to have the favor returned.

Logistically speaking, the size of the group is relatively small and varies roughly according to the size of the program and the particular term from a half dozen to as many as 25 or so. Ideally each situation has an ideal number that allows an intimacy in the group and sufficient time with the instructor but is large enough to ignite the synergy of a number of strengths and perspectives within the group.

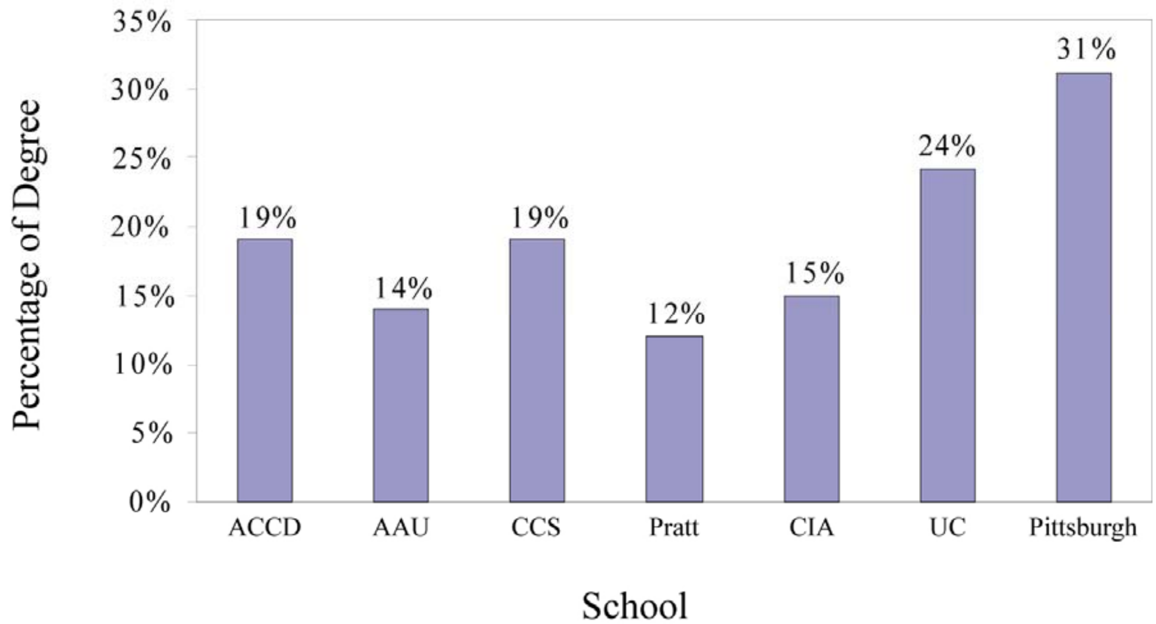

Figure 3.3 Core and concentration studio requirements measured as a percentage of the degree for each school

The norm for these studios is a formal meeting once or twice a week for an extended period of time (six hours). Such relatively long studio periods allow a great deal to be accomplished over the course of one class and also allow enough time in between classes for students to make significant progress without feeling the pressure of creating some sort of display three or more times a week to the detriment of real progress. Meeting once a week also diminishes the possibility of a micro-managing instructor or a student leaning on the instructor like a crutch. On a practical note, meeting once a week is also very convenient for the instructors who, more times than not, are taking time away from their jobs in manufacturer's design studios. While some of these instructors are simply commuting across town, others are regularly flying (or driving long distance) into different cities (Cuffaro, 2006; Matano, 2005; Pollard, 2006). Provided that dedicated studio space is used and that is standard practice in most cases, particularly in upper terms, this is the studio in which students will spend most of their waking hours; most of their other assignments will be completed here along with a fair number of meals. This is where the students take ownership of their space, their projects, and their education.

Digital Media

The degree to which the various programs have embraced computer based technologies varies widely although that is not readily apparent from the associated graph. The UC program is very overtly and outspokenly in favor of extensive use of digital media and offers instruction in those tools right from the beginning of the program (O'Kane, 2005). Pratt, on the other hand prefers to save the computers primarily for the later terms and even then uses them mostly to generate presentation materials yet the percentage of required computer courses of the two institutions is nearly identical (Goodwin, 2005). The low percentage of classes at Art Center is the greatest deviation from the average on the graph. This should not be taken as a lack of commitment to digital media. This is simply a reflection of the fact that relatively few classes are specifically and primarily concerned with teaching students software. Art Center was an early adopter of Alias as an industrial design tool and has continually expanded the role of digital media in the program. Another factor to be considered is the sort of student being admitted to the programs. Art Center graduate (class of 1990), designer, publisher, author, and Art Center instructor Scott Robertson points out that today's students learn software very quickly with roughly half of the first semester students already familiar with some sort of CAD (Robertson, 2006). "Software is just not a big deal anymore," according to Robertson.

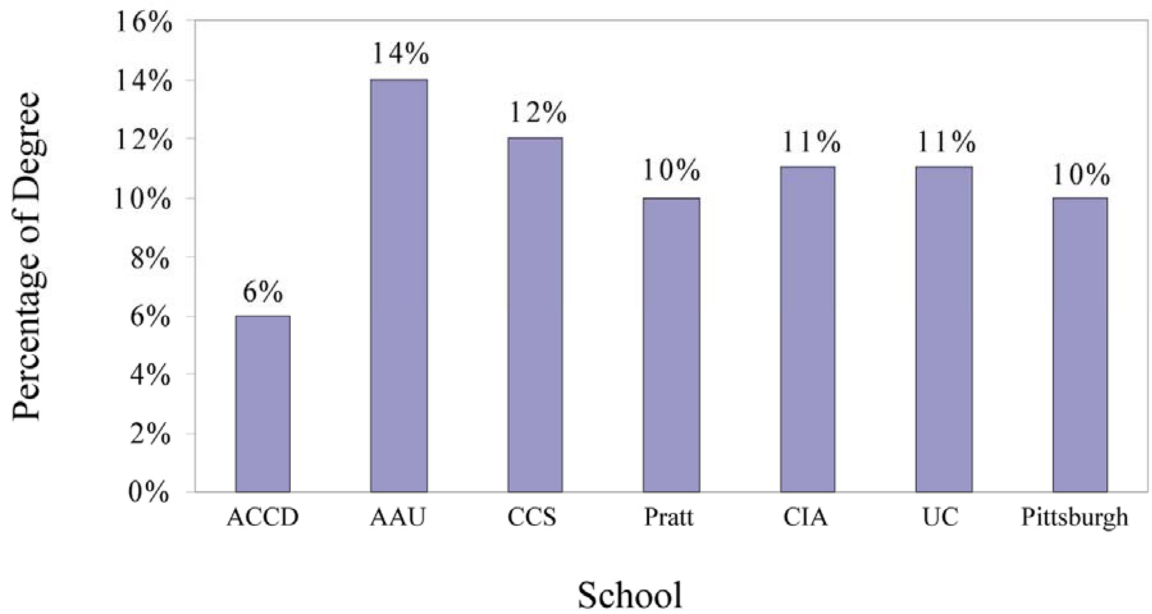

Figure 3.4 Computer course requirements measured as a percentage of the degree at each school

Supporting Lectures

This category is made up of a growing number of classes that afford students a more detailed understanding of many of the topics that impact automotive design. While many of these subjects have always been recognized as elements of automotive design in the past they were just as likely to have been covered quickly in the course of a studio project or simply mentioned as details or parameters that were either delegated to or dictated by other departments of a corporation. Product planning, marketing, branding and such came down as edicts from management (the professional equivalent of the studio instructor) and came in the pre-packaged criteria of the design brief. The designer was charged with meeting the brief but need not know how the brief was generated. Aerodynamics, drivetrains, chassis design, packaging could all be handed off to or handed down from engineering. The industry refers to this process as 'throwing it over the wall,' in a very linear, chronological, and time consuming product development cycle that often requires many iterations and contentious confrontations as design and engineering attempt to arrive at a design that could be produced without actually collaborating in the design process (McElroy, 2005).

One of the 'new tools' that is perhaps only circumstantially computer based is the heightened belief or recognition that branding and marketing are integral to the design process. J Mays, Ford's Group Vice President of Design, talks about this at some length and he is by no means the only proponent of this view (Armi, 2003; Hodge & Armi, 2002). Without going into great depth about the teaching of marketing and branding, suffice it to say that it is yet another part of the puzzle that has a reasonable claim to a portion of an automotive design curriculum over and above that which may be conveyed in traditional studio projects. Indeed, beyond the marketing aspects that may be covered in 'professional practice' courses that have been part of some curricula for years, many schools have introduced more targeted classes. Art Center includes a class called Automotive Product Planning in their program. The Academy of Art University offers Trend Analysis and Consumer Psychology. The Cleveland Institute of Art counters with Marketing and Design. Art Center, for one, has conducted a number of sponsored projects (Isuzu and Audi among others) in conjunction with students in the school's advertising program (Audi, 2004; Fujimoto, 2004a).

Courses designed to impart a better understanding of the engineering side of the design equation include Automotive Engineering, Vehicle Architecture, Automotive Product Planning (all requirements at Art Center) and Vehicle Packaging (a CCS requirement). Conspicuous by its absence as a requirement in any of the programs examined is a course in basic aerodynamics. It is worth noting that when the author was an undergraduate at Art Center (1987-1990), a second Automotive Engineering course was an elective but neither Vehicle Architecture nor Automotive Product Planning were available; aerodynamics was required and the entire industrial design student body was required to take a very basic engineering course called Structures. This was at a time when only two very limited enrollment Alias courses comprised the entire offering in the realm of digital media. Is it ironic that at a time when sophisticated math models of vehicle packaging can be easily generated and used as three-dimensional sketch underlays and surfaces modeled on the computer allow computation fluid dynamics (CFD) programs to provide virtual wind tunnel test data, there is little room in the curriculum to teach the fundamentals of vehicle engineering and aerodynamics that are made so much more accessible by these computer based technologies?

Other Common Elements

At least two other common, basic elements of the curricula should be mentioned. All the programs require some degree (between two and five classes) of art and / or design history and instruction that can be loosely termed ‘professional practice.’ Not surprisingly, the conservative, liberal arts oriented program at Pratt requires the most history courses: four in art and one in industrial design. The benefits of understanding this history are manifold. Historical studies allow art, or design, to be more easily understood in context. This facilitates the appreciation of the relationship of contemporary designs to context. With regard to creativity and originality, one must have knowledge of the metaphorical box in order to think outside of it. Historical studies provide this perspective.

Professional practice courses have traditionally been focused on portfolio preparation and other skills helpful to landing a job. The current trend expands upon that basic content to include more information useful to an entrepreneur or business proprietor. Pratt's requirements call for no such course but the other schools feature between one and five classes of this type. Much of the entrepreneurial possibility available to designers today is a result of the efficiency of computer–based technologies. Computers allow individuals to work at a distance from clients or collaborators and put an array of resources previously not readily available at a designer's finger tips. The expanded emphasis in this realm is in part a reaction to the understanding of both students and educators that career paths are much more non-linear than in previous generations and one cannot simply prepare for just that first job (Wardle, 2006).

Curricular Strategies

A number of program directors have identified this as a time of transition. Daniel Cuffaro at CIA is in the midst of a transition from a five year curriculum back to a four year schedule. Geoff Wardle has said that Art Center is currently reworking the curriculum to meet industry demands. Tom Matano, director of the AAU program feels that the field in general is currently in transition with respect to new software. Brigid O'Kane is working to bring the PACE project to Cincinnati to greater enhance collaborative education between schools at the university, particularly with engineering disciplines.

While the current situation may seem particularly transitory especially with regard to quickly evolving software and other technology-based tools, consider that this flux is a natural state for a vibrant, successful program. The consumer market for automobiles will not allow a manufacturer to become settled or stagnant with product offerings. The manufacturer must be constantly responding to the consumer, improving the product and responding to competition. The manufacturer may be producing cars or potential employees. The consumer may be looking for personal transportation or someone to design a sedan. In the quest to compete, technology and processes are continually evolving. The human resources that drive a company are an integral part of that evolution. It is no wonder that the demands placed on academia to provide appropriately skilled employees quickly follow the same path of technological development and change.

Integration of Content

Every program faces a continuous process of evolution to maintain a relevant, practical curriculum that serves both students and industry. For at least the past five years, and moving forward into the foreseeable future, one of the primary challenges of any automotive design program is adequately presenting all of the pertinent topics that are now seen as integral parts of automotive design. It is not enough to produce creative, compelling forms, rendered to perfection. To a greater or lesser extent automotive design includes aerodynamics, basic design and mechanical engineering, biomechanics, branding, color theory, communications, ergonomics, fashion, graphics, history, interface design, interior design, information design and technology, manufacturing, marketing, materials science, product lifecycle management, product planning, psychology, vehicle dynamics, and charisma to name a few. All this is of course in addition to the skills, both traditional techniques and computer based methods, which allow a designer to imagine and communicate those creative compelling forms: computer graphics and computer aided design, concept generation, drafting, drawing, modeling, perspective, presentation, rapid prototyping, rendering, and sculpting along with written and verbal communication skills. Add to this extensive list even the bare minimum requirements of a broader, general, college-level education (English, math, social and physical sciences…) and an elective or two allowing a student to explore topics of interest outside of the concentration. It is no wonder that well-crafted schedules and curricula are essential in order for students to have a chance of completing this education in eight semesters or 12 quarters. This dilemma is addressed in a variety of ways according to the different philosophies of each institution.

Art Center requires more units than any other 15-17 week-per-term program (144). In spite of this, there is a struggle to present all the content that is believed necessary. According to Geoff Wardle, Associate Chair, Art Center is currently reworking the curriculum because of this situation and in order to meet the demands of industry (Wardle, 2006). Wardle raises the vexing and legitimate rhetorical question, "how much is it right for industry to expect of a new graduate?" (Ultimately this leads to a debate over the point at which the needs of the student and the needs of the industry are no longer complementary. As long as the good of the industry also serves the students, the program is successful.) Although the rework is not complete and certainly cannot be accessed (moreover, Wardle and department head Stewart Reed did not feel at liberty to discuss specific plans), it appears that the Art Center strategy entails the integration of more topics into the studio environment along with the integration of design context into academic courses. Art Center instructor Bumsuk Lim would like students to have more time to absorb all the information and believes that two term projects could be beneficial (Lim, 2005).

Truman Pollard, Lead Designer at Mazda North American Operations and occasional instructor, recollects on his Art Center education concluded in 1979. "When I went through school … we had an eight semester trimester course of study. Art Center still has the same eight semester[s] … but has added a variety of computer digital skills. I wonder what they now leave out… I think most schools are in the same situation and have not adapted well to new technologies."

Some educators believe that the current content overload may be waning at least with respect to software training requirements (Robertson, 2006). Each new high school graduating class is invested with greater familiarity and facility with computers in general and design software in specific (Hambly, 2006). The generation of designers who have grown up with personal computers is fast approaching if not already upon us. Indeed, it is only the middle-aged professionals who graduated from their design schools in the late 1980s who were not academically trained on computers. If you are over 40 years old (designer or layperson), the computer is a revolution; under 40…and certainly under 30 … as likely as not, the computer is an appliance.

Imre Molnar, CCS Dean, sees the curriculum management as, "really tough, a continuous struggle." In order to remain economically competitive companies run lean and have little interest in training entry level personnel. The desire and the expectation of industry have become graduates that are fully versed in the computer tools (notably Alias) used in the studios. The CCS answer is the establishment of and adherence to "educational priorities" designed to land the student that first job (Molnar, 2006). It would appear that CCS counts on the first job providing the experience necessary to move gracefully to subsequent jobs. Art center, by contrast, puts greater priority on preparing the student for more than just that first job and seems to recognize that these days the first job could take many different forms. The specific educational priorities honored by CCS are traditional sketching, leading to monochromatic rendering, Photoshop, and Alias in that chronological order (Molnar, 2006). The program places particular emphasis on sketching and Alias. The Dean also recognizes the current need for graduate level education in transportation design as another strategy to address the growing demands of the industry.

Tom Matano and Hideki Masuda of AAU both recognize that a five year program with two additional semesters would be desirable from the perspective of the education. They both also believe that solution is impractical for the school in a business sense. Matano sees in the near future the possibility of technology solving the problem that it seems to have created (Matano, 2003). Certainly there are hardware and software products being developed that facilitate the design process in the digital realm and utilize input interfaces that resemble traditional drawing techniques. (This will be addressed more closely in subsequent sections.) Masuda considers that the program is not able to go into the depth that he would like in some areas and points out that accreditation limits the number of units that can be required for the degree (Masuda, 2006).

As mentioned previously, Cincinnati relies a great deal on the co-op element of the program to provide content that is not addressed in the campus curriculum. The UC solution is based on a longer program. Including the required co-op quarters, 18 quarters are necessary to graduate. Assuming that a student could attend four quarters a year and the necessary courses were available, the minimum duration of the program would still be four and a half years. The six quarters of co-op account for a year and a half over and above the traditional 12 quarters. In addition to collaboration with industry, UC makes great efforts to collaborate in studio with other disciplines within the university to broaden the education of the students without adding course requirements.

CIA is the anomaly of the group in that they are contracting the program from five to four years. What seems like a contraction may, in fact, be an opportunity to inject more content as outlined in the preceding chapter.

Examining these programs and other obvious possibilities reveals at least five distinct schools of thought with regard to infusing an automotive design education with all or -- at least more -- of the elements that are necessary today. Certainly many combinations of these avenues may also be viable. Most educators and professionals agree that the status quo is no longer sufficiently meeting the demands of the industry as technology and process expand the required breadth of a designer's knowledge. There is some debate as to the practicality of those demands from industry. These schools are:

- Longer Duration of Educational Programs
- Greater Specialization
- Greater Collaboration
- Technology as Savior
- The Graduate School Model

This first approach can be further subdivided into the five year Bachelors degree, the Bachelors degree with co-op requirement, the addition of graduate programs or other post-baccalaureate study, and the pursuit of multiple Bachelors degrees. The five year option simply adds units to the minimum number of units required for the degree. For instance, if the degree currently requires a student to earn 144 units, the five year program would require 180 units and allow an addition to the curriculum of up to 12 more classes. Cincinnati provides an excellent example of the co-op program. CCS and particularly CIA are contemplating using a graduate program to put the icing on the cake.

Students who elect to pursue multiple Bachelors degrees could be looking at eight years in school. Such students can focus on academics for a broad, general, liberal arts education (or engineering for that matter) and then focus on the studio aspects of a design degree since the academic requirements have been met. Certainly this approach has many variations such as two years of community college or some such thing to meet the academic requirements of the design school.

Moving towards greater specialization allows students to study a narrower field of transportation design in greater depth. This is somewhat antithetical to the generalist tradition of industrial designers but in an industry of increasing complexity and division of labor this must certainly be considered as an option. Possible divisions could be as broad as interior versus exterior or as specific as ergonomics, digital modeling, or concept generation.

Greater collaboration could possibly be paired with greater specialization but greater collaboration alone could add significant content to current curricula. By bringing engineers, graphic designers, psychologists and students or professionals from other related fields into the studio to work on common projects, students have significant exposure to more topics without adding (and consequently subtracting existing) courses from the program.

The fourth avenue sees technology as the solution. While it is almost certain that technology will become increasingly transparent to the design process over the short term and students are becoming increasingly computer savvy at younger ages, history tells us that technology will continue to generate new tools and processes. Inevitably there will be periods of refinement and adjustment to these new technologies in a cyclical pattern.

Occasionally but with some regularity, there will be periods in the cycle that force educators to make adjustments as students (and industry) struggle to keep pace while adapting to take advantage of the capabilities of new technology.

Just as Alias and other three-dimensional modeling software has become ubiquitous in both industry and academia over the past decade or so, Steve Nowicki, ASC Design Director, believes "these skills will be quickly replaced by digital clay, or a way to shape clay or some other form of media, that instantly updates a math surface file in real time while that media is formed to the shape of the design!"

Many programs follow elements of what one might call a graduate school model. This too is something of a strategy to ensure thorough coverage of the constituent topics of automotive design if not integral to the specific curriculum, then more importantly integral to the overall education of the program graduate. This model includes a highly selective admissions process to insure that students in the program are at the proper stage of educational development to benefit from the curriculum. At Art Center and CCS this selection process and assessment is characterized by the admissions portfolio. At Cincinnati the requirements are a high secondary school GPA, record of academic achievement, and exemplary performance on standardized tests. A second element of the model is the expectation that the student already has a well defined focus to his or her desired studies. This condition is satisfied by requiring students to apply to a specific program (transportation design) as opposed to simply being admitted to the institution as a whole. Graduate programs are largely driven by research. The nearly ubiquitous industry sponsored project may in some respects be looked upon as design research and like the research grants that traditional graduate schools seek to attract, the grants, or project sponsorships, can be a significant source of funding. Graduate students are often used to instruct undergraduates. In many of the programs considered, accomplished, upper-level undergrads are encouraged to teach peers and lower-term students through greater or lesser formalized conventions (mentors, tutorials, demonstrations, or informal studio exchanges).

Faculty

Curiously, several of the schools considered in this paper make a significant point of the fact that the faculty is drawn primarily from the ranks of working professionals continuing a time-honored tradition. Upon further examination this practice is more the standard than the exception. Because of geographic proximity to concentrations of automotive designers, CCS and Art Center are at a significant advantage relative to attracting leading professionals into the faculty but CIA, AAU and to a lesser extent UC also regularly tap the deep pools around Detroit and Los Angeles. Accomplished professionals intimately familiar with current industry conditions are able to give students a clear understanding of the industry while serving as master and mentor to apprentice students, strengthening the bonds between the school and the designer's regular employer. To the benefit of the institution and its students these bonds help to attract sponsored studio projects, internships, and job offers for graduates.

Of course, the instructors and the companies for whom they work also derive benefits. A close relationship with the students through studio interaction and internships helps to identify desirable potential employees. Sponsored projects and the more general act of teaching a studio provide creative stimulus and help generate new ideas for the professional designer and his or her employer. The instructor may be the ultimate ‘soaker,’ a term used to identify a student who is already an employee of a given company who has been sent to design school by the company in order to ‘soak up’ fresh ideas and transport them back to the corporate studio. Student soakers may tend to ruin a grading curve but like the student newly returned from an internship they raise the bar of the whole studio with regard to professionalism and skills.

There are down sides to the working professional as an instructor. As employees of large, multi-national corporations, there is always the possibility that a designer may be relocated by the company with little regard for the plans of the school. Of course this is understood so there are no hard feelings and more times than not there is an equally qualified designer ready to fill the vacated spot on the faculty. The possibility for commitment, allegiance and, continuity issues exists but since the programs are frequently able to draw from a relatively large pool of designers the institutions are not forced to rely on individual designers or even single companies. Flexibility is built into the system. Perhaps the biggest argument against the working professional as an instructor is the question of the designer’s effectiveness as a teacher. Just because someone is a skilled and accomplished designer, there is no guarantee that he or she has any aptitude for sharing that knowledge. Like drawing, teaching experience will improve the quality but at what price to the students during the process? A more effective remedy for an ineffective teacher may be to once again rely on the available pool of talent and tap another designer.

Facilities

The facilities maintained in support of the curricula by the institutions have much in common but the differences reflect the variation in philosophy and priorities. Virtually all the programs provide dedicated studio space to upper-level students. Among other things, this facilitates education within the studio that continues outside the confines of class periods and the instructor's direct influence. A has been previously discussed this arrangement is a key element in providing students with a sense of ownership.

Clearly programs that pride themselves on a hands-on education and strong fundamental understanding of materials, form, and craft invest heavily in shop resources: space, tools, machinery, paint equipment, and faculty and staff with the experience to educate their charges in model building and fabrication techniques.

Programs aspiring to be on, or near, the cutting edge of technology likewise invest significant capital in computer hardware, software and the appropriate human resources to teach the software and maintain the infrastructure. In addition to the tools of computer graphics and math modeling, digital three-dimensional modeling tools and data capture devices such as rapid prototyping machines, computer numeric controlled (CNC) lathes, mills, and laser cutters, digitizers and three-dimensional scanners may be found in 'electronic' shop areas.

Most programs see the use of 3-D printers and other forms of rapid prototyping (solid freeform manufacturing, stereo lithography, laminated object manufacturing, selected laser sintering, and fused deposition modeling among others) as communication aids and tools to efficiently create models or model components. There is value in becoming familiar with the technology but as didactic design tools their utility is limited. Few programs are interested in catering to the education of technicians.

A spirited debate in all areas of industrial design education concerns the balance between traditional model making and digital modeling. While there are advocates for both sides of the proposition, it is widely recognized that traditional hand fabrication techniques are highly effective tools for the teaching of design fundamentals and an appreciation for detail and craft. On the other hand, math models are the language of industry. The ability to use three-dimensional modeling software (particularly Alias) is a virtual requirement for employment. Perhaps the best way to come to grips with this conflict is to acknowledge the merits of both and provide appropriate places in the program. As Imre Molnar suggests with regard to the more general debate over digital or analog skill development, the use of technology is driven by industry but traditional skills (sketching and clay modeling) are *vital*. On the other hand there must be digital instruction and production in the later terms: two and a half years of intense fundamentals and then intense digital techniques through graduation (Molnar, 2006).

One aspect of the discussion that touches on an institution's facilities and asset allocation is the cost associated with a digital lab as opposed to a traditional shop, or the digital lab versus the collection of traditional art supplies that the lab could theoretically replace. Outfitting a fifteen to twenty seat computer lab with the appropriate hardware, software and peripherals is estimated to cost over $70,000. This number does not include any consumables and no allowance is made for the physical space, overhead, installation, or supporting human resources. A traditional, wood-based model shop of modest size (only one or two of most machines) requires an estimated budget of over $50,000.

Again, no provision has been made for consumables, the shop space, overhead, or staff, to say nothing of insurance. Completing this picture is the budget for an individual student's supplies. Most art supplies are consumables and may last several semesters or several days. A comprehensive but by no means excessive outfitting of traditional supplies costs on the order of $1,350. A student's personal computer and supporting items can cost on the order of $2,600. For a more in depth explanation of these estimates, please see appendix B.

Students

"Competition - is a very big part of the design education. Unlike other vocations, art work is always on display and critiques are open subjects. I would think term papers for lawyers do not get displayed for all to see." Truman Pollard

Mr. Pollard has identified one of the unique aspects of an automotive design education and the pressure that places on students. A design student cannot hide and under good circumstances few have any desire to. In the better studios there is a healthy competition for display space and there is a metaphorical cacophony of work screaming for the viewer's attention. This competition supports high standards. When queried about the use of electronic media in presentations Art Center's Bumsuk Lim declared, "Students really want to pin up artifacts that will remain in sight." Surely this is in part an indication of pride, ego, and a touch of marketing.

Some programs welcome all students with the desire and means to study transportation design and allow the competition to perform the natural selection of those with enough talent or perseverance. Other programs seek students with obvious creative and artistic talent to nurture and polish, while some seek academically outstanding students and trust in the desire of the student and the strength of the program to develop the creativity and communication skills that may have been lacking when admitted to the program. Of course this begs the somewhat lofty question, can you teach design? Clearly, process and technique can be taught but the aptitude for design may not be something that everyone can develop. Moreover, what of the student who displays obvious design sense but does not master the computer skills required by industry? On the other hand, perhaps developing or nurturing such a talent is not necessary to be commercially successful as a designer. Perhaps a passion and the training is enough. Beyond functional criteria, manufacturing considerations and such Scott Robertson points out that a successful designer must cater to the taste of the market. Often times this does not require particularly sophisticated design (Robertson, 2006). Robertson's own words are a bit more blunt: "The general public has bad taste so in some respects a good design doesn't sell."

The common thread that can be found running through students in all these programs is a passion for the subject matter and a greater degree of focus than is usually found in the average college student. That focus is derived from many sources: as mentions, passion for the subject matter, cost and rigor of the education and maturity of the students all play a part.

Internships

The popularity of internships has been on the rise (Nowicki, 2006; Reed, 2006; Shuster, 2005). While always popular with students as a means to gain experience, pay, and hopefully a foot in the door of a prospective employer, increasingly design offices are finding that the internship is an effective means of sizing up a job candidate. The internship can function as a protracted job interview of sorts. This minimizes the risk that a company takes when hiring a recent graduate – and also provides some insurance to the employee that he or she will like the new job.

Internships of some sort are common to all the programs examined. At Cincinnati they take the form of the co-op. Not all programs offer academic credit for terms spent on internships. This reflects a subtle difference in philosophy. Those programs that do not give credit for the internship see the experience as something of a bonus that should enhance if not simplify the normal requirements of the curriculum. Those that give credit send the message that the student is learning the same material as is offered in studio courses. The venue is just different. Giving credit for the internship also allows the student to move toward graduation more quickly than would be the case when taking a term away from campus without getting any units of credit.

Units and Degrees

Curiously, although the curricula considered are generally quite similar and most of the programs are accredited by NASAD the types of degree and the number of units required to earn them have some variation. Art Center offers a Bachelor of Science degree that requires 144 units earned in a trimester based program operating year round. Cincinnati's BS requires 190 units earned on the quarter system. As shown previously this is roughly equivalent to 126 units based on the length of a semester or trimester. Pittsburgh requires 180 quarter based units (roughly equal to 120 semester units) to earn the BS degree. SCAD also requires 180 quarter based units to earn its Bachelor of Fine Arts degree. Pratt is unique in bestowing the Bachelor of Industrial Design degree which requires 134 semester based units. AAU, CCS, and CIA all grant the BFA and use the semester system. The institutions require 132, 126, and 126 units respectively.

Future Directions

The path into the future is paved with microchips but from this vantage point the designers look to be marching with pens and clay tools in hand. Each program sees the future a bit differently but all agree that the computer and its associated technologies and media are tools to be used at the discretion of the designer like any other tool one might choose for a particular task.

Geoff Wardle sees Art Center as “tending towards entirely digital” and espouses the belief that digital design promotes greater understanding and dissection of design thought. Even so, he sees fundamental, traditional tools as essential and psychologically important. Given the ratio of automotive design students to professional positions and the non-linear career paths that are common today, there is the need to provide a rounded education so that students can “play more than one game” (Wardle, 2006). Colleague Stewart Reed sees multiple instructors rotating through a studio to provide “niche instruction” taking advantage of the specialties of numerous designers and exposing the students to a broader range of topics without adding classes to the requirements (Reed, 2006).

Many educators see the possibility and advantage of using digital media to facilitate the educational process but exactly how this will be achieved is less certain. Tom Matano has characterized this as a challenge. Scott Robertson suggests that Photoshop needs to become part of the foundation and its layering capability be used to demonstrate both traditional and digital visual communication techniques. Classes must do more than simply teach software. Robertson also calls for continuing in the generalist tradition, offering more instruction on the business aspects of design, and instilling students with creative thinking and the ability to communicate those ideas (Robertson, 2006). Hardly radical thoughts, Mr. Robertson's concerns do address the changing face of the industry with more designers working independently, following non-traditional career paths, and the perception that digital media has leached some of the imagination out of design.

At CCS Bryon Fitzpatrick is committed to servicing the industry and surmises that this may mean a more technical, engineering oriented twist to the program (Fitzpatrick, 2005). This appears quite natural in light of CCS participation in the PACE program and the industry trend towards PLM with greater collaboration between design and engineering.

Tom Matano already sees the day on the horizon when designers will stop using markers. Curiously, Matano paints the picture as a result of economic considerations in the art supply market (Matano, 2005). The primary market for quality markers was previously graphic designers. They have abandoned that media for computer graphics. Who will continue to use markers? More importantly, how can one teach a media once it is not commercially viable? "Out of necessity, the day will come when markers are replaced by some other tool…but these are tools. The fundamentals that they teach will remain."

Second in command to Matano at AAU, Hideki Masuda astutely points out that "Manufacturing Technology drives the look; computers allow designers to have more control. Computers are the new language."(Masuda, 2006) Indeed, that mastery of this new tool, this new language, will determine how much influence designers are able to wield within the industry. Without that capability, manufacturing engineers will, by default, control the results of the design process.

CHAPTER 4

INDUSTRY REQUIREMENTS AND DESIRES

Inefficiencies in the product development cycle cannot be tolerated in the current ultra-competitive market. Every manufacturer is fighting to reduce costs and capture market share. Many of the markets in play are no longer the big markets of the past that could be profitably shared by several manufacturers, each building several hundred thousand of a particular model for that market. The industry currently has gross manufacturing over capacity (Newbury, 2004). Factories that used to build hundreds of thousands of the same model car are being closed, using only a fraction of their capacity, or being retrofit to build a greater variety of vehicles that fit into multiple niche markets.

Industry use of computers in the design process shortens the product development cycle dramatically through simultaneous development of the chassis, interior, aerodynamics, crash testing and other elements of the design. Because most designers now over the age of 35 or 40 don't have adequate computer skills the industry is hungry for young designers who possess that skill set (Matano, 2005). Beside the ability to work concurrently on many elements of the vehicle development using a common math model, the use of such a model and computer technologies allows much improved communications between stakeholders in the design process even when the interested parties are on different continents. Efficient communications are key to minimizing development time. Design approval activities and the associated waiting time alone can take up to 35% of the design cycle (Buxton, Fitzmaurice, Balakrishnan, & Kurtenbach, 2000).

These conditions make design more critical to the success of a car company than ever. The proliferation of models and the ever-shrinking development times mean that there is more design work to be done and less time to accomplish it. Phil Mertens, Former Group Vice President Product Creation, Ford Motor Company points out that “design is increasingly more important due to fragmentation of the global market and required technology and amenities.” (McElroy, 2005)

The task of managing the development of even a single car model is daunting. Major manufacturers must manage the development of dozens. More and more this task is achieved using Product Lifecycle Management (PLM) tools that integrate all the required tasks and functions into software that can be accessed simultaneously in real time by all the required divisions of the company. Use of such sophisticated software also allows designers and engineers to achieve greater economies by sharing vehicle architecture, drivetrains, and smaller parts. The process starts with market driven criteria, quantified as specific design objectives and incorporated into the math model of the design proposal (McElroy, 2005). The math model is then built simultaneously by design and engineering functions. As surfaces are created digitally they can be evaluated not only visually but also structurally (FEA), aerodynamically (CFD), and with regard to manufacturing viability, materials and processes. Before the design reaches the physical prototype stage, suspension tuning and crash testing can be done on the computer; manufacturing and industrial engineers can begin to define the manufacturing process and layout assembly plants while purchasing agents can line up suppliers and evaluate costs. Clearly, the whole process depends on communication made possible by using a common language: the math model. It is essential that designers speak this language fluently ... and aggressively. Successful manufacturers must rely on superior design. “The only thing that is going to separate our company from the rest is great design,” declares J Mays, Ford Group Vice President of Design (Fonda, 2006).

In light of the responsibility carried by the design function, the lean state of the industry, and the universal adoption of the math model as the path to manufacture, it is clear that Art Center’s Geoff Wardle is correct when he states that industry makes great demands of young designers, very quickly putting responsibility into the hands of recent graduates (Wardle, 2006).

General Motors

General Motors uses Unigraphics (UGS) software for packaging and Alias for surfacing and design. GM looks for graduates who have already mastered these software packages and are not in need of further training. Providing that training in an academic setting is one of the driving ideas behind the PACE initiative. Art Center, CCS, CIA, Pratt, UC, BYU, and more recently AAU are the schools that the corporation regularly visits in search of new talent. They also look overseas to staff the design offices that GM maintains all over the world. At these schools GM seeks out the best ‘creative designers,’ a term GM uses to distinguish industrial (automotive) designers from design engineers and computer drafting personnel, as well as manual and digital sculptors (Shuster, 2005). GM also seeks summer interns from the ranks of rising seniors at these schools.

GM was one of the first companies to recognize the possibility of using schools and sponsored projects as long-lead, design research studios as early as the reign of Harley Earl (Armi, 1988; Crippen, 1984-1989). More recently GM has teamed with the

Smart Cities Research Group at MIT to explore the GM themes of energy, environment, affordability, safety, and congestion (Duchene, 2006).

The use of technology in the design process continues to evolve at GM as new technologies provide greater efficiency and better communication as affirmed by GM Vice President of Design Ed Welburn. “We continue to explore its benefits. But clay models are not going away. We are aiming for a right balance for what we should do in clay and what we do in digital environment. Our work in developing vehicles in math is very important. It is a huge enabler in communicating with Engineering very early in process, and Manufacturing as well. So much earlier [sic]. For tests for crashworthiness, structural analysis [sic]. And it helps us to communicate with our global partners. We have projects going on simultaneously all over the world, where we are sharing components, sharing entire vehicles. We can transmit data for virtual reality review.” (Yamaguchi, 2004) As the head of design at GM, Welburn is responsible for virtually all design but takes a hands-off approach when it comes to actually putting pen to paper, or stylus to screen, in the design process but when queried about his sketching habits he admits to sketching cars at home, in the office and occasionally during meetings. This helps him to understand the specific problems and issues that his designers are facing. “I think best when I am sketching.” (Youson, 2005)

Alan Rhodes, Global Senior Manager - Digital and Virtual Design at GM Design, recommends mastering traditional techniques and understanding how to choose the proper tool and then strike a balance between the two. He emphasizes that the computer is just a tool like any other. Successful designers have always known to use the right tool to express a particular design. “We just have more choices of tools today.” Rhodes would like to see more collaborative projects between design and engineering programs in academia to provide students with a better understanding of how industry operates. All the elements of automotive design (ergonomics, aerodynamics, surfacing, concept generation, engineering, materials, interface...) must be understood by the best designers, according to Rhodes, citing a trend in Asian industrial design programs that require a minor in engineering prior to beginning the industrial design curriculum (Rhodes, 2006). This sounds very much like the complement to a recent shift in the engineering program at Northwestern University where drawing and other visual communication skills are taught prior to the core of engineering courses.

Mazda

Conversations with Truman Pollard, Lead Designer at Mazda North American Operations, have yielded many insights with regard to Mazda (NAO) process and practice. Mr. Pollard sees Art Center and CCS as the leading programs in the country because they get the most support from industry because of their proximity to corporate design studios and close contact with the latest trends in the California car culture or in the manufacturing hub of Detroit. When it comes to looking at recent graduates to fill an opening in the design office he states flatly, “portfolio is everything.”

While 50 to 70 % of the work in this studio is done digitally, the “skill of drawing is very much alive. Pen on paper is a great sensation.” Frequently a designer will scan in a hand sketch to be completed and refined digitally. Alias, I-movie, PowerPoint, Adobe Premier, Photoshop, and Illustrator are commonly used in the studio. Pollard points out that technology is a personal tool (that is, a tool of personal taste) and he is seeing more use of animation, video, and other ‘non-traditional’ digital tools to communicate designs.

Like many of his peers in industry and academia, he emphasizes that the new media are tools just as are pens, markers, gouache, and the air brush.

Interestingly, while discussing the value of working full scale in clay to appreciate the form and scale of a design, the idea of 'soak time' entered the conversation. Soak time refers to the time that designers spend with a design, primarily during its development, while not necessarily working directly on the model. It is the time that the design seeps into the consciousness of the designer while he or she is not specifically focused on the design, living with the design and having it in the environment. This idea was something of a novelty to Pollard who chuckled and seemed to offer as something of an excuse, "we are understaffed" no time to just live with a model! The business culture is requiring everyone to do more with less. Speed is critical and ten days from sketch to form is not uncommon. He is adamant that part of the design process must be full scale three-dimensional models. "Clay models will always separate a good design solution from a pretty image, even if the image is freehand or on a computer. The computer screen, like a piece of paper, has real limitations to discern a full size product and we heavily rely on scale and full size clay models for surface development." (Pollard, 2006)

BMW

One of automotive design's most polarizing current leaders is Chris Bangle, BMW design chief. Depending on who you ask, he is the profound philosopher of flame-surfacing who has energized BMW and ignited an industry trend or he is the *enfant terrible* who has ruined the careful evolution of appropriate sophistication and understatement of one of the world's finest marques. In any event, he is surely influential. Bangle is not alone in his assertion that "renderings these days are irrelevant." In sum, Bangle sees renderings as generally inefficient and thus no longer one of the tools of choice. In Bangles eyes, the productive, useful work is done in three dimensions (digitally or physically). Sketches, and to a lesser extent renderings, are the tools that designers use in conversation about the design (expressed in three dimensions) amongst themselves in the studio. Bangle calls them "visual guidelines." (Perini, 2003)

Mercedes Benz

One of the new technologies in vogue in professional design studios that has not yet filtered down to academia is the use of the Powerwall. Generally speaking this is a very large computer screen (on the order of 20'long x 8' high or larger), associated projection system, and software that can display vehicle images in full scale (Buxton, Fitzmaurice, Balakrishnan, & Kurtenbach, 2000). Instead of looking at full scale drawings, clay models, or real cars designers and upper management can look at digital images projected at life size. This can also be used to show 'full scale video' or to turn a math model or 3-D rendering as if it were a three-dimensional object on a turn table. This technology can also be used as something of a digital pin up wall. It is not too great a stretch to imagine that it is only a matter of time before students have the chance to become familiar with this media during the course of the educational process.

During the design of Mercedes Benz new A Class traditional techniques were used only in the early phase of manual sketching. Even at the outset, some designers drew right on the computer monitors or Powerwall screen with styli. Sketching directly on the Powerwall insured that the engineering and packaging parameters remained integral to the sketches. After the design had been refined on the Powerwall, the technology facilitated a critical review of nine design proposals, allowing side by side comparisons in full scale. Selected proposals were modeled in clay at smaller scale and after further review three were built full scale. Continuing use of the Powerwall permitted real time modifications to be seen full scale and shared with other departments, further speeding the design process (Perini, 2004).

Independent Design Studios and Consultancies

Many of the same techniques and processes used at the major studios are also used by smaller firms. It is not unusual for large corporations to subcontract design work to smaller studios (or absorb them as has been the case with BMW and Designworks among others). In such a case it is natural for the corporate giant to want deliverables in the formats that they customarily use. While such technology was once prohibitively expensive for all but the best funded organizations, software and the required hardware has generally continued to drop in price while the efficiencies made possible by the technology have grown. Moreover, the fact that virtually everyone is using digital models to create production tooling makes this technology essential for small and large studios alike. Indeed, it may be argued that sophisticated, relatively low cost software has leveled the playing field between the large corporation and the small consultant to a significant extent. Clearly this relationship to technology has also been a benefit to educational programs.

ASC

American Specialty Cars (ASC) began life as a one person company specializing in sunroof installation. ASC originally stood for American Sunroof Company. Since its founding in 1965 it has grown to about 1,000 employees and has been instrumental in the design of numerous production vehicles from major manufacturers (ASC, 2005).

ASC regularly recruits from CCS for both interns and entry level positions not only because it is a respected program but also because of the close proximity to ASC headquarters. ASC also visits Art Center looking for designers. Alias sketching and modeling are high on the list of requirements but ASC employs digital modelers specifically to do the surfacing and math modeling with the direction coming from the designers. The better a designer understands the digital modeling function, the more direction he or she can provide. Creativity and communication are important components of a good designer. Top designers must also have the background to confidently interface with marketing, engineering, modelers and other functions involved in the design process (Nowicki, 2006).

Steve Nowicki, ASC Design Director, looks at traditional media in a manner similar to that expressed by Chris Bangle. Quick sketches with pen and paper are used for communication between designers and modelers to prove concepts and share ideas. Beyond that almost all of the design work is done on the tube or in three dimensions.

Nowicki has a positive take on the direction that automotive design education is currently taking. He sees more attention rightly being paid to not only the needs of the consumer but also the needs of industry like ergonomics, features, production, and manufacturing. The one shortcoming he notes is in the realm of business and relating to the real world which is why internships are encouraged. "Industrial designers, especially automotive designers, need to wear many hats if they truly want to be successful." (Nowicki, 2006)

George McCowan is a designer at ASC. He notes that at the outset of a project Alias and traditional paths are sometimes followed in parallel with much of the modeling starting over a scanned sketch. “Young guns don’t use markers,” observes McCowan. Over 85% of the work is done electronically but this is highly dependent on the individual studio manager. With regard to technology in the design process he feels that some creativity is sacrificed for digital efficiency and that is noticeable in the designs. McCowan is hopeful that technology will soon facilitate the return of the art (McCowan, 2006).

Foresee Car Design

Foresee Car Design is a small highly successful design consultancy located in Southern California and Gibraltar (Fujimoto, 2004b). Principal Cornelis Steenstra is quite clear about what he looks for in a recent graduate or entry level designer: “talent, passion and the desire to innovate. Education is secondary….” Like many designers and educators, he is quick to note that software such as Alias and Photoshop are tools. A designer’s ability to communicate clearly and facilitate the translation into an actual model is paramount. New technologies are a back up to experience with traditional materials in both two and three dimensions (Steenstra, 2005).

In Mr. Steenstra’s experience using entirely traditional methods as opposed to digital increases lead time up to 80%. The majority of Foresee’s clients ask for a combination of traditional and digital output (C. G. Steenstra, 2005). For further information from Foresee and Cornelis Steenstra, please see appendix C.

Aria Group

Another independent Southern California product development consultancy, Aria Group’s clients include BMW, Bombardier, Ford, Honda, Mercedes, Mitsubishi, Nissan, Panoz, Proton, Toyota, VW/Audi, and Volvo (Aria, 2005). Derek Ferretti, designer with

Aria Group, offers the following observations. At Aria and in the industry in general, engineering and design are becoming one. Technology provides efficiency; beyond software, this also applies with respect to 3D rapid prototyping machines. “Traditional methods are being squeezed out by deadlines” yet the gap between reality and the digital world is still a problem (Ferretti, 2005). “Touching and seeing is the best validation,” according to Ferretti.

CHAPTER 5

TOOLS, TECHNIQUES, AND TECHNOLOGY

Traditional techniques, media and methods are well known to educators and practitioners. Computer based tools should not be considered as replacements for the traditional varieties but rather as complements to them. In this chapter attitudes towards the new tools and insights from several technology developers are addressed. As one might surmise enthusiasm for relatively new or emerging technologies is generally greater amongst younger generations but even established, middle-aged designers (and educators) recognize the value of more efficient tools of communication. Frequently it becomes difficult to separate a small generational bias against computer based tools from a genuine and legitimate concern for the short-comings of those tools as perceived by acknowledged, experienced, master practitioners of automotive design. On the other hand, a lack of skill and experience with a particular tool (be it a marker, a paint brush, a clay steel, or an Alias workstation) is not necessarily an indication of a universally inferior tool. One might argue that before a tool can legitimately be criticized, it must be mastered. Of course, once mastered, objectivity may be lost to the other extreme.

Computer Based Tools

The great concern of passionate designers and educators who have made a career using traditional tools is that the computer and its many ancillary technologies will, in some fashion, 'steal the soul' or somehow degrade the quality of automotive design. One such designer and educator is Katsuaki Katoh who describes the computer as a "metal bar for a demon." This is akin to the metaphor of a bull in a china shop. Katoh's fear is that the novice, without a firm foundation in traditional techniques, will grab hold of digital media and swing it about recklessly, destroying what it touches with no sensitivity, oblivious to the process and spirit of product development (Katoh, 2005). Metaphorically speaking, sketching is a Swiss army knife while Alias is a gleaming broadsword. Would you trust the page with the master's battle weapon when he cannot quarter an apple with his pocket blade?

Walter de'Silva, Head of Audi Brand Group Design, is somewhat less cerebral but no less passionate about the situation. "You can't design a car from a computer. You have to feel it, touch it, caress it; you have to love it. It's like a human body. Then…it's good." (Monticello, 2006)

With today's economic pressure to shorten lead time and the great temptation of the technological capability, a very simple idea sketch sometimes will go almost directly to full scale in three dimensions! This eliminates much of the traditional process involving sketches and renderings (manual or digital) of higher quality and refinement. As the amount of drawing within the design process decreases so too may the designer's satisfaction in the drawing diminish along with the opportunity to practice drawing. Consequently, there is the serious risk that the quality of the drawings will decrease in a downward spiral (Ito, 2006).

Other common complaints leveled at the computer are the danger that it can mask a paucity of traditional skill; that it "produces sterile, unemotional design" (Wardle, 2006); that it frequently overlooks human scale (Reed, 2006); that it is physically demanding in its extreme sedentary demands and ergonomics (Pollard, 2006); that digital images, particularly three-dimensional models, often lead people to believe prematurely that the design process is complete (Holland, 2005); and that it changes the social dynamic of a studio environment to the detriment of collective effort (Buxton, Fitzmaurice, Balakrishnan, & Kurtenbach, 2000). While some of these objections could possibly be written off as reactionary, personally biased, trivial, or simply curmudgeonly, others warrant more serious discussion and those are the issues that software developers are seeking to address with ongoing improvements.

Beyond the media and the technique that computers bring into a design studio, there is a fundamental physical change in the studio and subsequent change in the way that members of a studio interact. This is true in both corporate and scholastic studio settings although computers are less likely to be found in the actual studio space in academic environments. Traditionally studios were laid out to facilitate teamwork and progress toward a common goal. Drawing boards and pin up areas were readily accessible to everyone in the studio and the work was very approachable. With the introduction of computers into the studio, the work became much less accessible and what had been quite public became much more secretive and private if only because of the scale and the relatively temporal nature of the screen display. Researchers at Alias studied this shift and examined the sociological change in the relationship between members of the studio and the design process. Their findings, and that of others, led to 'active desks,' rear projection screens with built-in transparent digitizers, in an effort to take advantage of computer software but retain the sociological and psychological benefits of the traditional drawing board. Active desks sometimes allowed the use of traditional, physical drawing tools such as rulers, squares, and sweeps to generate digital drawings. The next step taken by Alias to replicate some of the physical / social advantages of the traditional studio was the development of PortfolioWall software that allows a big screen to become and electronic pin up board (Buxton, Fitzmaurice, Balakrishnan, & Kurtenbach, 2000).

The fear of a great number of teachers of industrial design is that the computer is used to mask a deficiency of the student. Basic understanding of form can be overshadowed by a high level of proficiency with a given software program. I would argue that the same dangers exist with regard to someone who has a degree of mastery with traditional sketching and rendering techniques but fails to understand the translation of sketches into three dimensions or the communication of an existing three dimensional form (such as a clay model) in a sketch or rendering. Both computer software and pen and paper are tools used to develop a three dimensional form. Only in three dimensions is the risk of artifice completely dissolved.

One theme that has run throughout this investigation is that of the computer and associated software as tools to be used at the discretion of the designer as a designer would elect to make use of any tool, traditional or digital. Implicit in that understanding is the idea that the designer is responsible for the choice he or she makes. A lack of familiarity or mastery of a tool may lead to a poor choice or mistaken notions about the capabilities of a particular tool. Specifically, I believe that there is a widely held misconception that digital technologies are not appropriate for ideation and concept generation. Perhaps out of ignorance or habit, too many authorities dismiss Alias and similar tools as almost exclusively for generating presentation and communication materials at the conclusion of a project or design phase and not tools that are integral to the heart of the creative process. Ken Okuyama, former Art Center Chair, states, “The computer doesn’t give you any fresh ideas. It is an execution tool, not an ideation tool.”

(Martin, 2003) This is a grossly generalized statement. Design tools are intensely personal and what works well for one designer in a particular part of the process may not work for others. Moreover, let me suggest that in general no tool will “give you any fresh ideas” to any greater degree than another tool. Certainly when the discussion is confined to a particular designer, he or she will more than likely have favored tools that are used more frequently and with greater success than others but even in the case of an individual, one fruitful method of idea generation is to simply switch tools to explore what other solutions may be suggested by the alternative media.

As discussed throughout this paper, the great beauty of computer-based design tools is efficiency leading to both speed and general quality of results based largely on communication. From the contemporary perspective, it is almost shocking to realize that using traditional methods, at the ‘end’ of the design process there would be almost no data that could be used directly for production; the artifacts of the culmination of the design process (drawings and models) would require interpretation or translation into useful ‘engineering’ data before anything could be produced (Holland, 2005). Using a common language, for instance the digital math model, allows designers, design engineers, manufacturing engineers, product planners, and management to communicate relatively quickly and efficiently with little or no need for translation or other such duplication of effort.

Alias

The predominant digital surface modeling and sketching software in the industry and in academia today is Alias. Virtually every program requires at least one class dedicated to this software. Alias offers a variety of specific software packages for particular applications including AutoStudio, ImageStudio, Sketchbook Pro, StudioTools, Maya, and PortfolioWall. It should be noted that Alias was recently purchased by Autodesk, one of the primary providers of CAD software. There is some speculation that given the possible synergy of that combination, Autodesk may mount a serious challenge to the PLM leadership of UGS.

As the previous chapter illustrated, corporations are anxious for new hires to take on responsibility and the time for on the job training is very much in limited supply. In the past employers were much more likely to patiently, if eagerly, wait while a new employee trained on specific software. These days many companies demand that new hires are already proficient with the software that the company uses. Paul Dyck, Product Marketing - Design, Alias|Wavefront, explains, “Most of the cost of a tool is in the learning. If a new hire knows a software, the software is, in effect, less expensive to the company.” Like most software developers, Alias also realizes the marketing advantage of being able to point to a pool of recent graduates entering the workforce with proficiency in their software. This is part of the reason for their commitment to the PACE program. Clearly software developers must attend to the needs of their customer base so Alias and others must focus on the requirements of the automotive industry. One of those requirements has become providing a software that can be taught in the academic setting so that graduates come to industry fully prepared.

Alias continues to develop the software trying to draw on traditional skills so that the software is about design not technology. I suspect that such an approach also facilitates integration with academic curricula. At the same time, the object is not to simply mirror traditional techniques. That would thwart, if not preclude, evolution and progress (Dyck, 2005).

The speed that is possible with Alias due to its marking menus and customizable interface is one of the primary strengths of the software, Dyck points out, especially in light of the niche marketing and model proliferation that characterize the market today. Alias also focuses on the integration of two and three dimensional design processes and the ability to use the software as a design tool not just for modeling and rendering an already mature design proposal. Moving forward, Alias will continue to focus on these strengths, integrating the physical and the digital, and taking technology out of the way allowing designers to concentrate on the process and not the tool (Dyck, 2005).

"Knowing your tool well will help you focus on the task and not the tool." (Xiong, 2006) Of course making the tool highly intuitive if not simple is also helpful. Most tutorials and software instruction manuals encourage designers to make use of the layer feature. Placing three-dimensional package models on a layer and then sketching over that data is a simple method to facilitate the generation of plausible concepts. Note that this procedure, while exponentially more powerful, is very much analogous to using overlays and underlays when drawing with traditional media.

Alias is continually looking for ways to facilitate data input and integrate traditional skills with new media. Toward that end, Alias researchers closely examined the traditional practice of full scale tape drawing. Like many traditional methods the creation of a tape original is highly inefficient because the data represented by the artifact is very difficult to transfer, share, store, and convert into three-dimensions. The research team faced the challenge of creating an input device or method and associated software that could deliver a full scale tape drawing in a digital format using the same, or very similar, skills as those employed in traditional tape drawing. The team developed a two handed input technique that looks very much like the familiar tape drawing process without the balls of tape that inevitably end up on the studio floor. Full scale tape drawings are often overlaid if not applied directly to engineering package data. Using the digital version, the package criteria can be locked on a layer projected beneath the layer or layers that are being used to create the tape drawing. The successful research prototype has evolved into a feature of the PortfolioWall software (Buxton, Fitzmaurice, Balakrishnan, & Kurtenbach, 2000).

UGS

UGS, also sometimes known as Unigraphics, is the industry's foremost provider of PLM and one of the partners in PACE. Among the software elements that focus on the design functions of the PLM equation are CAID (design), CAD (engineering), CAE (simulation), and CAM (manufacturing) packages (UGS, 2005). While the UGS CAID program, called NX, can stand alone as a fully functional, three-dimensional modeling program, its strength lies in its integration with and relationship to all the other PLM elements available from UGS and more specifically its parametric abilities. Given that position it is no wonder that UGS is particularly concerned with the integration of design and engineering functions. In general PLM is about communication.

Even the casual observer of the automotive industry can recognize failures in the industry revealed by beautiful concept cars followed by less than attractive production cars allegedly based on the previous concept car. Tord Dennis, Product Marketing Manager for Teamcenter Community, UGS, attributes this to the overly fragmented process of automotive product development. Designers do not seem to talk to customers and as a result may never really understand the 'DNA' of a vehicle. Engineers don't talk to designers and as a result of poor communication, unloved vehicles get built. Designers come out with wonderful concepts that the engineering function seems to morph into undesirable production cars. PLM seeks to allow all stakeholders to speak the same language, communicate clearly, and work as a team towards a common goal. UGS allows, indeed encourages, specialization and relies on communication to allow numerous specialties to collaborate effectively thus permitting all to make a contribution while still saving time in the process (Dennis, 2006).

UGS is hoping to gain market share among industrial and automotive designers in both industry and academia. PACE is one of the tools being used toward that end. UGS tries to act as a matchmaker bringing schools and industry together for mutual benefit. As an educator, Dennis believes in offering a wide variety of software for students to learn in context and collaboration between departments that more closely simulates the ideal of that relationship in industry.

Rhinoceros

Robert McNeel and Associates was founded in 1980 and was initially an AutoCAD dealer (McNeel, 2005). Today, McNeel is a world-wide software development company that produces, among other products, a three-dimensional modeling software named Rhinoceros, Rhino for short. While ultimately not as powerful or feature laden as Alias, Rhino is a very effective tool for many jobs doing a great percentage of the work at a significantly lower price. Clearly this is often a major consideration for small companies or academic institutions. Rhino is not primarily a

CAD / engineering sort of tool having been created specifically with industrial design in mind but, in keeping with the synergies achieved between design and engineering, has some of those capabilities built in.

Collegiate design programs are a significant marketing tool for Rhino software. Unlike many softwares that are designed for a particular commercial application, originally McNeel targeted industrial design and teachers and students as the primary market for Rhino with the understanding that those students and teachers would take the software into industry (Gillespie, 2006). McNeel makes the same commercial, unrestricted, upgradeable versions of their products available to students and academic institutions at a greatly reduced cost in hopes that as students enter the work force they will provide word of mouth marketing of the product or purchase the software for themselves. This philosophy extends down to the high school and even junior high school level. A student version costs less than $200 and a lab license for an entire classroom (as many seats as the lab has workstations) is less than $1000 (Mills, 2005). One third of industrial design programs in the US are using Rhino in some capacity. Rhode Island School of Design Students are required to buy a laptop that is preloaded with Rhino software (Hambly, 2006).

While Rhino is marketed to the academic community, it is mildly ironic that it is designed to be self-taught. For the most part the educational paradigm has not shifted in that direction institutionally. This is one of the ideas that McNeel attempts to impart in the educator training that it provides (Hambly, 2006). Part of the philosophy behind Rhino is that instructors do not want to teach software; they want to teach design. Rhino is a tool that facilitates that process and seeks to remain transparent itself, imposing as little as possible on the flow of the design activity (Gillespie, 2006).

Rhinoceros developer Brian Gillespie has a healthy respect for old-school techniques and seeks to integrate all the tools on the continuum with the software such that the effectiveness of each is heightened. “Paper is very handy. We want to be able to bring anything into Rhino: tracing, [sketches, images] digitizing tools to get info from three-dimensional parts, CAD info….” One of Rhino’s primary strengths in comparison to many similar softwares is the ability to easily ‘sketch’ a three-dimensional model. Because Rhino has relatively few modeling constraints it is quite simple to create representational sketch models to quickly communicate ideas or prove concepts. This is not possible with many competing softwares because the constraints require the designer to create a much more detailed, valid solid or surface model. Rhino provides flexibility in that the user can do a looser, more conceptual model or take the additional steps required to create a fully valid model. Just because it is not required to be a valid model does not mean that it cannot be one. The goal is to make complicated three-dimensional models uncomplicated to create and subsequently edit. In addition to its rapid learning curve, flexibility, and value, Rhino is a highly complementary tool and is frequently purchased simply for use as a translator converting one file format to another allowing different software programs to share data (Gillespie, 2006).

Gillespie sees Rhino continuing to meet the needs of its loyal customers, continually improving the product and adding functionality as required. Rhino makes extensive use of its customers in the testing of new releases. Beta versions are supplied to 50,000 to100,000 Rhino customers prior to the general release of the software. Not only does this serve the function of testing the software but it is also a clever marketing strategy. Speed is an ongoing concern. Toward that end Rhino will continue to develop the recently introduced “universal deformation technology” that allows a model to remain intact while elements of the form are edited. More collaboration with rendering engine suppliers will lead to quicker and better rendering. The ability to move from two-dimensional patterns into three-dimensional models and from three-dimensional models to two dimensional drawings (drafting) is another area that will improve efficiency. In answer to the issue of design process renderings looking like finished proposals, Rhino is developing the ability to do ‘sketchy’ renderings so that the focus of an audience can be placed on the general form, a specific detail, or any element that the presenter deems appropriate. Rhino is also keen to facilitate collaboration with third party developers that will expand the functionality and market of Rhino. As new hardware and input devices hit the market McNeel is happy to develop software adjustments to take advantage of these advancements as they are adopted by Rhino customers (Gillespie, 2006).

Adobe

Clearly the products of Adobe Systems, particularly Photoshop and Illustrator software have played a significant roll in the evolution of computer graphics in automotive design and industrial design in general. Currently both are sliding from the forefront to a supporting roll as fundamental, digital stepping stones. Indeed, as digital tools become increasingly prominent in design curricula, one should expect a level of mastery of such software to become part of many programs’ foundation coursework. Furthermore, Adobe Acrobat and Photoshop in particular (because if its layering capabilities) could be, and in fact often already are, used frequently as presentation tools to teach both traditional and digital techniques.

Wacom

Wacom is the world leader in digital pen tablets and related technologies. A Japanese company, the name is derived from the Japanese word 'wa' meaning harmony and 'com' short for computer. This is an elegantly simple explanation of the company *raison d'etre*. Wacom's mission is to "improve / develop solutions that allow harmonious interaction between computers and humans" through input devices, and general human computer interaction (HCI). The primary focus has been on the pen (comfortable, intuitive, familiar) and its evolution into the stylus. In the beginning there were tablets and styluses used in consort as input devices for CAD programs with command menu templates. About 1992 AutoCAD version 12 came out and the Windows-based program made the old tablet style input obsolete. At this point, Wacom recognized a need in the graphic arts industry based on the understanding that the mouse and keyboard do not facilitate 'art.'(Marcum, 2005)

Anyone who has attempted to draw with a mouse understands that the mouse has shortcomings as a 'freehand' input device. With a tablet, the physical interface of drawing - where the pen hits the paper – becomes the stylus contacting the tablet or screen. Hardware variations such as stylus tips (hard, soft, spring loaded…) and screen textures seek to mimic the traditional feel of media on paper. Depending on the software used, thickness, shade, and transparency of line can be changed with the pressure or angle of the stylus. This can usually be tuned to suit the user.

One might argue that all this ‘tuning’ of stylus tip, screen texture and software options is an interruption to the design process – an impediment to designing in the zone. On the other hand, isn’t this analogous to choosing your paper (velum, bond, rag, colored,…), sharpening your pencil just so, finding your favorite brand of marker, using just the right amount of water with the gouache, and so on?

A central theme of the Wacom product line is allowing designers to use the traditional skills with the new digital media in order to keep the designer in the zone, not worried about the interface, the commands, the menus, the icons…. The flagship Cintiq product line allows the designer not just to sketch on the tablet very much like a pad of paper but the Cintiq is mounted such that one can adjust the angle to suit, like a drawing board, and spin the tablet around for a desired drawing angle as if it were a sketch pad. The very sophistication of the product allows it to be used like a simple, traditional drawing pad (Holland, 2005; Marcum, 2005).

Michael Marcum of Wacom sees continued integration of two and three dimensional sketching and modeling. User interface will continue to be simplified while becoming more powerful with two handed input, greater tasking of the non-dominant hand (particularly for navigation), and gestural commands. He also stresses that the computer needs to be a *design* tool not just for presentation and communication (Marcum, 2005).

The Wacom tablet, like the digital tape drawing explored by Alias and the three-dimensional scanner, is a bridging technology allowing traditional media methods to generate data directly (or almost directly) in the digital realm. Such strategies circumvent the inherent shortcomings of traditional media while facilitating the educational process.

Other Technologies

Clearly this is not an exhaustive list of technologies or the companies that provide them but a few other tools need to be noted. Rapid prototyping in its many forms and its current place in some design institutions has already been mentioned. In industry RP is commonplace and greatly facilitates all sorts of design exercises that require physical parts. In academia it is usually just a shortcut in the model making process.

Virtual reality (VR) and simulation are very hot trends in the industry particularly with regard to interior designs. This level of sophistication has not yet reached the academic level in automotive design. It remains to be seen if it will become the next big thing at the major design schools or if it will be rejected as too costly or simply inappropriate in an undergraduate, learning environment. Perhaps this is a technological spark that will ignite the field of automotive interior design (which has frequently taken a back seat to exterior design) on an academic level and the fire will be fanned in industry.

Electronic presentations and reviews are absolutely the norm in industry particularly outside of a specific studio. The use of electronic data, Powerwalls, and VR rooms allow remote reviews for design staff and management at multiple locations and possibly at great distance. Can holographic projections be far behind? This format is a tool of convenience and efficiency. Those benefits do not necessarily translate into academic settings. An exception to this might allow automotive design programs at greater than arms length from Detroit or Southern California some degree of access to the pools of professional designers upon whom Art Center and CCS rely and have used to such great effect over the years. Generally, students and instructors alike seem to prefer physical artifacts (drawings, posters, and models) that are not as temporary as images on a screen but for reasons of convenience or particular content, PowerPoint and PDF presentations are not uncommon particularly when accompanied by pin ups and or models.

CHAPTER 6

A PEDAGOGICAL PROPOSAL

“We as an industry know change is happening but we don’t seem to be able to deal with it. The design schools – which are way too conservative – aren’t researching this; the relationship between engineering and design is in a stasis. But, man, we’ve got to go so much further.” Chris Bangle, BMW Design Chief (Green, 2006)

“The loss of market share and the dominance of the Europeans and Japanese in the American market are clearly issues that must be solved. The solution to the specific problem of unattractive vehicles, however, will not come from other disciplines like marketing. It also won’t come from verbally oriented heads of companies who rely on ‘data’ from consumer research and marketing rationales from fast talking designers to justify poor taste decisions.” C. Edson Armi, automotive design scholar, art historian (Armi, 2003)

At Ford J Mays has implemented a design process based on the “German model” that he became familiar with while at Audi. The process links design and engineering very early in the development of a new vehicle. Mays is an advocate of a stronger bond between design and engineering and a greater role for design while striking a balance between the functional and emotional elements of a design (Armi, 2003).

”We learned how to draw great cars at Art Center, which is an excellent way to get into the industry. But you don’t learn much of what you need to know.” Ed Golden, Ford North American Car Design Director (Armi, 2003)

How does academia respond to these challenges? Technology has accelerated the rate of change in the industry to what seems at times to be a constant state of flux. New tools and technologies supersede or augment the previous practices with dizzying regularity. Manufacturers are striving to integrate design and engineering processes with varying degrees of success. Because so much of the academic agenda is focused on servicing the needs of industry, design programs tend to follow the lead of industry and consequently seem to be racing at the taillights of corporate design studios with little chance of getting close enough for the mutual benefit of the metaphorical slipstream. The education of automotive designers and the hopefully consequent improvement in commercial automotive design is the shared responsibility of the academic and corporate worlds. These two parties must be partners. Academia must provide some leadership in the process. This relationship is not unlike that of the design and engineering functions within a corporate structure. Like design and engineering, design schools and manufacturers require partnership and collaboration to achieve common goals.

Niche Education and Niche Teaching

In conversations about future directions at Art Center, Stewart Reed mentioned 'niche instruction' by multiple instructors in a single studio as a means to expose students to a broader range of topics, specialties, and experiences without adding requirements to the already crowded curriculum. [Indeed, team teaching is nothing new. In 1989 the author studied under Ed Taylor and Geza Loczi currently Director of Design**,** Volvo Monitoring and Concept Center, at Art Center in an advanced transportation design studio.] Niche is more than just an industry buzzword these days. Product planners in Detroit are focused on niche markets and niche vehicles. Art Center is practicing niche teaching. Can this be extended to niche education?

Most of the programs considered by this paper have a particular reputation and specialty (a niche). Art Center is the bastion of conceptualization, communication, and blue-sky creativity. CCS is the more pragmatic but equally competent brother. AAU is the upstart who is keeping Art Center and CCS on their toes with fresh ideas and new technologies while accepting the wildcards without portfolios. UC prides itself on the real world experience of the co-op and CIA produces team players with the interpersonal skills to thrive in a corporate setting. While industrial designers have always been generalists and that continues to be recognized as an asset, specialization within that broad knowledge is recognized as valuable equally. Geoff Wardle characterizes Art Center's goal as producing graduates with well rounded abilities to prosper in a number of different situations but also with a specialty that makes them particularly attractive, answering expectations of employers and going further (Wardle, 2006).

Automotive design programs must recognize and embrace their strengths taking care that in an effort to be all encompassing unique identities and qualities are not lost to anonymity. In the case of an as yet unformulated identity, a program, like a student, must develop a firm foundation and on top of that build a reputation of mastery in a particular area. These days it is popular to call that area a niche. Art Center instructor Bumsuk Lim has observed that program [and by implication CCS] "does not have the big advantage that it once did. The playing field is more level. There are opportunities for new programs…particularly those that can find a niche."

Following this model, human resources departments and design management can shop the various automotive design programs to fill the 'niche markets' found in their design studios just as consumers look for a niche vehicle to fulfill particular needs. If you need a truck you don’t go to a BMW dealer. Given a solid understanding of fundamentals, surely a creative design studio is well served and better equipped when staffed by people from a range of backgrounds with different strengths, specialties, and perspectives. Metaphorically, the complete garage has both trucks and sports sedans (among others) each coming from a different manufacturer just as one would expect a vibrant design studio to employ designers from different schools.

ASC designer George McCowan advises that in industry, “You find out first hand that one person cannot 'design' a vehicle. One person's education just doesn't cut it. I would suggest to a student in school to explore …various areas of automotive expertise (conceptualization, engineering, rendering, math modeling, visualization, sculpting, etc, etc, find something they love to do, and carve a niche.”

Vehicle Interface Design Project at Georgia Tech

This leads back to the idea of niche teaching in order to expose students to as many aspects of automotive design as possible. Although not labeled as such, in the fall of 2003, senior industrial design students at the Georgia Institute of Technology (Georgia Tech) experienced niche teaching first hand. In order to leverage the experience of the author in automotive design and the experience of fellow graduate student Vicki Haberman in interface design, the pair, along with professors David Ringholz and Kevin Reeder devised a five-week module designed to expose students to the basics of both automotive and interface design. The project was run consecutively in each of the three senior studio sections.

After an introduction to the topics and the project parameters, with the instructors’ guidance students chose the vehicle types that they would focus on for the duration of the project and divided into groups of three or four based on common vehicle interest. The vehicles chosen represented a wide variety ranging from police motorcycles and recreational ATVs to catering vans, taxis, and ambulances. A fairly standard design process was followed beginning with project definition and research, continuing through iterations of ideation, concept development, refinement and evaluation and culminating in presentations of the final proposals. Central to the process was the construction of full scale sketch models with as much functionality as practical in order to perform user testing simulations and gain feedback that could be applied to the final proposal.

In approximately one third of a semester, students had the opportunity to complete a design project following established norms of the design process while learning and applying principles of human centered design, ergonomics, research (particularly user testing), interface design and of course visual communication. Particular attention was also paid to package criteria, ingress/egress, and feature integration. While by no means an all encompassing exploration into the many important aspects of automotive interface design, this project gave each student significant experience with two specialized areas of design and many of the more broadly applicable constituent parts of those fields that might have otherwise been skimmed over or not discussed at all in the curriculum. This was accomplished without compromising any of the pre-established educational goals of the course syllabus. Based on the author's personal experience niche teaching, taking advantage of the strengths of three instructors, this is a viable avenue to expose students to the wide variety of topics that constitute automotive design.

Participatory Research

During the course of graduate studies at Georgia Tech I have had the opportunity to teach a number of different courses including the project outlined above, both as an assistant and as the primary instructor. This has been primarily in studio courses at the junior and senior level and in automotive design and history electives. The following sections briefly detail a few pertinent experiences gleaned over the course of that teaching. The most general lesson that I have taken away from teaching studio courses and transportation design is that students must have a sound foundation of fundamental visual communication tools to succeed in a project-based studio and advance in an industrial design education. Generally speaking, without the fundamentals students become frustrated very quickly and lose faith in themselves and their abilities. When a student gets frustrated with a lack of, for instance, drawing skill, there is a make or break point at which the student will put down the pen in frustration and grief or turn the page and try again. Eventually those who keep turning the pages will overcome that frustration and have the opportunity to flourish but the studio does not stand still while those pages are being turned. The time to overcome the frustration is in the earliest terms of the program and in courses designed to teach fundamental skills, not design process. Students who fail to achieve a certain level of competence with a set of fundamental communication skills are at a severe disadvantage in the junior and senior years. They have not learned the common language and they are not able to fluently converse with peers or professors.

Automotive Design History

As an instructor and student of automotive design history, the benefits of such study are readily apparent. An appreciation for previous designs serves many ends. Frequently it serves to fuel a passion and increase a student's motivation. It helps students to understand design in context. With an appreciation for a design in its historical context it is not too great a leap for the student to appreciate his or her design proposals must be created with the contemporary context in mind. Knowledge of design history is a creative advantage, research resource, and design foundation. Designers often speak of thinking outside of the box, without an appreciation for history it is difficult to define the box and subsequently work outside of it. One of the greatest benefits of such a class is the opportunity to learn and practice written and verbal communication. Too often the ability to communicate in writing and in presentations is overlooked. It is assumed that students will pick up those abilities simply through occasional practice or their visual communications will be sufficient unalloyed with literary or verbal skills. This is a dangerous assumption and may leave a student lacking a necessary design tool.

Introduction to Automotive Design: The Experiment

In the spring of 2005 during the course of the auto design class that I was teaching I conducted a rather unscientific experiment to test the hypothesis that designs generated on the computer are noticeably different than those generated by traditional media. The assignment to be completed over a three week period was to design and model (physically) a sculptural automotive form. Regardless of the experiment the assignment served to give students a better understanding of the fundamentals of form development and the play of light on reflective surfaces to reveal form. In order to test the hypothesis students were divided into three groups of roughly equal size: those reasonably comfortable with digital media, those with some experience but not a familiarity with digital media, and those with no digital media experience. Those experienced with computer graphics were to design the forms entirely ‘on-the-tube.’ Those with some experience were encouraged to use both digital and manual techniques to create the forms. The last group was charged with the design of the forms using only traditional media. At the conclusion of the project we examined the models and two-dimensional sketches produced by the students. I also conducted an informal survey of their experience.

There was no clear difference in the character of the forms from the three different groups. What was abundantly clear was that the population that I used to conduct the test did not possess the fundamental skills necessary to generate the designs without using a significant degree of traditional techniques and across the board students produced timid designs that they felt confident about accurately modeling or outrageous designs that called for greater modeling skills than they had at their disposal. Regardless of the group, the majority of the students felt confined and restricted by the media parameters of the project. Subjects from this population almost universally see the computer as a presentation generation tool and *not* as a design tool. Just as Alias models tend to lead clients (and other observers) to believe that the model shown is a finished design, students feel like the design must be finished before using a digital model or rendering to describe it.

Upon further examination after the fact, it appears that the ideal population for such an experiment would be neither a group such as this nor a studio of visual communication and computer graphics experts. At either end of the spectrum one might reasonably expect that the skill level takes precedence over the media. Such an experiment might furnish more interesting results using a population of fifth or sixth term transportation design students. Although my experiment was less than an unmitigated success, the project was very popular and effective with the students furnishing them with the excitement of real horizons, cores, reflections, highlights, shadows, and bounce light.

Objectives, Philosophy, and Parameters

The lofty goal of education is understanding. On the road to understanding there are more immediate and mundane, though no less real and significant, economic concerns of the stakeholders. While a good education is in everyone's enlightened self interest, institutions and the people who run them also understand self preservation. With that understood the practical objective of an academic automotive design program is to sustain itself and perhaps grow. This is achieved by providing an education that students deem worthwhile at a cost that provides a reasonable return on the investment. The most obvious and immediate measure of a worthwhile education and a reasonable return on investment is a graduate's ability to find a well-paying job in his or her field of study. That condition is most likely to be met when a program is able to provide graduates with the knowledge and skills that the industry is seeking. (Notice there may be a subtle difference between what the industry seeks and what the industry needs.) The grossly simplified version is to satisfy the students by satisfying industry while hopefully providing graduates with a broad enough education to follow a possibly winding career path.

The economics of each institution are determined by the ownership of the school. Clearly there are significant differences between a state school and a private, for profit institution. Educational philosophies will also vary. Some schools strive to educate as many people as possible either because of a profit motive or the somewhat altruistic desire to simply provide education to all who seek it. Others strictly limit the size of their programs in order to promote quality over quantity and / or for exclusivity. Still others will simply respond to market forces.

Beyond these factors for the purposes of this discussion, the objective of this proposal is to provide an outline to improve automotive design education without requisite changes in enrollment or cost. The automotive design programs considered over the course of this investigation each feature approximately 45 individual courses or 'slots' in the schedules. By no means do I propose to replace, modify or otherwise comment on each of these courses. Courses and general philosophies will be suggested and described based on the research. Certainly each course suggested could warrant the development of a syllabus but that is outside the scope of this paper although a worthy direction for future investigation.

Curriculum

The automotive design curriculum can be divided up into five broad categories: Academics, Foundation, Tools, Processes, and Experience. Academics encompass traditional liberal arts and sciences courses. Foundation entails courses that teach the basic, fundamental language of design. The definition of the remaining categories is not so readily recognized. The category labeled Tools is comprised of courses that are primarily concerned with teaching specific skills: a particular software, model building, sketching…. 'Processes' is a bit more vague but generally deals with courses that primarily seek to impart knowledge: ergonomics, interface design, research methods, aerodynamics….The fifth category, Experience, captures the major project studios and other circumstances that afford students the opportunity to coalesce and apply their growing expertise. These are also the primary venues for assessment and evaluation, providing the opportunity for performance to demonstrate understanding (Gardner, 1993).

Academics

Arguably, liberal arts and sciences (academics) are not the foundation but the very bedrock of a post secondary education. These subjects are paradoxically both essential and extraneous to a complete automotive design education -- and one might extrapolate to any specialized university level course of study. As such, two factors become apparent.

Initially, as much of the 'bedrock' as practical must be in place before an automotive design program is undertaken. This might take the form of a particularly rigorous preparatory high school career including Advanced Placement classes and other programs that yield college level credit and / or advanced standing at the collegiate level. In addition or in place of this scheme, academic credit might be earned at a different institution (junior college, college or university) prior to enrolling in an automotive design school. While many design schools offer fine academic departments or access to such departments through other schools within a university (UC for example) or via cross-listing agreements with other institutions, I believe that the better education comes from multiple sources, particularly for a creative designer's mind always looking for different perspectives and examining problems from multiple angles. There is also the argument that in seeking the best possible education one would elect to attend an institution renown for its liberal arts program to study in that field, then go to a school whose forte is automotive design to pursue that education. This route begins to approach the graduate school model discussed previously.

The immediate objection to this suggestion is likely to be one of the cost: time and money. Legitimate concerns to be sure, consider that many students take five or even six years at the same institution to complete some four year design programs. The primary reasons for this are the economic cost of the program and the 'educational intensity.'   With academic requirements largely satisfied before embarking on the automotive design regimen, a student is able to more narrowly focus on the task at hand while taking advantage of the knowledge and experience derived from the academic studies already completed. Theoretically a greater level of understanding results from a similar if not smaller investment of time and money.

The second factor is the necessity to present academic subjects in readily apparent design related contexts. Physics problems can easily be related to automotive kinematics. Psychology can be studied relative to product planning, branding, or even color theory. Sociology can introduce students to the demographics of target markets. Modern History (twentieth century and beyond) is inherently appropriate when the focus is placed on the context in which events occur. This is the same context in which products (and vehicles) 'occur.' These are but a few very simple examples of the manner in which academic courses may be more readily integrated with the primary thrust of study in a design program. Not only is this more likely to retain a student's interest and motivation but it provides solid examples of the manner in which traditional topics relate to specialized fields. This is a leap of understanding that many students fail to make regardless of their particular field of study (Gardner, 1993).

Foundation

Certain elements will naturally and very apparently fall into this category but surprisingly the research has shown that some of these elements do not have dedicated classes in some programs. They are, if not largely overlooked, relegated to a line item on the syllabus of a more broadly oriented class. Foremost among these is perspective. Without the foundation of perspective any subsequent drawing class is considerably devalued. In keeping with a spiral or cyclical curriculum that reinforces concepts with regularity, perspective should be continually addressed with each visual communications course but the burden of teaching perspective in general would surely overwhelm the syllabus of any drawing class not specifically dedicated to teaching perspective.

Clearly communication is an integral part of the design process. Verbal and written communication skills are as significant to the process as visual communication abilities. The successful automotive designer, student or professional, must have a broad range of communication tools to present a design. Presentation and content are partners in understanding just as they are partners in design. With this in mind, English becomes a foundation design course more so than an academic liberal arts course and the focus becomes expository writing and public speaking. Call it English for Proposals and

Presentations. Two courses serve the program better yet, English for Proposals followed by English for Presentations.

While the use of the computer may be commonplace to high school graduates, its specific uses in academic and design contexts may be unfamiliar to those just entering an automotive design program. Moreover, as digital media becomes increasingly prevalent, familiarity with not only software but also hardware becomes essential. The computer is a fundamental design tool with which students must become comfortable and familiar. Toward this end I propose Information Management & Technology. This course would cover word processing, operating systems, the internet, spread sheets and data management, documentation and archiving, basic hardware and common peripherals.

Graphics and color are subjects that are frequently taught in the course of an introductory industrial design studio, a reasonable spot in the curriculum for those topics. Alternatively, consider a course dedicated to just those two topics but presented using both traditional media and digital media. Such a course would prepare students to learn concepts with multiple tools in parallel and to appreciate the strengths and weaknesses of digital and traditional media. This course would also introduce software such as Illustrator complimented by traditional media like gouache. An early appreciation for graphics also promotes better visual communication in other design courses.

Some would question the value of spending time with a media such as gouache especially with a computer and graphic design software so close at hand. I believe in the value of actually mixing color, appreciating opacity and texture as physical qualities in order to better understand the properties of color … as it comes from a tube or a mouse click. I also believe in the discipline, craft, and attention to detail required inking a composition, or painting color tiles manually.

Research for Design is a foundation course that would support an introductory industrial design studio as students learn about the design process. It would also provide data to be used in the Information Management & Technology course. This affords another opportunity to tie classes together and show the relationship between them just as multiple disciplines contribute to a common goal in industry. In subsequent courses research will be a key to solving design problems with creative solutions. This course will provide students with the means to perform that research with confidence and will allow those courses to focus on topics other than research methods.

Because of the widespread use of digital models and the focus on efficiency, the direction is certainly towards the elimination of the drafting function in industry but can this be done on the academic level? Most software still needs to be ‘smarter’ to be able to automatically dimension a three-dimensional model for an orthographic three view so that a machinist or fabricator can easily create the part. Granted, virtually all the manufacturing for a major automobile company is done such that a math model of a particular part, as opposed to a drawing, is the requirement. Parts may never be touched by an individual machinist or fabricator who is responsible for making the part. Expert digital surfacer and designer of the Mosler MT 900, Rod Trenne (formerly of UGS) maintained that paper was no longer needed in the process of building a vehicle (Trenne, 2001). While theoretically true, I disagreed then and now especially in academic situations. Not only does drafting instill a degree of discipline, attention to detail, and visual literacy in students, it also serves to enhance the understanding of the representation of three-dimensional forms in two dimensions. With this in mind, Drafting is a proposed foundation course. Like Graphics and Color, this would be taught with both traditional and computer based techniques and would entail the introduction of a CAD software. While drafting software can easily be limited to a two-dimensional program, and more clearly parallels traditional drafting, I believe that a three-dimensional, solid modeling program with orthographic layout and dimensioning functions would serve students better without being overly complicated.

I am a firm believer in sketching. Enough cannot be done. Students should be sketching every term and prolifically. I am also a firm believer in the basic principle that good industrial design is squarely focused on the user. Sketching People is the result of the synthesis of these two fundamental philosophies. An early competency in sketching the human form allows students to comfortably include people (users, customers, target markets) or the relevant appendages thereof, in all their designs. Not only does this force students to continually consider the user but it greatly facilitates the communication of the design with regard to function and especially with regard to scale. Another advantage of such a course is the development of the sketching technique of the flowing anthropomorphic curves that fall in and out of fashion on automotive exteriors and are in some respects requisite elements of automotive interiors. Sketching People is not envisioned as a traditional figure drawing class. Focus should be on proportion and gesture to the extent that activity can be conveyed. Also particular attention should be paid to the hands, feet, and face. The idea is to provide designers with the tools needed to communicate the relationship between a product (vehicle or component) and the user.

Notably, UC requires a class called Figure Drawing for Industrial Design that is not dissimilar to this proposal.

The final foundation course that I propose is 3D Sketching. This affords an early introduction to the rapid creation of rough physical models that can be used in the design process as a creative tool analogous to pen and paper sketches. For those students accustomed to thinking in two dimensions this will expand their horizons and for students who have always been better at thinking and creating in three dimensions this allows them to accept, acknowledge, and build upon a strength. Because those who design in three dimensions (creating models as opposed to sketches) are usually in the minority they sometimes get the impression that their approach is inferior. This class is in part designed to show the value of using a variety of tools and processes. Additionally, the course will afford a step into the nature of materials and possibly a gateway to more sophisticated modeling techniques.

As a segue between the foundation and tools sections, practice is paramount in the understanding and development of both skills and concepts. Relative to drawing (using traditional media or digitally) and other such tools, practice takes the form of sketching, reams of sketching. With regard to concepts, practice comes in the form of projects that allow a student to apply knowledge of a particular process or discipline. Kuni Ito, instructor at CCS, echoes the sentiments of countless educators, declaring "…no shortcuts to learning, you cannot get around practice."(Ito, 2006) This sentiment is equally true of digital and traditional media. A common misconception among students with regard to many skill sets but particularly in the digital realm is the idea that once a software (or other tool) is learned to the degree that it may be useful, it is no longer worth practicing and pursuing toward mastery. If anything, the opposite is the case and practice is required to simply maintain a level of facility with a tool.

Tools

Designers draw for two basic reasons: the thought process, communicating with oneself, and communicating an idea to others. Drawing for Understanding focuses on the later. Beyond describing a form, a material, a context, or some other physical property, this course addresses the communication of how something functions, how it is assembled, how it is made. Simply put, this is a study of drawing that communicates 'how' as opposed to 'what.' Exploded views, ghost views, section views, schematics, even story boards and flow charts are appropriate to this pursuit. Similar to a number of other courses proposed, this would be taught using both traditional and digital media. An additional opportunity to further explore a three-dimensional CAD program, toward the conclusion of the course animation could be introduced using Maya or a similar program. Although not strictly speaking drawing animation and other video technology is an excellent tool for communicating 'how' and it is certainly the computer based progression from a story board. This course would fall in about the fifth term of an eight term curriculum.

A designer's ability to present an idea is crucial yet the skills involved in presentation are rarely given their due. While most students master the traditional pin up and model display presentation from a visual perspective, the sometimes accompanying verbal presentation and the electronic presentation seem too frequently left to chance. The Presentation class addresses these issues and builds on foundation elements in English and graphics. A prominent feature of this class would be video taping verbal presentations for review and critique and staging simulated (or real) video conference design reviews.

Sketching Materials and Surfaces is very much like a traditional visual communications course. The exception to that being the introduction of computer technology taught in parallel with traditional markers and pencils. This course would fall roughly mid-way through the curriculum after an introductory surface modeling software course such as Alias and a fairly sophisticated traditional media class that would build on fundamental drawing courses and introductory studios.

Once the basics of visual communication have been mastered the most effective way to improve one's visual communication is to increase the speed with which a drawing is created while maintaining acceptable levels of quality. In somewhat crass terms, time is money. Efficiency equals economy and can improve the bottom line. In the later terms Speed Sketching offers an opportunity to develop this skill. The focus is on simple traditional media in this course to emphasize speed, simplicity and flexibility, unencumbered by significant hardware or power requirements. That said, many of the principles explored apply to computer based media as well.

The integration of computer based tools with traditional techniques relies in part on teaching a number of software programs. The specific programs required are dictated by those used in industry. Whenever possible, software needs to be taught in the context of a design project or in parallel with a traditional media in order to facilitate understanding and efficiency. Software should be taught in a design studio as opposed to a computer lab. This is appropriate to send the message that software, like a clay model or a marker sketch, is a design tool and a means to an end. Isolating the computers in a lab sends the message that computers are different.

At a minimum, students should learn Adobe Illustrator and Photoshop (or similar), a three-dimensional, solid model CAD program (CadKey, Inventor, Solidworks, ProEngineer, UGS or something similar), and Alias. Over and above that, each additional design software that is learned is another arrow in the quiver of the designer. While Alias is the industry standard there are plenty of employers who use Rhino or other such programs.

Process

None of the programs profiled have a required course specifically concerned with interface design. Certainly elements of that topic are covered in the human factors and ergonomics classes that some institutions include in the curriculum. With the trend toward increased emphasis on interiors in the industry, and subsequently in academia, more than a superficial knowledge of interface design becomes necessary. Surely interface and ergonomics are as important to automotive design as are aerodynamics and a basic understanding of the mechanical aspects of a vehicle. One might argue that to the industrial, automotive designer ergonomics and interface are significantly more important than aerodynamics and other factors that will find champions amongst the design engineers in the vehicle development process. It is the designer who must be the advocate and expert with regard to ergonomics and interface.

These topics are at the very core of producing a human-centered design that appeals to and serves the driver and passengers, the consumer. Hideki Masuda points out that many design students are “selfish.” Students tend to design what appeals to them as individuals and frequently fail to take into account a target market (Masuda, 2006). This produces an ego-centric design and truly addresses an audience of only one. This strongly suggests the value of a course in Human Centered Design and clearly is tied in with Sketching People.

The clear message from industry is that design and engineering are partners in the vehicle development process. As such a common language must be shared. Automotive designers must have more than a superficial understanding of the engineering that complements the design. Two courses are intended to fill that need. Automotive Engineering and Package Design is followed by Automotive Engineering and Aerodynamics. The first in the series covers the basics of vehicle dynamics, chassis and suspension design as well as all the package design criteria. The second picks up with materials, drivetrains (with emphasis on emerging technologies, alternative fuels and engines), and aerodynamics.

Product Planning, Marketing, and Branding gives students a grounding in the processes that initially direct the design (generate the design brief) and those that facilitate sales. Increasingly these elements are taken to be an integral part of the design. Understanding them allows a student to better understand the 'DNA' of a particular model and incorporate that into the proposal. This is another class that affords students the opportunity to practice written and verbal communication skills.

As mentioned at the beginning of this section, Ergonomics is an essential part of any design that strives to address the needs of the user, to be human centered design. In the case of both ergonomics and interface design the applications extend well beyond the interior and the control surfaces of the driving interface. In order to accommodate all the stakeholders, ergonomics extends all the way back to the assembly line to help insure the safety, comfort, and efficiency of the people assembling the vehicle. Likewise, ergonomics must look under the hood to address the concerns of the mechanic who will maintain the vehicle, in the trunk and at the hubs to facilitate tire changes and, at the gas cap to name but a few.

Experience

Middle and upper level automotive design studios, portfolio classes, and internships are the most obvious examples that define the experience category. The significant changes from the accepted norms here lie in the degree of collaboration involved in the studios and associated niche teaching, and the frequency of the Portfolio Class.

Beginning with projects in middle level automotive design studios, projects will include participation with other disciplines within the school or from neighboring institutions. In addition to offering greater educational opportunities through multiple instructors with different fields of expertise (niche teaching), this interaction between students and programs seeks to mimic interactions found in industry between different elements of a corporation. In the seventh and eighth terms the studios could participate in a PACE project or something similar in partnership with engineering schools. This sort of collaboration is beneficial to all involved as it prepares students of any discipline for conditions and processes common to industry.

The Portfolio Class recurs every other term beginning with the second term. In the earlier terms portfolio building, documentation, graphics, format and most importantly assessment will be the focus. In later terms the thrust of the class shifts toward portfolio maintenance, professional practice, and the impending job hunt including the creation of a website to host an electronic portfolio and market the student. The importance of the portfolio cannot be overstated. According to design professionals, HR personnel, and educators it is the most important, and reliable, factor in evaluating a graduate's understanding of the topic and fitness for the job (Ferretti, 2005; Gardner, 1993; Lim, 2005; Pollard, 2006; Robertson, 2006; Shuster, 2005). In addition to the practical aspects that a portfolio serves with regard to employment, regular discussion of portfolios helps students to develop a critical eye capable of self-assessment and assessment of the work of peers. Assessment is defined by Howard Gardner as "obtaining information about skills and potentials of individuals with the two goals of providing useful feedback to the individuals and useful data to the surrounding community." Over the course of the entire curriculum assessment should happen naturally in context not as an artificial test becoming ubiquitous yet transparent (Gardner, 1993). This skill is essential for personal development as well as the ability to assume a role of design leadership.

Internships offer students a tremendous opportunity to experience the corporate world first hand. They provide networking opportunities and familiarity with industry practices that frequently lead to employment opportunities after graduation. The internship experience and the work produced during that time is also a good evaluation tool and in some peoples minds even more useful than the portfolio. Steve Nowicki states, "I like to see some internship experience, and [I] offer an internship program at ASC. Preferably, I would like to hire a designer with a few years of experience under their belt, but the good designers usually have good jobs already! The internship training and projects assigned during that period are good indicators of a designer's potential." (Nowicki, 2006) In the modern era this is perhaps the closest approximation to an apprenticeship that is in common practice. In addition to the benefits to the individual student there are benefits to the interns peers and the design program as a whole as have been outlined in previous chapters.

Facilities

The most important physical space to an automotive design program is the studio. It is imperative that upper level students have dedicated space to work on projects uninterrupted by periodic displacement. In the process of taking ownership of (and responsibility for) personal studio spaces students, by extension, are more likely to take ownership of both their designs and their education. Although subtle, taking ownership can rise to the level of an epiphany and mark a real turning point in the development of a designer. The importance of ownership extends into the professional design studio in the realm of leadership and teamwork resulting in arguably better designs and more satisfying work environments. Leadership and teamwork provide a strong defense against design by committee (and other evils) on personal, academic levels and in the corporate studio (Armi, 2003). (Although perhaps apocryphal 'the camel is a horse designed by committee' is attributed to designer Frank Hershey, author of the original Thunderbird among others.) Not only do upper level students need dedicated studio space, that space should be secure, comfortable, and accessible to those students around the clock.

Computers need to be located in studio spaces, not exclusively located in relatively isolated, sterile computer labs. If the computer is to be used as a design tool it must have a place in the design studio along side the pens, the markers, and the clay. Computers should also be found in classrooms and temporary studio spaces to facilitate parallel instruction with traditional and digital media.

Shop spaces are in a period of transition. The advent of both digital modeling and rapid prototyping have physically and philosophically infringed on traditional model construction shop space. Traditional wood and metal working machines and tools are being displaced by laser cutters, three-dimensional printers, digitizers and other computer-based tools. With the exception of clay models and sketch models, traditional methods and materials may no longer be needed to construct appearance models for presentation or to be used in the design process but more conservative educators may argue that traditional model building has inherent value in the understanding of materials and manufacturing. This knowledge can be gained from lectures or reading but true understanding is more likely to come from first hand experience that cannot be gained in the library, lecture hall, or at a keyboard.

Leaning toward digital, virtual, or other computer based modeling or continuing to stress traditional model making is an area that can differentiate one program from the next providing niche education. One facility that every program should have is a garage that affords students the opportunity to examine vehicles from the inside out. At the far end of this continuum would be a large automotive shop equipped to actually build running prototypes, another educational niche still within the broader category of automotive design education.

The Human Element

Niche teaching appears to be a viable solution to some of the scope creep of an automotive design education. Additionally it promises to provide a generally higher quality education. Beyond niche teaching to leverage the specialized knowledge and experience of multiple instructors, I propose the possibly radical idea of adding more full-time faculty to automotive design programs not to displace the corps of practicing professionals but to augment them. A balance needs to be achieved between those who are professional designers and those who are professional educators in order to provide students with the greatest understanding. Professional designers specialize in the content of the education (the design), while educators focus on the method of delivery (the manufacture).

Numerous programs value and facilitate learning in the studio between peers. This is an essential element of the education. To maximize the benefit from this sort of interaction it could be expanded by formalizing some of these relationships. The establishment of regular recitations to supplement or supplant classroom instruction in specific skill areas, software and media provides the opportunity for greater depth and breadth of both essential and specialized communication skills. Such recitations, tutorials, or ‘help desks’ would ideally be run by upper-level students with demonstrated mastery of specific tools. Barring the availability of such students, staff resource positions could be created.

Students are of course the center of the educational equation. As a proponent of human centered design, fundamentally the program must be constructed around the student body. The success of an institution and the students it admits hinges on the desirability of the program's graduates as determined by employers. Schools must attract and carefully select students from the field of applicants those who are not only willing but able to take advantage of the program of study. In order for a student to benefit from instruction, that teaching must be targeted at the student's developmental level (Gardner, 1993). From a practical perspective, given the degree of specialization and the rigor of instruction, it is far simpler to select students within the target than to alter the aim of the instruction. Towards this end, Gardner recommends delaying specialization (choosing a specific field of study) until a student is approximately 21 years of age to increase the likelihood that a student is developmentally prepared having previously been exposed to a greater variety of experience. This theory complements the idea that a student would be well advised to attend a post secondary institution to focus on liberal arts and sciences prior to committing to the highly specialized path of automotive design.

Whether inherent or instilled, students must thrive on 'competitive collaboration.' The high standards of a program initially depend on the demands of the institution and individual instructors but ultimately the charges' effects on each other may become the primary vehicle to convey and maintain standards (Berger, 1991 as cited by Gardner). To that thought I will add that students *must* become the primary vehicle conveying and *raising* standards if understanding is to be achieved and students are to take ownership of their designs and their education.

Conclusion

Automotive design is enjoying a renaissance today even as the industry as a whole and the domestic industry in particular confronts crisis. Design is widely recognized as the element that most distinguishes one manufacturer from another and attracts the consumer to a particular brand or model. Add to that the great proliferation of models created to compete for smaller niche markets and the need for good automotive designers is obvious. The excitement found in the design studios of the major corporations is also found in the educational automotive design studios at academic institutions scattered across the country where evergreen enthusiasm and passion meet with new technology-based tools affording ever increasing avenues of creativity and design innovation. Educators seek to provide students with the best possible opportunities available for understanding and success in the industry.

Just as there are always numerous viable solutions to design problems, so too are there many well paved avenues of automotive design education. This investigation has provided many insights not the least of which is the strengths to be found in the differences between programs. Like individual students or product planners imagining a new car, automotive design programs are well advised to discover an indispensable niche and focus on that area.

Design programs are in transition, scrambling to keep up with the proliferation of topics and tools encompassed by automotive design. The best minds in academia and industry agree that fundamental design and communication concepts remain relatively constant while the rapidly changing technology simply provides more efficient tools with which to practice the art and science of automotive design. The exceptional designer remains a generalist with an appreciation for all of the many subjects that contribute to automotive design and a few specialties in which he or she has particular expertise. Such a designer also is a master of many tools traditional and digital. Wise choice of tools provides the right balance between creativity and efficiency.

Focus on the traditional but embrace the new technology. Teach them in parallel so that concepts are confirmed by multiple, outwardly disparate tools. Use niche and team teaching to expose students to a wider range of experience and specialties and to take advantage of the best qualities of professional designers *and* professional educators. Engage in collaborative studio projects with students from other disciplines such as advertising, psychology, marketing, and especially engineering to better model conditions and practices in industry. Encourage internships and co-ops as short duration apprenticeships, for exposure to the latest technology, real world experience, strengthened ties with industry, and the experience returning to the academic studio. Work in partnership with industry (not in its wake) perhaps literally as advanced design and research studios. Be willing to take risks. Occasionally take the leadership role from industry to develop new technologies and processes independently, with the industry or with companies dedicated to technology development and sales.

Happily this thesis has raised far more questions than it has answered. The very broad topic seeks more depth. A greater degree of educational theory must be introduced. Theories and proposals have been put forth that beg to be tested. Ideas for particular courses need detailed syllabi and specific research. Hundreds of new conversations with more educators, technologists, and designers beckon and dozens of previous conversations call for continuation.

APPENDIX A

GRAPHIC COMPARISON OF PROGRAMS

This is a reprise of the pie charts from the text shown here at a smaller scale to facilitate comparison showing curriculum by topic.

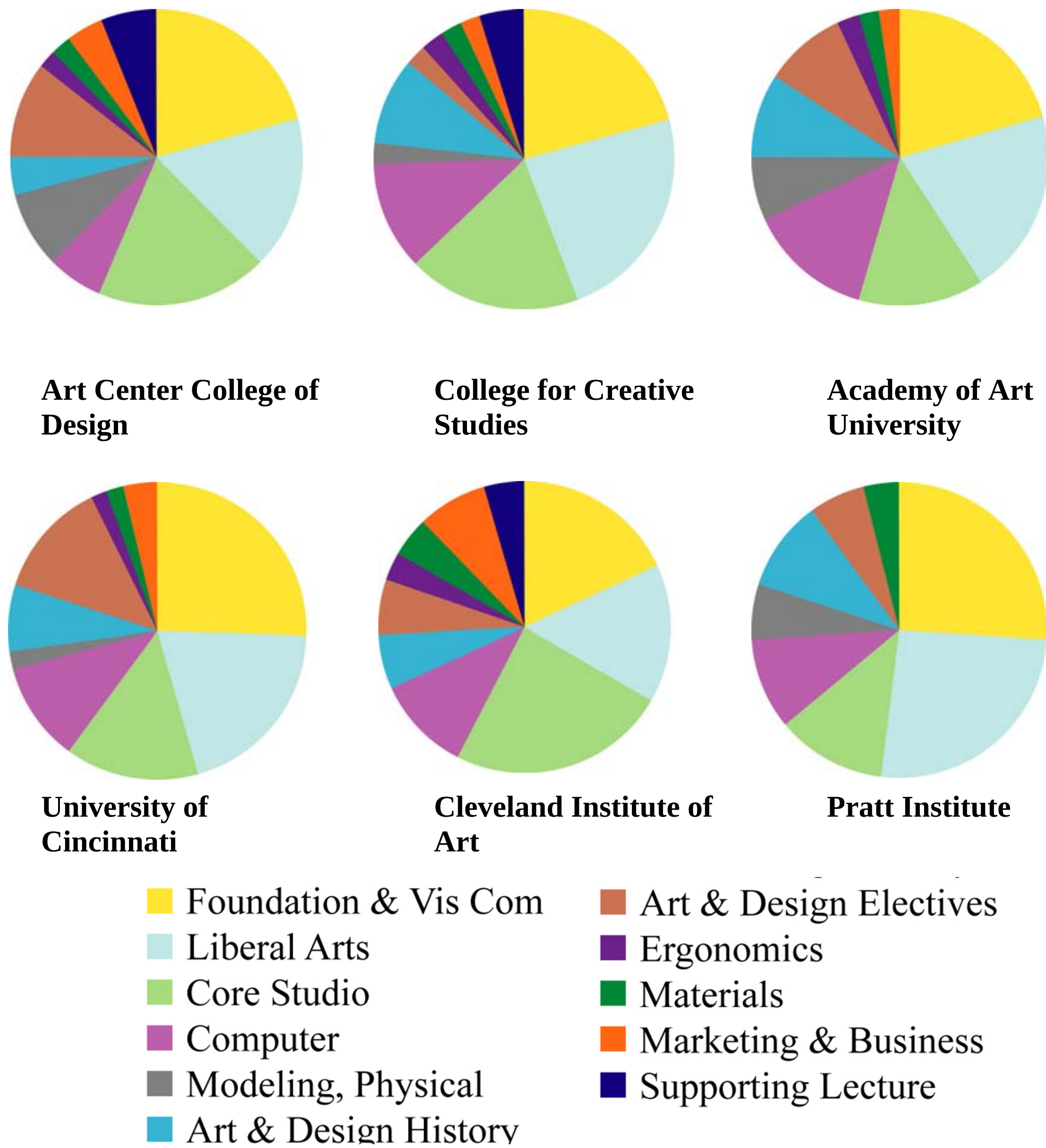

Figure A.1 Graphic Comparison of Programs

APPENDIX B

FACILITIES AND SUPPLIES COSTS

The following are lists with price estimates of basic supplies and equipment required for an individual student and for a program to outfit a small shop or computer lab. The estimates were generated by quick searches on the Internet from a variety of sources.

School: Computers, Peripherals, Etc.	
computers, networking	20,000.00
high-speed internet access, security	5,000.00
printer: color laserjet	5,000.00
printer: b&w laserjet, $3,500	7,000.00
large format printer, 1200x600, 24", 4-ink	2,000.00
scanner, $200 each, quant=8	1,600.00
LCD projector	1,200.00
Wacom Tablets	
Intuos, $750 each, quant=7	5,250.00
Cintiq, $2500 each, quant=1	2,500.00
software	
Microsoft Windows Server	2,000.00
Office: Word, Excel, PowerPoint, Access, Publisher, quant=20	1,298.00
Adobe: Creative Suite, $400 each, quant=20	8,000.00
Rhino, $1,000 unlimited user pack	1,000.00
Alias, 51-99 seats, $459 each	459.00
Macromedia Flash, 8-pack, $200 each, quant=2	400.00
Macromedia Dreamweaver, 8-pack, $150 each, quant=2	300.00
Autodesk AutoCAD 2006, 10-49 Network Lic, $995 each	995.00
Total:	$64,002.00

School: Machines & Tools

table saw	
10" table, 5HP	1,200.00
12" sliding	6,000.00
planer, 20" planer - 5 HP	2,250.00
jointer, 12" x 76" professional	2,200.00
drill press, $350 each, quant=2	700.00
drill bits	
regular: variety, average $1 each, quant=50	50.00
boring bits: variety, average $3 each, quant=30	90.00
scroll saw: 20" with stand and light, $425 each, quant=3	1,275.00
router	
lathe: heavy-duty, $850 each, quant=2	1,700.00
lathe tools variety, average $15 each, quant=20	300.00
sander: combination 6"x48" belt & 12" disc	500.00
oscillating spindle sander	600.00
clamps	
bar clamp: 60" K-Body, $50 each, quant=8	400.00
bar clamp: 36" racheting clamp & spreader, $10 each, quant=12	120.00
hand clamp: 4", $6 each, quant=20	120.00
band clamp: 15', $8 each, quant=2	16.00
vises: 3.5" bench, $25 each, quant=6	150.00
milling machine: wood & metal	2,200.00
3-D Printer	10,000.00
CNC	
milling	9,000.00
metal lathe	12,000.00
compressor: 3HP with 11 gal tank	250.00
paint booth	2,000.00
paint guns	150.00
clay oven	1,000.00
dust collection	2,000.00
dremel, $50 each, quant=4	200.00
dremel bits, 145-piece assortment pack, $20 each, quant=5	100.00
cordless drill, $120 each, quant=4	480.00
drill bits - 'tips'	50.00

hand tools, measuring, etc	
hammer, $6 each, quant=10	60.00
screwdrivers: variety, average $1.25 each, quant=40	50.00
pliers: variety, average $6 each, quant=20	120.00
wrenches: variety, average $7 each, quant=20	140.00
chisels: variety, average $9 each, quant=20	180.00
files/rasps: variety, average $3 each, quant=20	60.00
square: 24" aluminum, $13 each, quant=8	104.00
combination squares: 12", $8 each, quant=6	48.00
combination squares: 16", $13 each, quant=6	78.00
caliper: dial, $35 each, quant=5	175.00
tape measures, $8 each, quant=10	80.00
Total:	$58,196.00

Student: Computer and "Equipment"

computer with monitor	1,000.00
scanner	150.00
printer, color inkjet	275.00
digital camera	200.00
storage media	40.00
software:	
Adobe In-Design, Illustrator, Photoshop, GoLive	400.00
3D modeling package	300.00
Microsoft Office	200.00
back pack	40.00
Total:	$2,605.00

Student: Traditional Media

paper	
sketch pad: 12"x18", 50 sheets, $7 each, quant=2	14.00
newsprint pad: 18"x24" 100 sheets, $10 each	10.00
Bristol: 19"x24" 20 sheets, $20 each, quant=5	100.00
tracing paper, roll: 24" wide, 50 yd	20.00
pens, ball-point	4.00
pastels: soft, set of 60	120.00
marker: colors, $2.50 each, quant=25	62.50

marker: grey/black, $2.50 each, quant=20	50.00
marker: sharpie, $1 each, quant=20	20.00
pencils: graphite, $1 each, quant=20	20.00
pencils: colored, set of 48 Prismacolor	50.00
pencil sharpener: electric	40.00
gouache: $7 per tube, quant=12	84.00
paint: spray, primer & paint, $5 each, quant=10	50.00
paint brushes: set of 8	15.00
x-acto knife/caps	10.00
x-acto blades, 100	30.00
spray mount: super 77	10.00
fixative: prismacolor	6.00
fixative: pastel	20.00
erasers (manual)	10.00
tape	
black photgraphic tape, 60 yd: 1/4" ($4), 1/2" ($4), 3/4" ($5), 1" ($7)	20.00
drafting tape, 60 yd: 1/2" ($5), 1" ($7)	12.00
templates: ellipse, $4 each, quant=10	40.00
templates: circles	12.00
protractor	6.00
compass	20.00
caliper: dial	35.00
triangles, set	20.00
rules	
flexible 36" stainless	10.00
12" triangular engineering scale	9.00
typesetter/pica rule	4.00
T-square, 36" aluminum	30.00
tape measure	5.00
baby powder	2.00
clay	100.00
clay tools: $8 each, average, quant=6	48.00
portfolio: black canvas, 31"x25"x4"	35.00
art box	30.00
35MM camera, basic no lens	125.00
film	50.00
Total:	$1,334.50

APPENDIX C

THE FORESEE ONLINE CAR DESIGN SCHOOL

In the course of research for this paper I examined the website of Foresee Car Design (Steenstra, 2005a). My interest was piqued on several fronts so I pursued that avenue of research further. Those efforts lead to the pleasure of interviewing and exchanging emails with Cornelis Steenstra, head of Foresee Car Design. One of the more unique aspects of the website was the pages devoted to the Foresee Online Car Design School (Steenstra, 2005b). Clearly this does not qualify as an undergraduate transportation design program but it is obviously closely related in tools, technique, and process. Moreover it could not exist without computer technology. Is this the modern day equivalent of Johnson's correspondence course?

The following is Mr. Steentra's response to one of my questions about the school that I believe very eloquently expresses a bit of his motivation and philosophy. I have taken the editorial license of splitting his response into several paragraphs.

> The car design school was intended to offer a basic understanding of this profession to people who would not have easy access to specialized education due to location. There are only a few good schools teaching transportation design or related courses, and before investing a lot of money in going there it would be good to find out what it entails and if one has the talent.
>
> We have had a wide variety of students from all parts of the world. Initially aimed at 14-18 year olds, we had people as old as 58 taking the training,

just to get it out of their system. The course is not intended to replace any renowned institutions, but rather prepare for them. We do not provide a graduation as such, but have people now working within Nissan, Renault, Porsche, Volvo and Mini.

I am not concerned in creating my own competition since there is always a need to develop and innovate. Trading helps me to grow to, to look at things again, to develop new trends and tastes, a new perception of what looks good. I would be concerned with institutions turning out great number of 'qualified' car designers where their own financial gains were a priority over the quality of the designers and their chances for employment. I find that some institutions here do have that tendency, and I find it embarrassing for the graduates that I can not hire them because they are not qualified, in whatever sense, despite having the diplomas. I would say that even in education the saying 'quality rather than quantity' in this profession is very important (Steenstra, 2005).

The Foresee Online Car Design School is by no means the only 'non-traditional' approach to a rudimentary automotive design education. Numerous websites, books, and DVDs make drawing and computer graphics tutorials readily available and the variety provides the complete range of sophistication to match the student from the completely green novice to the seasoned professional who needs a tune up or wants to put a new software in the arsenal.

APPENDIX D

CHRONOLOGY OF RECOMMENDED COURSES

This is not a complete syllabus but rather a list of proposed courses in chronological order by semester applied to an eight semester curriculum. Additional courses not listed would be added in each semester to yield the average number of courses per semester of five or six, thus filling out the program.

1) Information Management & Technology

   English for Proposals

   Research for Design

   Intro to Industrial Design Studio

   History of Automotive Design

2) Perspective

   Graphics and Color

   Sketching People

   Drafting

   English for Presentations

   Portfolio

3) Human Centered Design

   3D Sketching

   20^{th} Century History

   Automotive Design Studio1

   Automotive Engineering and Package Design

4) Ergonomics

Presentation

Alias

Automotive Engineering and Aerodynamics

Automotive Design Studio 2

Portfolio

5) Automotive Interiors 1

Product Planning, Marketing, and Branding

Interface Design

Sketching Materials and Surfaces

Modeling

6) Drawing for Understanding

Automotive Interiors 2

Automotive Design Studio 3

Portfolio

7) Speed Sketching

Advanced Automotive Design Studio 1

8) Advanced Automotive Design Studio 2

Portfolio

APPENDIX E

SURVEYS

The following pages contain images of the IRB approved surveys used during the course of the research for this paper. A pilot survey using a similar instrument was first administered to Georgia Tech industrial design students in 2003. After further refinement and IRB approval the surveys were distributed to approximately 200 subjects in the targeted populations. Only about six percent of the surveys were returned. Of those returned, responses varied greatly and few significant patterns could be discerned. If anything it could be taken as a sign of the disparate attitudes held by the various stakeholders. Of those who responded from industry it is clear that 60 to 80% of studio work is done digitally. Individual surveys pointed out the logistical and economic challenges posed by the use of computers in academic studio settings and a number of other individual concerns also noted by authorities in the text of this paper.

Dear Industrial / Automotive Design Educator, January 20, 2006

The following survey is part of the research for my Masters thesis at the Georgia Institute of Technology Industrial Design Program entitled *Automotive Design Education: Integrating Computer Based Tools with Traditional Techniques.* As an educator you deal with this topic regularly. Your experiences and observations in the studios that you lead are invaluable. Your input is greatly appreciated. Please feel free to forward this to your colleagues. Your responses to this survey will be kept confidential unless specific permission is sought and granted. Taking this survey will only take a short time. Participation in this survey is entirely voluntary. You will receive neither reward nor retribution as a result of your participation. Returning this survey will constitute your consent to use the information herein. Thank you for your time and your assistance in advancing my research and the understanding of our field.

School: ____

Class(es) Taught (last two terms):__________________________________

Please rate the following statements from your personal perspective indicating the degree to which you agree with each statement**. 1= strongly disagree; 5 = strongly agree**. If you have no experience on which to base your response, or no opinion, circle 0.

1) The curriculum at my institution sufficiently prepares a student to use the design tools regularly used in the industry. 0 1 2 3 4 5

2) Computers are a useful design tool. 0 1 2 3 4 5

3) Clay modeling is a useful design tool. 0 1 2 3 4 5

4) Computer modeling is a useful design tool. 0 1 2 3 4 5

5) Computer rendering is a useful design tool. 0 1 2 3 4 5

6) Traditional media rendering is a useful design tool. 0 1 2 3 4 5

7) Use of computer-generated images and / or models accelerates the design process. 0 1 2 3 4 5

8) Use of computer drawing tools in the design process promotes an understanding of the underlying engineering principles of a product and the importance of those principles. 0 1 2 3 4 5

9) Use of computer drawing tools accelerates the established educational process. 0 1 2 3 4 5

10) Traditional drawing / rendering skills must form the foundation for use of CAID tools. 0 1 2 3 4 5

11) Computers are integrated into studio design classes. 0 1 2 3 4 5

12) Logistical considerations of computer use in the studio classroom are a significant impediment to their use. 0 1 2 3 4 5

13) Economic considerations of computer use in the studio classroom are a significant impediment to their use. 0 1 2 3 4 5

14) Classes specifically designed to teach CAID techniques are offered. 0 1 2 3 4 5

15) Classes specifically designed to integrate CAID into the studio classroom are offered. 0 1 2 3 4 5

16) Classes are offered that teach specific design software packages. 0 1 2 3 4 5

a) What software packages are taught in "computer" classes? _______________

b) What software packages are taught in conjunction with a studio class?
____

c) What software packages are available for student use on your campus?
____

d) How many computer terminals with CAID capability are available to ID students on campus? [None] [1-20] [21-40] [41-60] [more than 60] _____

e) How many full-time ID students are enrolled on this campus? [less than 40] [41-70] [71-100] [101- 130] [131-160] [more than 160] _________________

f) What inherent advantages and disadvantages of computer rendering and modeling over traditional techniques do you see? _______________________
____
____
____

g) Would you be willing to be the subject of a more in-depth interview on this topic via phone, email, or in person? Yes No
If "Yes" to above, what is the best way and time to contact you in order to make arrangements for this interview?_________________________________
____

Thank You!

Please return to: David Lynn, Racerpen@Comcast.net, 404 428 8287

If you would like a copy of the results of this survey, please contact me.

Georgia Institute of Technology IRB Protocol H06011 1-24-06

Dear Industrial / Automotive Design Student, January 20, 2006

Please take a few minutes to complete this survey about automotive design education. This survey is a part of the research leading to a Masters thesis at the Georgia Institute of Technology Industrial Design Program. The provisional title of the thesis is *Automotive Design Education: Integrating New Tools with Traditional Techniques*. While the thesis will ultimately focus on automotive design in particular it is hoped that it will be readily applicable to any field of industrial design. Your participation in this survey is extremely helpful and most appreciated. Your responses will be completely confidential. Participation in this survey is entirely voluntary. You will receive neither reward nor retribution as a result of your participation. Returning this survey constitutes your consent to use the information that you provide. If you would like further information about this research, please contact David Lynn via email (Racerpen@comcast.net).

School: ____

Year in major: 3 4 5 +

Age: ______

Major: Trans Product General ID Other: ________________________

Please rate the following statements from your personal perspective indicating the degree to which you agree with each statement by circling the appropriate number. If you have no basis for a response, please circle 0.

1= strongly disagree; 5 = strongly agree.

1) The curriculum sufficiently prepares a student to use the tools of design regularly used in the industry. 0 1 2 3 4 5
2) Computers are integrated into my studio design classes. 0 1 2 3 4 5
3) Clay modeling is a useful design tool. 0 1 2 3 4 5
4) Computer modeling is a useful design tool. 0 1 2 3 4 5
5) Computer rendering is a useful design tool. 0 1 2 3 4 5
6) Traditional media rendering is a useful design tool. 0 1 2 3 4 5
7) Use of computer-generated images and / or models accelerates the design process. 0 1 2 3 4 5
8) I have confidence in my computer modeling / rendering skills. . 0 1 2 3 4 5
9) I have confidence in my traditional rendering skills. 0 1 2 3 4 5

10) I have confidence in my 3-dimensional modeling skills. 0 1 2 3 4 5

11) Use of computer drawing tools in the design process promotes an understanding of the underlying engineering principles of a product. 0 1 2 3 4 5

12) I prefer drawing / rendering on the computer to drawing / rendering by hand. 0 1 2 3 4 5

13) I prefer modeling on the computer to modeling three dimensionally (by hand fabrication). 0 1 2 3 4 5

h) Would you be willing to be the subject of a more in-depth interview on this topic via phone or email? Yes No

i) If "Yes" to above, what is the best way and time to contact you in order to make arrangements for this interview? ________________________________

____

____

____

Thank You!

Please return to: David Lynn, Racerpen@Comcast.net, 404 428 8287

Georgia Institute of Technology IRB Protocol H06011 1-24-06

Dear Automotive Design Employer, January 20, 2006

The following survey is part of the research for my Masters thesis at the Georgia Institute of Technology Industrial Design Program entitled *Automotive Design Education: Integrating Computer Based Tools with Traditional Techniques.* As you know, industrial designers focus on end users. In the educational context, you are the consumer of program graduates. Your input is greatly appreciated. Please feel free to forward this to your colleagues. This survey is appropriate to both HR and management positions. Your responses to this survey will be kept confidential unless specific permission is sought and granted. Participation in this survey is entirely voluntary. It will only take a short time. You will receive neither reward nor retribution as a result of your participation. Returning this survey will constitute your consent to use the information herein. Thank you for your time and your assistance in advancing my research and the state of automotive design education.

Industry: ____

Position: ____

Please rate the following statements from your experience indicating the degree to which you agree with each statement. **1= strongly disagree; 5 = strongly agree**. If you have no experience or no opinion on which to base your response, circle 0.

1) Design schools are sufficiently preparing their students to use the design tools that are the standards in the industry (including CAID). 0 1 2 3 4 5

2) Design schools teach appropriate CAID software. 0 1 2 3 4 5

3) We prefer to hire graduates from specific schools. 0 1 2 3 4 5

   Which schools and why? _______________________________________
   ____
   ____
   ____
   ____
   ____
   ____
   ____

a) What percentage of images you create in your studio is produced using a computer? [none] [1-20] [21-40] [41-60] [61-80] [81-100] ___________

b) What other media is used regularly? ______________________________

c) How many different software packages does your studio use regularly? _____
Which ones? ____

d) In general how much "on the job" software training is required for entry level designers? ____

e) What inherent advantages of computer rendering and modeling over traditional techniques do you see? ___________________________________
____
____
____
____
____
____

f) What inherent disadvantages of computer rendering and modeling over traditional techniques do you see? ___________________________________
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____
____

g) Would you be willing to be the subject of a more in-depth interview on this topic via phone, or email? Yes No

If "Yes" to above, what is the best way and time to contact you in order to make arrangements for this interview? ___________________________________
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____
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Thank You!

Please return to: David Lynn, Racerpen@Comcast.net, 404 428 8287

If you would like a copy of the results of this survey, please contact me.

Georgia Institute of Technology IRB Protocol H06011 1-24-06

Dear Software or Hardware Developer / Vendor, January 20, 2006

The following survey is part of the research for my Masters thesis at the Georgia Institute of Technology Industrial Design Program entitled *Automotive Design Education: Integrating Computer Based Tools with Traditional Techniques.* As a manufacturer and provider of computer based design tools, your products and your marketing are integral parts of my research. Your input is greatly appreciated. Please feel free to forward this to your colleagues. Your responses to this survey will be kept anonymous unless specific permission is sought and granted. Participation in this survey is entirely voluntary and should only take a few minutes of your time. You will receive neither reward nor retribution as a result of your participation. Returning this survey constitutes your consent to use the information you have provided herein. Thank you for your time and your assistance in advancing my research.

Industry: ____

Position: ____

Please rate the following statements indicating the degree to which you agree with each statement**. 1= strongly disagree; 5 = strongly agree.** If you have no experience on which to base your response, or no opinion, circle 0.

1) Collegiate design programs are valuable marketing tools for our products. 0 1 2 3 4 5

2) Collegiate design programs are appropriate settings to teach specific CAD, CAID, or CG software and hardware. 0 1 2 3 4 5

3) Design schools are appropriate settings to teach the use of our product. 0 1 2 3 4 5

4) We offer seminars (or other in-person training) to professionals to learn our CAD, CAID, or CG software or other product. YES NO

5) We offer seminars (or other in-person training) to students to learn our CAD, CAID, or CG software or other product. YES NO

6) Academic demand for our product is on the rise. 0 1 2 3 4 5

7) Industrial demand for our product is on the rise. 0 1 2 3 4 5

8) We offer academic institutions special discounts. 0 1 2 3 4 5

9) We offer students special discounts. 0 1 2 3 4 5

Please briefly explain the philosophy of your company with regard to academic institutions and your product: ____
____
____
____
____
____
____
____

Would you be willing to be the subject of a more in-depth interview on this topic via phone, or email? Yes No

If "Yes" to above, what is the best way and time to contact you in order to make arrangements for this interview? ____
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Thank You!

Please return to: David Lynn, Racerpen@Comcast.net, 404 428 8287

If you would like a copy of the results of this survey, please contact me.

Georgia Institute of Technology IRB Protocol H06011 1-24-06

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