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Changing Design Education for the 21st Century

Michael W. Meyer
Don Norman

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MICHAEL W. MEYER
Design Lab and Rady School of Management, University of California, San Diego, USA
(corresponding author)
mwmeyer@ucsd.edu

DON NORMAN
Design Lab, University of California, San Diego, USA
dnorman@ucsd.edu

Abstract
Designers are entrusted with increasingly complex and impactful challenges. However, the current system of design education does not always prepare students for these challenges. When we examine what and how our system teaches young designers, we discover that the most valuable elements of the designer's perspective and process are seldom taught. Instead, some designers grow beyond their education through their experience working in industry, essentially learning by accident. Many design programs still maintain an insular perspective and an inefficient mechanism of tacit knowledge transfer.

Meanwhile, skills for developing creative solutions to complex problems are increasingly essential. Organizations are starting to recognize that designers bring something special to this type of work, a rational belief based upon numerous studies that link commercial success to a design-driven approach.

So, what are we to do? Other learned professions such as medicine, law, and business provide excellent advice and guidance embedded within their own histories of professionalization. In this article, we borrow from their experiences to recommend a course of action for design. It will not be easy: it will require a study group to make recommendations for a roster of design and educational practices that schools can use to build a curriculum that matches their goals and abilities. And then it will require a conscious effort to bootstrap the design profession toward both a robust practitioner community and an effective professoriate, capable together of fully realizing the value of design in the 21st century. In this article, we lay out that path.

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> "Education for designers (like nearly all education) is based on learning skills, nourishing talents, understanding the concepts and theories that inform the field, and, finally, acquiring a philosophy. It is unfortunate that our design schools proceed from wrong assumptions. The skills we teach are too often related to processes and working methods of an age that has ended."[1]

Victor Papanek, one of his era's most noted designers, was sharply critical of his chosen profession. We believe his quote applies as much today as it did when he wrote it 50 years ago. From one perspective, traditional design schools are perfectly capable of producing practitioners to serve the various design specializations. Indeed, the world seems to have implicitly recognized the value of design through its choices of products and services. However, although numerous studies show the value of design for companies,[2] out of the entire roster of Fortune 500 companies, only 10–20 have chief design officers—roughly 2–4%. The full potential of design is yet to be recognized. Perhaps the fault lies with the design profession itself: how many designers are capable of being a C-level executive at one of the world's largest companies? Perhaps the lack of senior executives is an indictment of our education.

Design is a complex field. It is both practice and academic discipline. Each category encompasses numerous specialized disciplines whose parameters are fluid, ill-defined, and changing continually, with a number of different design societies dedicated to them. Some societies have stated that their discipline represents all of design. This kind of misunderstanding is not unique to design—every professional discipline has similar issues. Nonetheless, every professional discipline also shares a core set of fundamental principles that sets it apart from other disciplines. So it is with design.

In this article, we talk only about one broad class of design: Human-Centered (HCD). By this we mean simply designers who design for people and society. This distinguishes HCD from other disciplines of design—engineering and science, for example—where devices, algorithms, and experiments are designed without any intention that they be directly used by people or organizations. Examples include the design of scientific experiments to test new chemical reactions or to assess the conditions on a distant planet, or the design of a semiconductor chip or an algorithm for a technical purpose. These are all legitimately design activities, but they are not part of the purview of this article. Note that the type and nature of design being taught in schools and design departments today is primarily human centered, even if it is not called by that name.

Today, the world faces new challenges. Designers are starting to play a larger and larger role in not only designing but managing beyond the design studio and even deciding upon the activities that need to be done across the business. Our concern is that design education has not kept up with the new demands of the 21st century. We do believe that existing design schools and designers are still needed—what we suggest is a broadening of the material taught. Different schools might choose different paths (some deciding not to alter what they do). Some will choose to focus on components of new skills. We recommend that all schools of design cover a set of core principles, but then offer advanced courses that might be unique to the special talents of the school or that might lead to one of a number of specialties within design.

1 Victor J. Papanek, *Design for the Real World: Human Ecology and Social Change*, rev. ed. (1971; New York: Van Nostrand Reinhold Co., 1984), 285.

2 Michael Westcott, "Design-Driven Companies Outperform S&P by 228% over Ten Years—The 'DMI Design Value Index,'" *dmi:Dialog* (blog), last updated March 10, 2014, https://www.dmi.org/blogpost/1093220/182956/.

In 2019, Ken Friedman suggested a list of challenges for design,[3] stating that "These challenges create a new context for the design process. Some forms of design remain similar to what they have long been. Other forms of design emerge in response to new developments, new tools, new situations, and new technologies."

Here are the eleven design challenges. (The texts in parentheses are our additions, to clarify the challenges for this article.[4]) The Eleven Design Challenges are divided into four groups: Performance, Systemic, Contextual, and Global. The four groups are cumulative in the sense that each depends upon the skills, knowledge, and requirements of the previous groups. Thus, Systemic builds upon Performance, Contextual upon Performance, and Global upon Contextual.

Performance Challenges

Challenges related to what designers must do, rather than a challenge to their skill sets.

1. Design acts on the physical world and on the linked world of intangibles.
2. Design addresses human needs and desires (sometimes focusing upon specific things—be they tangible or intangible—sometimes focusing on abstract things such as experiences, purposes, and goals).
3. Design generates the tangible and intangible built environment as well as the social environment. (Design is a discipline of making. It makes the physical, as in the built environment, and devices, machines, and tools; and the intangible, as in services and procedures.)

Systemic Challenges

Challenges related to addressing the entire system, not just a single part.

4. We live in a world marked by ambiguous boundaries between artifacts, structures, systems, and processes.
5. We work in a world of large-scale social, economic, and industrial frames.
6. We design for a complex environment of ever-shifting needs, requirements, and constraints.
7. We design for a world in which intangible content often exceeds the value of physical substance.

Contextual Challenges

Challenges related to dealing with complex systems that are strongly affected by their environment, local culture, and political concerns.

8. The projects, products, and services we design often cross the boundaries of organizations, stakeholder, producer, and user groups.
9. These projects, products, and services must meet the expectations of many organizations, stakeholders, producers, and users.
10. These projects, products, and services must meet demands at every level of production, distribution, reception, and control.

3 Ken Friedman, "Design Education Today: Challenges, Opportunities, Failures" (Chatterjee Global/150th anniversary Commemorative Lecture, College of Design, Architecture, Art and Planning, the University of Cincinnati, October 3, 2019), https://www.academia.edu/40519668.

4 These additions are in keeping with comments and suggestions made by Pieter Jan Stappers.

5 United Nations, "United Nations: Sustainable Development Goals," accessed January 17, 2020, https://www.un.org/sustainabledevelopment/sustainable-development-goals/.

Global Challenges

Challenges related to dealing with complex sociotechnical systems.

11 We must address the major societal issues facing the world, including the sustainable development goals specified by the United Nations, which seek to "address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice" with the goal of achieving "each goal and target by 2030."[5]

These four groups and eleven challenges define the future of design. How do we train people to become capable of working within these groups? Mind you, few individuals are capable of working across all four. We need a design curriculum that provides options, allowing different individuals to select which level of problem they wish to address. Today, most design education addresses the first group, Performance Challenges; a few schools provide training relevant to Systemic and Contextual Challenges, but only a very few cover Global Challenges.

Four Design Scenarios

To make the challenges more concrete, consider these four scenarios.

A Performance Challenge

Li Na is designing living room lighting systems for middle- and upper-class homes. Some homes are very modern, others very traditional. Li Na is experimenting with traditional light sources, LEDs whose intensity and color can be changed, and luminous panels, some of which are made of flexible material that can be made into many different shapes or simply placed on the wall or ceiling to provide a diffuse light throughout the room. The lighting manufacturer would like a platform that enables multiple variations of the lamps, both to meet the variety of requirements today, but also to support future developments.

Skills Required for Performance Challenges

This form of challenge can be addressed using traditional performance-based skillsets. Knowledge of the task requirements and the company's business models is important, as is expertise in materials and manufacturing. Any new skills required are mainly technical: knowledge of advances in lighting technologies, new computer-based design tools, and new materials and manufacturing processes.

A Systemic Challenge

Jin has been asked to put together a team to design a new form of a radiological imaging system that presents surgeons in the operating room with a 3D display of the operation. The display must depict images of critical organs, blood vessels, muscles, and more to guide the surgeon, who will either be using traditional instruments (scalpel, forceps, clamps, and so on) or performing laparoscopic diagnosis. The display will also be visible to the other members of the surgical team. Numerous technical and regulatory requirements must be met when designing this kind of medical device. Different parts of the medical team might want to see different representations of the same scenes. For example, the surgeon might prefer a 3D (AR or VR) rendition, whereas radiologists tend to prefer two dimensional slices. The anesthesiologist, family physician, and surgical nurses would likely need other formats.

Skills Required for Systemic Challenges

This challenge requires systems thinking. The work requires a multidisciplinary team, in this case comprising medical personnel, technologists, experts in computer displays, and people with expertise in interface design. Managing the team might very well be the biggest challenge—each representative is likely to have strong opinions about what is needed, as well as the belief that their views take priority over others. The ability to research the design requirements is limited because it is a novel product, and although components of the vision exist in hospitals and research centers around the world, no single place has put it all together. The most important skills are management and leadership—traditional training in typography, color, form, and materials would be of little or no relevance.

A Contextual Challenge

Kim is leading a team developing a new sanitation system for a rural community in southern India. The government will supply indoor toilets and sewerage pipes, but the toilets do not necessarily fit inside one room homes, they require water supplies, and the pipes require digging ditches throughout the village. Up to now, the community has used outhouses that are polluting the water supply. The community is extremely suspicious of government initiatives and foreign experts, all of whom tend to institute changes without input from and discussion with the people in the community. A “foreigner” is anyone from outside the village.

Skills Required for Contextual Challenges

This challenge deals with a complex system in a situated context. Like systemic challenges, the major skills required are those of management and leadership, but in this case, there is an emphasis on cultural and political acceptance. Although both systemic and contextual challenges call for multidisciplinary teams composed of experts, government officials, and community leaders, contextual challenges necessitate the use of a co-design approach—giving the community a major say in the process, even if the community prefers results that may negatively impact some components of the final result.

A Global Challenge

Erin is a designer working with the United Nations to assemble a major initiative to tackle the United Nations’ second Sustainable Development Goal (SDG): hunger. The initiative will require input from a diverse group with a variety of skillsets, representing multiple nations, government agencies, and

NGOs. Addressing an SDG at this scale will require the designer to work with large budgets, large groups of people, and an array of political and cultural differences. The project will almost definitely necessitate many political and practical compromises.

The work requires a profound understanding of the culture and needs facing the target population through research conducted by anthropologists and design researchers. But even if UN executives agree to this in principle, the pressure may be on to complete the research quickly, or even skip it entirely by gleaning data from existing government-sponsored surveys and white-papers. The goal of such precipitation is often to more quickly implement solutions recommended by expert advisors. Erin's previous experience with similar projects strongly supports a different approach based upon a combination of bottom-up knowledge from the local communities most affected combined with top-down advice and facilitation by experts. Indeed, it is this belief plus her experience that got her chosen to lead the project. Nonetheless, she cannot do this without convincing the expert teams assembled by the UN.

Skills Required for Global Challenges

Global challenges deal with complex sociotechnical systems. The associated tasks are similar to ones associated with contextual challenges, but at a far greater order of magnitude—multiple bureaucracies, multifarious issues, massive complexity, and great expense. It might seem unusual to offer the task of managing it to a designer because of its primarily political, cultural, and organizational character. But this is a task where success will depend primarily on HCD and design thinking tools and approaches. Our goal must be to train designers to be able to take leadership roles on these sorts of problems.

Meeting a global design challenge is a team effort that comes with a heavy dose of cultural and political limitation. A variety of tasks will call upon the designer's skills and creativity: interpreting the vast quantities of information that will serve to define the problem; ensuring that root causes are addressed; monitoring implementation; and developing strategic modifications or even making significant changes when implementation is not generating the expected result. Traditional HCD approaches, with their emphasis on designer skills, will almost definitely have to be transformed into community-driven, bottom-up collaborations with experts who have knowledge across the relevant domains—a community-driven form of co-design.[6] This reconsideration of traditional design practices should form a part of basic design education: questioning everything is an important attribute of the creative designer.

Undertakings like this will test the very limits of a designer's education, but we expect such demands to become increasingly common. Some may object, saying that designers are beginning to act more like project/product managers or management executives. We agree. But point out that designers will have unique, multi-disciplinary skills, understanding how to use the specialized knowledge of all the different disciplines involved in the task in a way that best produces a positive outcome. With appropriate training

6 Elizabeth B.-N. Sanders and Pieter Jan Stappers, "Co-creation and the New Landscapes of Design," *CoDesign* 4, no. 1 (2008): 5–18, DOI: https://doi.org/10.1080/15710880701875068; Natasha Iskander, "Design Thinking Is Fundamentally Conservative and Preserves the Status Quo," *Harvard Business Review* (online), September 5, 2018, https://hbr.org/2018/09/design-thinking-is-fundamentally-conservative-and-preserves-the-status-quo.

7 Westcott, "Design-Driven Companies," para. 4.

and experience, designers are well suited to become leaders of these large, complex sociotechnical systems. Yes, these are non-traditional roles for designers, and this is precisely what is required to tackle the major global challenges of the 21st century.

What Do These Scenarios Imply for Design Education?

It is plain to see from the above that designers' responsibilities are expanding beyond the technical to include the organizational and managerial. Addressing the large, complex design problems of the future will continue to require the exercise of those organizational and managerial roles, integrated to support the application of more traditional design skills. Without attention to and supervision of the details of implementation, ensuring that the requirements and interests of multiple stakeholders are addressed and tensions among them resolved, the design will fail. So, who better to lead than the properly trained designer?

Businesses have already begun to embrace this notion, drawing upon empirical evidence that guides them in how best to manage their initiatives and employ their limited resources. Indeed, three separate studies over the past twenty years have shown that companies employing a design-driven approach outperform competitors by approximately 2:1.[7]

Of course, no single person is likely to have all the skills required for the four different scenarios and design challenges. But the skills need not be within a single person: large, complex projects are done by teams. What matters is that the team's composite skillset will be able to satisfy the demands of the project.

One conclusion to be drawn from the Global Challenge Scenario is that it is a mistake to perceive design as separate from design implementation. The two must go together, because it is only during the implementation phases that the reality of the world imposes itself most strongly, requiring revisiting and changing many design decisions. And this discovery and reconsideration is why designers must consider implementation a part of design. We believe this applies to all four groups. Even in traditional craft-based design, the separation of design from manufacturing or implementation often leads to inferior results.

Organizations seeking to build or elevate their own design capabilities benefit from deeper and broader reflection and discourse both within the community of design as well as with other academic fields. Within the design community, where design theory and process were once the domain of the occasional book by a luminary such as Bruce Archer, Jay Doblin, Victor Papanek, or Paul Rand, the bulk of practitioners pushed to have their artifacts rather than their writings celebrated. Now that balance is shifting, as evidenced by the rise in volume and change in content of the professional journals, conferences, and societies. We now see deeper and broader contribution of content from other academic fields into the tools, frameworks, and hands of designers. This is clearest in the newer specializations such as service, information, and interaction design, which benefit greatly from the cognitive and behavioral sciences.

The result of this work, which we generally refer to as "design thinking," has long been celebrated within the design community with a large collection of serious works and books: for a sampling, see Nigel Cross,[8] Donald Schön,[9] and Herbert Simon.[10] The recent popularity of design thinking is a positive development in the appreciation of the skills of designers beyond product design and aesthetics as well as a danger, for the proliferation of introductory (and relatively shallow) workshops, seminars, and courses on design thinking[11] trivializes the process and the required skillsets that are involved, leading to much confusion and inappropriate usage. This misunderstanding of design as technique rather than a discipline also generates team conflicts. As a result, attempts to apply the newly acquired (and relatively shallow) design thinking skills often fail in application unless an experienced design practitioner serves as guide. John Kolko provides an excellent description of the weaknesses in how design thinking is often used as well as its strengths when appropriately applied.[12]

Design schools and subsequent professional experience instill in practitioners a uniquely valuable understanding of process and application. The problem is that the understanding remains at the level of tacit knowledge. And while some of the top design schools are beginning to evolve their educational models, traditional design school curricula are constructed to perpetuate the teaching and learning of manual skills and working in a studio format. Even in those schools moving beyond craft training, the students still only have a light and superficial understanding of the problems they are presented with, and this, coupled with their attempt to apply traditional design methods, often leads to the treating of the symptoms rather than the underlying root causes. Even where this is not the case, there can be a lack of appreciation of the skills, knowledge, and resources of the people for whom a design is intended.

In order to effectively and consistently instill the broader skillsets and mindsets that make the modern designer an effective leader and collaborator in the challenges above, we argue below that design education must evolve to become an academic discipline. In this model, all designers would share a central core that grounds them as designers, and a deep specialization in the media that define them specifically as industrial designers, interaction designers, graphic designers, and so on.

How We Got Here: The Origins of Design Education

Contemporary design education has several origins. The Royal College of Art in London began in 1837 as the Government School of Design. The Glasgow School of Art began in 1845 as the Glasgow Government School of Design. The Rhode Island School of Design (RISD, United States) began in 1877. Konstfack (Stockholm) began in 1844. The National Academy of Craft and Art Industry (Norway) began in 1818, surviving today as the design faculty of the Oslo National College of Art. Much of the curriculum developed over the years at these schools and several of the European academies survives in design education today.[13]

8 Nigel Cross, "Designerly Ways of Knowing: Design Discipline Versus Design Science," *Design Issues* 17, no. 3 (2001): 49–55, DOI: https://doi.org/10.1162/074793601750357196.

9 Donald A. Schön, *The Reflective Practitioner: How Professionals Think in Action* (New York: Basic Books, 1983); Donald A. Schön, *Educating the Reflective Practitioner: Toward a New Design for Teaching and Learning in the Professions* (San Francisco: Jossey-Bass, 1987).

10 Herbert A. Simon, *The Sciences of the Artificial*, 3rd ed. (Cambridge, MA: MIT Press, 1996).

11 Jon Kolko, "The Divisiveness of Design Thinking," *interactions* 25, no. 3 (2018): 28–34, DOI: https://doi.org/10.1145/3194313.

12 Ibid.

13 This paragraph was provided to us by Ken Friedman. There are other alternative histories. One of our reviewers pointed out that "the most groundbreaking work was actually done by the French in the early 1800s. At the time, even the British considered them far superior compared to their own schools, which were introduced later. The late 1800s design education in the US in some parts was a combination between the French and the British curricula." And unfortunately, we are not aware of the early history of design in other areas of the world, in particular Asia. One of our main sources of design history is Bernhard Bürdek's *History, Theory and Practice of Product Design*, which does cite the British arts and craft movement at the end of the 19th century, but does not credit either France or Asia (Japan, China, and Korea) with early work. We suspect that the definition of design gets stretched here. We are certain that other countries—especially Asian—had thriving arts and craft traditions, but do we count them as design? Are they HCD? And, most importantly for this paper, how much did they influence design education? Consider Chris Alexander's work *The Timeless Way of Building*, where he points out that architecture has a history dating back several thousands of years. Obviously, the utensils, tools of living, eating sleeping, traveling, and warfare go back just as far. But the relevant question is, "Did they influence design education?" Bernhard E. Bürdek, *Design: History, Theory, and Practice of Product Design*, 1st English ed. (Boston, MA: Birkhauser-Publishers for Architecture, 2005); and Christopher Alexander, *The Timeless Way of Building* (New York: Oxford University Press, 1979).

One hundred years ago, Staatliche Bauhaus—the Bauhaus School—was created to reconcile the teaching and practice of fine arts with applied arts (design), and took as central to that effort "the development of a new formal vocabulary based on experimentation and craftsmanship that would do justice to the industrial manufacturing process."[14] Founder and first director Walter Gropius described Bauhaus workshops as intended to be "laboratories for industry." Essential to the realization of that intent were the (often less appreciated) pedagogical innovations of Johannes Itten and László Moholy-Nagy, who brought both the concept of a common foundation to the Bauhaus Vorkurs (foundation course), and the focus on developing a theoretical basis for design work. This shift from design as an artisan trade to an educated discipline represents the initial professionalization of design.

The Bauhaus helped legitimize the teaching of design as an academic subject, and with that the formation of a combined academic-and-practitioner community. The heavy emphasis on craft skills and treating design as applied art is no longer appropriate however—most schools of design have moved away from this strict point of view (including the modern Bauhaus University in Weimar, Germany). Today, design is recognized as its own discipline, separate from art—and even applied art. We propose to consider the Bauhaus as an early prototype upon which to iterate and improve.

In 1922, Walter Gropius illustrated the curriculum through what has become known as the Bauhaus Curriculum Wheel. The four-year curriculum covers five fundamental area of studies:

1 Space, color, and composition;
2 Materials;
3 Nature;
4 Materials and tools;
5 Construction and representation.

Taken at face value, the wheel says nothing about the study of people, or any mention of how things are to be used or understood (all fundamental parts of today's curricula).[15]

Diving into the details of curriculum, however, we do see evidence of a dawning consideration of designing for people. Under Moholy-Nagy's leadership over 1923–1928, the third-year metal workshop shifted its focus from the ornamentation of handicrafts to the crafting of simplified functional objects. In roughly the same period, Oskar Schlemmer emerged as the leading proponent of an anthropocentric approach in the school's pedagogy.[16] Ultimately, he devised and taught a required course, "Der Mensch," which incorporated elements of human mechanics and kinematics, psychology, and the environment in which the person lived.[17]

Unfortunately, in their efforts both instructors exercised two pedagogical traditions that continue to plague design education: a) Moholy-Nagy's shift to the primacy of functional considerations was taught as a transfer of tacit knowledge within the studio environment; and, b) Schlemmer, though lacking formal training in the scientific fields he sought to incorporate in "Der Mensch," chose to develop and teach those sections himself, rather than in collaboration with others more established in those fields.

14 "The Bauhaus: The Origins up to 1919," *bauhaus100* (online), accessed January 17, 2020, https://www.bauhaus100.com/the-bauhaus/phases/the-origins/.

15 Don Norman, "Why We Need So Much More Than the Bauhaus," *bauhaus now* 1, no. 1 (2018): 18–21, available at https://jnd.org/then_and_now_the_bauhaus_and_21st_century_design/. Although we were unable to get permission to reproduce the wheel, it is easy to find, both in the reference cited in this footnote and by simply searching for "Bauhaus curriculum wheel."

16 Oskar Schlemmer and Heimo Kuchling, *Der Mensch: Unterricht am Bauhaus, Nachgelassene Aufzeichnungen*, Neue BauhausbüCher (Mainz: F. Kupferberg, 1969).

17 Rainer K. Wick, *Teaching at the Bauhaus* (Berlin: Hatje Cantz, 2000). We were unable to get permission to reproduce one of Schlemmer's diagrams: see "The Human Being in the Circle of Ideas," for Oskar Schlemmer's required course *Der Mensch, 1928–29.*

Bauhaus's contributions to design education truly were transformational at the time, for design as a craft drawing upon the technology of 1929. Now it is time for today's community of design educators to follow in the transformational spirit of the early Bauhaus to modify design pedagogy to accommodate the many different styles and goals of 21st century design.

The State of Design Education

> "The main trouble with design schools seems to be that they teach too much design and not enough about the ecological, social, economic, and political environment in which design takes place. It is impossible to teach anything *in vacuo*, least of all in a field as deeply involved with man's basic needs as we have seen design to be. To the problem of the dichotomy between the real world and the world of the school, there can be, understandably, many different answers."[18]

Over the course of 2014 and 2015, Don Norman wrote several papers arguing for the need to change design education.[19] In particular, these papers reflected on the increasing complexity of modern design that was not being covered in traditional education.[20] And it wasn't just Norman—Jeremy Meyerson also wrote about the topic from England's Royal College of Art.[21]

Were these criticisms and suggestions correct? We believe the spirit of the criticisms was correct, but the solutions need refinement. Indeed, Norman's later papers[22] are more forgiving. He argues in one[23] that traditional design education has served us well and should not be discarded, but that it does not meet all of today's needs. We must recognize that design, like all fields, has many different sub-disciplines, some of which are quite new, requiring technological, analytical, and cognitive skills not covered by traditional curricula. Different education is required for those interested in the different specialties.

Is traditional design education deficient? Many of the most traditional schools defend their teaching, arguing that they are producing modern designers. They state that they are teaching their students vital lessons in creativity, collaboration, communication, and other common elements needed to train a successful future designer.[24] If we look at the achievements of many who have graduated with traditional training, we have to agree. How, then, do we reconcile our critique of existing curricula with the graduates' accomplishments?

Clearly, the curricula are conflating the teaching of design process and the teaching of craft as applied to specific design media, but in many cases are also providing students with a broad-minded approach to even the most complex of problems. Nonetheless, we believe that education is still primarily focused upon creating practitioners of great craft, and although this is a wonderful accomplishment—one we do not wish to do without—it is not enough. Yes, during their professional practice many great designers manage to overcome the limitations of skill-based training. We believe that many more would benefit from a different, broader approach during their education.

Design is an applied field, and our students must practice the application of good design process, often within a studio environment on actual project

18 Papanek, *Design for the Real World*, 291.

19 Don Norman, "The 'Science' in the Science of Design," forword to *The Psychology of Design: Creating Consumer Appeal*, ed. Rajeev Batra, Colleen M. Seifert, and Diann Brei (New York: Routledge, 2016), xiv–xvi; Don Norman and Scott Klemmer, "State of Design: How Design Education Must Change," *LinkedIn Pulse*, March 25, 2014, https://www.linkedin.com/pulse/20140325102438-12181762-state-of-design-how-design-education-must-change/?trk=mp-author-card.

20 Ken Friedman, Yongqi Lou, Don Norman, Pieter Jan Stappers, Ena Voûte, and Patrick Whitney, "DesignX: A Future Path for Design," *jnd.org* (online), December 2, 2014, http://www.jnd.org/dn.mss/designx_a_future_pa.html; Don Norman, "Why DesignX? Designers and Complex Systems," *core77* (online), December 6, 2014, http://www.core77.com/posts/27986/why-designx-designers-and-complex-systems-27986; Donald A. Norman and Pieter Jan Stappers, "DesignX: Complex Sociotechnical Systems," *She Ji: The Journal of Design, Economics, and Innovation* 1, no. 2 (2015): 83–106, DOI: https://doi.org/10.1016/j.sheji.2016.01.002.

21 Jeremy Myerson, "Scaling Down: Why Designers Need to Reverse Their Thinking," *She Ji: The Journal of Design, Economics, and Innovation* 2, no. 4 (2016): 288–99, DOI: https://doi.org/10.1016/j.sheji.2017.06.001.

22 Donald A. Norman, "When You Come to a Fork in the Road, Take It: The Future of Design," *She Ji: The Journal of Design, Economics, and Innovation* 2, no. 4 (2016): 343–48, DOI: https://doi.org/10.1016/j.sheji.2017.07.003; Norman, "Why We Need So Much More Than the Bauhaus," 18–20; Don Norman and Eli Spencer, "Community-Based, Human-Centered Design," *jnd.org* (online), January 1, 2019, thoughts based upon a talk at the 2019 World Government Summit, Dubai, February 10–12, 2019, https://jnd.org/community-based-human-centered-design/.

23 Norman, "When You Come to a Fork."

24 Jon Kolko, *How I Teach: Reflecting on Fifteen Years in Design Education* (Austin: Brown Bear, 2017).

work. But surely we can devise a means of teaching both process and media more effectively than simply relying on the transfer of tacit knowledge in a traditional master-apprentice relationship.

When it comes to courses in applied psychology or cognitive science providing students with an understanding of human behavior and the theories underlying choice, decision making, perception, attention, and interaction, most schools offer either no courses or simplified ones, where many issues are bundled into one course with just enough time to let students understand that these areas exist. The same approach holds for other non-traditional design areas where topics in anthropology and culture, political science, business, or ethics are miniscule or absent.

Design schools need to clarify and streamline the uniquely valuable elements of studio teaching and draw more extensively on knowledge developed in other established fields, translating that understanding into a form useful to practicing designers—otherwise designers will not be able to cope with the increased demands being placed upon them. Instead, other disciplines will take over, such as cognitive and computer science, engineering, or business. These fields can add considerable value, but they are seldom skilled in the several main components of modern design: tackling the root cause rather than the symptom; emphasizing the role of people; considering the entire system; and capitalizing on the value of rapid prototyping, testing, and iteration. These fields are apt to focus upon technology, cost, and efficiency without a deep understanding of the societal impact, and the role that communities can play.

One design issue illustrates particularly well the unfortunate consequences of glossing over the actual behavior of both people and technology in the real environments in which both work: the consideration of failure modes. Invariably, both designers and non-designers (but more non-designers, especially engineers) develop things on the multiple assumptions that the technology always works, the environment is stable, and people do not err.

However, all of these assumptions are wrong. Highly efficient and productive systems of technology within a particular environment do fail, and then are prone to a difficult or even impossible recovery. People do err, sometimes for lack of attention or sleep, but in many instances because of inappropriate designs. Moreover, although people are often assumed to be monitoring the operations, this assumption ignores decades of behavioral evidence. Multiple studies since the 1940s illustrate that when people are asked to monitor smoothly performing systems for long periods, they are unable to maintain their attention.

It is relatively easy to design systems that are easy to use and understand when everything goes well. But as all of us have come to recognize as we deal with today's often frustrating technologies, when things go wrong, it is often difficult to discover what has happened and what the alternative actions might be to aid the recovery. This is true for such everyday things as our computers, mobile phones, and even household thermostats as well as for the more dangerous and critical large, complex systems, for example, that generate a nation's electricity, or control a modern airliners. We can point to several major accidents in ships and aviation that have occurred because design principles were violated—sometimes even elementary, well-known principles.[25]

The kind of design education we are advocating in this article assures that the appropriate knowledge of technology—critical knowledge about the way people interact with technology—is not only understood but deployed in the development cycle. The technology and business fields are important contributors to the design process, but they do not have all the necessary skills, nor the viewpoints required, to independently come up with a technically sound design.

Today's Design Education

There are at least two very different types of educational institutions that teach design in North America: stand-alone design schools not associated with a university (often associated with schools of art and architecture) and departments or schools of design located within a large research university. A research university concentrates on research activities by the students and faculty, which invariably means that it emphasizes academic principles and research that increases the general knowledge of a discipline. There is much less emphasis on practice.

In stand-alone schools of design, the work of the faculty and students is of utmost importance: exhibits, posters, displays, and standing within contests. Contest prizes, especially in the highly regarded national competitions, are praised.

In other words, stand-alone schools emphasize practice, while research universities emphasize scholarly work, evidence-based principles, and theory development.

Stand-Alone Schools of Design

We examined three schools in detail: Rhode Island School of Design (RISD: Providence, Rhode Island, USA), Savannah College of Art and Design (SCAD: Savanah, Georgia, USA), and Parsons School of Design[26] (New York, New York, USA). The three are generally viewed as excellent stand-alone schools of design (or art and design) in the United States. We restricted this analysis to the United States, but our experience with design education in other countries and regions causes us to believe that our findings are universal. We have visited design firms and schools (and in some cases taught) in Mainland China, England, Hong Kong, India, Germany, Italy, Japan, the Netherlands, New Zealand, San Marino, South Korea, and Taiwan. Although the curricula of the three American institutions that we examine in detail and the institutions we have visited across the world all differ from one another, they are all similar in spirit.

Here is a typical curriculum, quoting from one of the American institutions. Their undergraduate Bachelor of Fine Arts (BFA) degree in User Experience Design rests upon a "foundation studies" block of three drawing and two form-and-color courses. The "major curriculum" consists almost entirely of workshop, studio, and experiential learning courses focused on

25 National Transportation Safety Board, *Marine Accident Report NTSB/MAR-19/01: Collision between US Navy Destroyer John S McCain and Tanker Alnic MC, Singapore Strait, 5 Miles Northeast of Horsburgh Lighthouse, August 21, 2017*, June 19, 2019, https://www.ntsb.gov/investigations/AccidentReports/Reports/MAR1901.pdf; National Transportation Safety Bureau, "Safety Recommendation Report: Assumptions Used in the Safety Assessment Process and the Effects of Multiple Alerts and Indications on Pilot Performance," September 19, 2019, https://www.ntsb.gov/investigations/AccidentReports/Reports/ASR1901.pdf.

26 Parsons is only partially a stand-alone school. It is a part of The New School (New York). On their website, they state "We're the only American art and design school within a comprehensive university, The New School, which also houses a rigorous liberal arts college and a progressive performing arts school." "Parsons School of Design," Association of Independent Colleges of Art & Design (AICAD), accessed January 23, 2020, https://www.aicad.org/schools/parsons-school-for-design/.

the media of interaction and user experience design, with only one course in human-computer interaction, one on perceptual and cognitive human factors, and one on contextual research methods, out of a total 37 courses required for the degree.

The BFA in Industrial Design within this same institution is even more focused, with a foundation studies series of three drawing and three form-and-color courses, along with a creative thinking strategies course that is optional and may be replaced by an additional studio course. The major curriculum continues the focus on the media of industrial design, with only one human factors and one contextual research methods course out of the 36 required.

Perhaps even more interesting is that there is virtually no commonality of courses between user experience and industrial design—just the foundational drawing, form and color courses, and the single research methods course. The programs are separate, monolithic, discipline-specific tracks.

One of the other schools has only one course in "Human Factors, Ergonomics and Interface" in their BFA in Product Design. The instructor at the time we wrote this article was not a human factors professional, but had degrees in graphic and industrial design. There are only three courses in the entire curriculum devoted to non-design topics—three liberal arts electives.

The third school states in the description of its major in Industrial Design that students "apply knowledge of user experience, human factors, applied ergonomics, contextual inquiry, user preference studies and usability assessments in the design development process," but there are no courses that have in their titles any of those terms. The school does however require one course in the freshman year entitled "Topics in History, Philosophy, and the Social Sciences" and three liberal arts electives in succeeding years.

Schools and Departments within Research Universities

Design schools located in full-service universities, especially any of the world's major research universities, tend to provide a much broader, richer educational experience than those at stand-alone schools of art and design. These universities are much larger than stand-alone schools. They have a wide range of departments and subject matters and can provide a broad general education to all of their undergraduate students, regardless of major. Stand-alone schools may not have the resources to do this, even if they wish to.

As a tangible illustration, consider the excellent Bachelor of Design (BDes) program at Carnegie-Mellon University (CMU: Pittsburgh, Pennsylvania, USA). Whereas the programs at the three stand-alone schools of art and design discussed above are all constructed with more than 90% design-specific classes and less than 10% from other fields, CMU's program has 65.5% design classes, 6% required computing, English, history, and psychology, 15.5% electives that must be from departments outside design, and 13% electives that are at the student's discretion. This illustrates the kind of balanced education, both within and outside of design that we believe is necessary in today's world.

Learning from Others: Management, Medicine, Law, and Computer Science

On Finding the Proper Balance between Academia and Practice

Design is primarily a field of practice. Its evidence-driven components exist but are weak, and do not encompass all areas of design equally. But design is not the only discipline to have tensions between its training in research and practice. Several other disciplines can serve as models of how this difference might be approached. The field of management offers the MBA degree to practitioners and the PhD to academics (who then often serve as the professors for both types of courses). Medicine has practicing physicians and researchers, many of whom have both the MD and the PhD degree. Some people in medicine only do research, some only have a clinical practice, and some do both. In the United States, the degree Juris Doctor (JD) represents the practice side of law, requires a bachelor's degree (in any subject), and usually takes three years: it is the first degree of law. The faculty will primarily have PhD degrees (in addition to JD degrees). Note that the master's degree, LLM—Master of Laws—is a higher degree than the Juris Doctor (JD) degree. The Stanford law school offers four levels of degrees: LLM, JSM (Master of the Science of Law), JSD (Doctor of the Science of Law) and MLS (Master of Legal Studies, which does not permit the recipient to practice law). Many other fields also have a mix of practitioners and scholars.

In considering how designers should be educated, we need to distinguish between two different requirements of educational institutions. Design has traditionally been a field of practice and so its place in schools of art, architecture, and design could be argued as being reasonable. However, design has expanded far beyond its base in art, and commingling designers with artists does a disservice to both areas. Design is not art, even if there are components of art within design.[27]

Today's designers are required to use technologies that continue to evolve. They must gain a deeper understanding of social issues, human behavior, and modern business models. They must meet new ethical challenges that go along with an expansion into different global territories with different sustainability issues, different cultures, and different value systems. The academic foundations of design are now essential—the deeper and more competently we delve into the interaction of these worldly issues with the practice of design, the better we will be able to develop new procedures, frameworks, and rules, and a proper science of the design process.

How do we incorporate all these new requirements into modern design education? How do we train practitioners and build a sold academic foundation informed by evidence? And perhaps most importantly, how do we accomplish this in a designerly fashion—in a way that identifies, celebrates, preserves, and perpetuates the essential differences that define the successful modern designer?

Design is not the only field to have faced these challenges. The three prominent learned professions of law, medicine, and business can serve as

27 Similarly, engineering is not mathematics, even if many areas of engineering application require an understanding of applied mathematics. Note the word "applied"—applied math is seldom taught in departments of mathematics.

a model. Each field produces large numbers of practicing professionals even as it advances the fundamental knowledge of its discipline. All have unique structures and practices in their education systems, which either stand alone or stand apart within their universities. Further, their people—faculty, researchers, and students—all have their respective collective identities and an internal cohesiveness that is more focused than the university as a whole, and more distinctive than other departments in the university.

Consider the cohesion established by the foundational principles that govern each field: “equality before the law,” “first do no harm,” and “value creation.” Then there are the frameworks and lexicons that these fields share across specialties, such as the language found in contracts, the structure of human physiology, or the elements of product positioning. Even though each professional school offers exceedingly diverse specializations—corporate vs. criminal law, oncology vs. pediatrics, operations vs. marketing—each is also bound by a common ethical foundation, uses a shared vocabulary, and works with the same tools.

This sounds remarkably like the field of design.

Case Study: The Evolution and Maturation of the Business School

Of these three major professions (law, medicine, and business), we propose that business schools provide the most useful model to inspire modern schools of design, primarily because both law and medicine have a long history of cultural baggage, muddled by centuries and even millennia of imperfect recording and retelling, while the history of business is much more recent, and therefore more accurately recorded. Business education has three major historical themes that are readily transferred to design.

The Transition from Practice as a Skill to Practice Following Principles, Science, and Evidence

Business first existed as a trade, learned through apprenticeship to an established merchant or self-taught through (bitter) experience. Later, it became possible to obtain formal instruction in various elements of the commercial trades, such as stock-keeping or stenography. Eventually, integrated schools of business emerged to professionalize the study and practice of enterprise management as an integrated field. This bears a close resemblance to the origin and evolution of the design profession.

The Documentation of Procedures and Practices

The first business school was founded in 1819: ESCP Europe (École Supérieure de Commerce de Paris). The first American business school was the University of Pennsylvania’s Wharton School in 1881. Harvard Business School, the first to offer the Master of Business Administration degree, was founded in 1908 with the express intent of professionalizing the practice of business and public administration. Since the early 1900s, the history, motives, methods, successes, and failures of academic practices in business have been exceptionally well-recorded and analyzed.

Continual Experimentation, Feedback, Reassessment, and Redesign

Over the past century and a decade, business schools have experimented, discarded, iterated, evolved, and embraced methods of research and instruction (such as the case study), that have proved uniquely appropriate and effective for their field. The schools themselves, their composition of faculty and student body, and their relationships to industry and to the public at large have similarly evolved. These have been conscious and at times controversial acts, with thoughtful, open debate amongst the various stakeholders. The design community can look back not just at our discussions, but also at how the resulting initiatives paid off—their successes, failures, and unintended consequences—to inform and inspire our own efforts. Combining this with our own unique understanding of design will help us to construct a substantially more well-informed future for the education of our professional community.

The Transformation from Business as Practice to Business as Academic Discipline

In their early years, business schools tended to form and grow either through the accretion of trade courses into coherent areas of study, or through the addition of practical application courses within an existing curriculum. While schools sought to establish or maintain their standing as academic departments, the simultaneous needs to graduate immediately employable students, to find faculty capable of teaching the more hands-on courses that drove the perception of employability, and to fund the hiring of these faculty, led to an increasingly close relationship with industry. This continued as an enduring trend.[28]

So many faculty were drawn from the trade that pedagogy became firmly rooted in tradecraft (much as design was firmly rooted in craft skills). As a result, many business and academic leaders sounded alarms. In 1959 both the Ford and the Carnegie Foundation issued well-researched, well-reasoned reports seriously questioning the academic credibility of business programs in higher education. Their content and language were alternately sobering and alarming.[29]

In particular, the reports found that the imbalance had resulted in institutions lacking a theoretical grounding to support and advance the subjects they taught, and in faculty lacking the resources and incentives to build and advance that grounding in a scientific manner. The reports laid out thoughtfully constructed paths to resolution, with defining characteristics of distinct but connected developmental paths for both practitioners and academics, explicit mechanisms to promote collaboration and relevance between the two, and a borrowing of toolkits and mindset from the sciences to promote rigor in the formation and advance of a theoretical foundation for the field.

Both proposals took care to emphasize that they were neither one-size-fits-all nor universally aspirational. They provided a set of baseline requirements and a framework different programs could use to construct the curriculum and organization that best served their mission, resources, and constituencies.

28 Frank Cook Pierson, *The Education of American Businessmen: A Study of University-College Programs in Business Administration* (New York: McGraw-Hill, 1959).

29 Robert Aaron Gordon and James Edwin Howell, *Higher Education for Business* (New York: Columbia University Press, 1959); Pierson, *The Education of American Businessmen*.

It took 30 years before the major principles had been implemented, but by 1990, business schools had taken the recommendations to heart and conditions had improved. In fact, the programs had so effectively established themselves as academic peers within their parent colleges and universities that they eventually faced the same criticism as every other department on campus—the provision of practice and application had been subsumed by an emphasis on theory and academic publication. The quest for academic rigor meant that the schools were failing the vital missions of serving their students and communities.

Ernest Boyer argues (convincingly, in our opinion) that the emphasis on research and scientific rigor had initially served society exceptionally well. However, by extending and sharpening that focus, institutions had overshot the mark. Research findings had diminished in relevance to practice, and the teaching of students destined for practice had suffered to an unacceptable degree.[30]

Where the earlier problems were largely structural, this was a problem of priorities. To resolve this, Boyer proposed a model that recognized four distinct and mutually supporting forms of scholarly activity: discovery, integration, application, and teaching. By treating each form of scholarship explicitly, and actively balancing their weighting, individual faculty could realize their own full potential and the institution could realize its full collective mission. This will feel familiar to most of us working in a university setting, as it has become one of the dominant influences in faculty hiring and advancement, not just at business schools.

One of the authors of this article is faculty at a school of management and can attest that the tools and frameworks above are in current use. Harvard, for example, has dramatically expanded its use of clinical faculty, from a single person in the 1990s, to teaching teams of five to seven clinical faculty working in collaboration with one or two traditional faculty in order to promote greater relevance to practice in its MBA curriculum.

We believe that this history is highly relevant to design. The analogies are strong. The evolution and maturation of business schools has been effective. Thus, their history warrants consideration for the lessons it may convey. Certainly, both professional and academic business education have achieved a reputable, even enviable, stature worldwide. While the popular image of business schools remains rooted in the traditional Harvard or Pennsylvania (Wharton) model, the reality is that most schools now actively redesign their programs on an ongoing basis. Note that even today there is debate about the nature of the business school and its role in society. As a result, the curricula undergo continuous change and refinement.

Lessons for Design

As a case study, the history of the business school suggests lessons for the future of the design school.

Design, today, is roughly at a state comparable to the 1959 business school. The Ford and the Carnegie Foundation reports that critiqued the state of the schools in 1959 suggested improvements and changes that have proven effective. In a similar fashion, medical education was profoundly

30 Warren G. Bennis and James O'Toole, "How Business Schools Lost Their Way," *Harvard Business Review* 83, no. 5 (2005): 96–104, https://hbr.org/2005/05/how-business-schools-lost-their-way; Ernest L. Boyer, *Scholarship Reconsidered: Priorities of the Professoriate* (Princeton: Carnegie Foundation for the Advancement of Teaching, 1990).

changed by the 1910 Flexner report sponsored by the Carnegie Foundation.[31] It probably is time for design to do the same: commission a similar study, headed by some neutral party. Such a study would have to include participants from academia and practice, including current designers in both fields as well as neutral parties from outside of design (perhaps from business and medicine). This new commission must also be sensitive to the difficulties faced in both medicine and business during and after the implementation of changes in their educational practices.

We believe that there must be more academic rigor. But there is a danger of too much emphasis on theory, principle, and rigor (and the related practice of hiring and promotion based almost entirely upon publication in rigorously reviewed sites), thereby tending to emphasize work that is narrow and deep. Such work can distort the power modern design has to be a broad, wide-ranging discipline, where designers as generalists can create marvelous works that cut across the narrow disciplines. Design must develop a method of assessing excellence that avoids reliance upon the existing narrow academic precedents. Most importantly, design must not ignore the mechanics of putting learnings into practice: the practitioner side of design.

To help us strike an effective balance and truly advance the practice, we can draw upon the frameworks developed by Robert Gordon and James Howell, Frank Pierson, and Ernest Boyer.[32] Further, though the Flexner report was written over 100 years ago, it still remains key to understanding the transformation of medicine into today's evidence-based field of practice, although it should not be surprising that as time passes, some changes are required.[33]

Rather than try to define a single best aspirational model for curriculum, faculty composition, degree structure, or relationship between practice and academia, we should instead pursue a model that is evolutionary, diverse, experimental, and iterative. Our goal is to have a common basic framework that is broadly accepted by the design community and that allows for multiple curricula, perhaps emphasizing different kinds of design and training philosophies, perhaps building upon the core strengths of different institutions. This would allow all design schools to emphasize the commonalities in the different fields of design while also allowing for each institution to make its courses appropriate to its students and faculty, allowing differentiation among the various schools. This approach has been very successful in other fields, such as the curricula for computer science, business, and medicine that we have examined.

Curriculum Guidelines

To define an appropriate curriculum for any field, it is necessary to step back and understand what binds that field together. From there, one can determine the core approaches that all students (and faculty) must share, as well as the separate skills and knowledge that might be restricted to those within a more specialized field. Determining the proposed mixture of required courses for everyone and then the appropriate split into the sub-disciplines for educational purposes is not easy. Moreover, there may not be one correct answer (although there are doubtless many wrong answers).

31 Abraham Flexner, *Medical Education in the United States and Canada: A Report to the Carnegie Foundation for the Advancement of Teaching* (New York: The Carnegie Foundation for the Advancement of Teaching, 1910).

32 Gordon and Howell, *Higher Education for Business*; Pierson, *The Education of American Businessmen*; Boyer, *Scholarship Reconsidered*.

33 Frank W. Stahnisch and Marja Verhoef, "The Flexner Report of 1910 and Its Impact on Complementary and Alternative Medicine and Psychiatry in North America in the 20th Century," *Evidence-Based Complementary and Alternative Medicine* 2012, article no. 647896 (2012): 1–11, DOI: https://doi.org/10.1155/2012/647896; *Wikipedia*, s.v. "Flexner Report," last modified January 13, 2020, https://en.wikipedia.org/w/index.php?title=Flexner_Report&oldid=905081847.

Examine the departments of a modern university. In the United States the organization of a typical research university is fractal. For example, our university is divided into divisions and schools such as Engineering, Social Sciences, Arts and Humanities, Business, Medicine, Science. In turn, each of these divisions is divided into departments, which in turn are often divided into sub-fields. Even in these sub-fields there are multiple specialties. Often the faculty who do their work within a specialty or sub-part have very different training, beliefs, and skills from those in other parts of the same department. In some cases, they are not even capable of understanding the work of their colleagues. Nonetheless, all faculty within a group share a base of knowledge, understanding, and approaches common to their department. As we move up in the hierarchy from specialties through sub-fields and departments, divisions, and even the university itself, at each level the shared views become more general and abstract, but still there is a common thread that binds specialties and subfields together rather strongly. Even within a large department, there is common agreement on many aspects of the work, which makes it meaningful for everyone who resides within the same department. The differences within divisions are weaker, but nonetheless present. The university itself includes many contradictory points of view and approaches to their knowledge, but there is still a common theme of the university as a place of learning, knowledge, and education.

Just as in most disciplines, modern design departments have many different sub-disciplines: product, interaction, graphic, communication, industrial, textile, fashion, digital, experience, packaging, multimedia, and so on. Indeed, in many cases (especially in larger organizations) these differences are so profound that the sub-disciplines are actually separate departments, although properly housed in the same division or school of design. This is not necessarily bad—all fields are so broad that it would be inappropriate to expect all members of the field to be experts in all the sub-disciplines. Any field where this is not true is likely to be either extremely new, or extremely narrowly focused. Design is neither new nor narrow.

We have suggestions, but there is no answer that will satisfy everyone. We start by examining two case studies of curricula: interaction design and computer science. We have selected these two because both have undertaken careful studies of their curricula, and both include important new domains within design itself.

Interaction design is a relatively new discipline that came from two different sources, with each initially unaware of the other. One part came from the behavioral sciences of human factors, ergonomics, psychology, and cognitive science, all of which worked with computer scientists in the development of modern display-based computer interfaces. This became the field known as Human-Computer Interaction (HCI). The other came from the industrial and graphic designers who were working on the early computers, especially at Apple and the Xerox Palo Alto Research Center. The pioneering work of movie animators at Disney, described in the book *The Illusion of Life* by Disney animators Frank Thomas and Ollie Johnson, was inspirational for both groups, and helped establish a bridge between the two different approaches. The book was required reading for many fledgling interaction designers in California's Silicon Valley.[34] Today, although the two different groups are still considered separate disciplines, HCI and Design, they usually work together in multidisciplinary teams, each contributing different components of the total product.

We believe that its history distorts the true powers of interaction design: understanding all forms of interaction between people, the environment, technology, and designed artifacts. It should not be restricted to computer displays.[35]

Computer science has many similarities with design, with many people who call themselves computer scientists being practitioners, sometimes self-taught, who are programmers working for companies, developing useful systems and applications, much as many practicing designers who work in product design. These activities can be contrasted with academic scientists and designers who advance the general state of knowledge within various research communities (mostly in universities, but also in research divisions of industry). More importantly, however, one subfield of computer science, Human-Computer Interaction (HCI) overlaps much of interaction design and many interaction designers work in industry or as faculty within design or even computer science departments. They publish in HCI journals and magazines and attend and present papers at the annual ACM CHI conference.[36]

The technical societies for computer science have conducted thorough reviews of curricula that we find to be useful examples of how design might handle the tensions among the many different sub-specialties as well as between practitioners and academics.

Case Study 1: The CUMULUS Report on Interaction Design

CUMULUS, the International Association of Universities and Colleges of Art, Design and Media published "A Matrix of Competencies for Interaction Design" in March 2018,[37] based on Adam Dunford's 2018 MSc thesis defended at Chalmers University of Technology (Gothenburg, Sweden). One would think that this specialized subset of design could have a rather well-defined set of concepts, and therefore, a relatively standardized curriculum. Nope. Here are some pithy excerpts from Jamie Cavanaugh's CUMULUS essay:

> "Here's the problem in a nutshell: there's no common description or criteria for creating an interaction design degree. This poses a problem for both industry and for prospective students.
>
> "For industry, education becomes a poor predictor of the success of a job candidate because it is unclear which skills are taught in Interaction Design programs. For the prospective students, it's unclear 'what they're getting' when enrolling in an Interaction Design program.
>
> "Several insights were gathered from Adam Dunford's research that are critical to understanding what industry needs and expects from interaction design education:
>
> - Interaction design lacks a unifying disciplinary core
> - Industry disagrees on what interaction designers should know
> - Academia disagrees on what interaction designers should be taught

34 Frank Thomas and Ollie Johnson, *The Illusion of Life: Disney Animation* (New York: Disney Editions, 1981).

35 We apply a similar criticism of the current, limited use of the term "experience design."

36 The acronym takes the letters HCI and rearranges them into CHI to make them pronounceable. One of us, DN, argued strongly, when the decision was being made, that this was wrong because people should always come before the technology. Therefore, ACM being a computer science community, was not the correct home (even the name is wrong "Association for Computing Machinery": the association is for the machines, not the people!). However, he lost the battle. (Given the power of ACM and the weakness of all competing human factors and design societies, it was probably better for the profession that not only did CHI end up in computer science, they managed to get their courses highly recommended in all computer science curricula, and thereby also enabled interaction designers to get better pay and even to become members of the National Academy of Engineering. Political considerations can be more powerful than logical ones.)

37 Jamie Cavanaugh, "A Matrix of Competencies for Interaction Design," *DesignHigher* (online), March 14, 2018, https://www.designhigher.com/competencies-for-interaction-design/.

- Both practitioners and academics agree that interaction design education is inadequate (although they don't always agree why)
- The skills and knowledge required to practice interaction design exceeds what can be taught…."

Case Study 2: Curriculum Development in Computer Science

The Society for Computer Science (Association for Computing Machinery—ACM) produces recommended curricula, updated every few years, most recently in conjunction with the Computer Science division of The Institute for Electrical and Electronic Engineers (IEEE).[38] In the 2013 report they divided the field into five sub-fields, with different curricula for each: computer engineering, computer science, information systems, information technology, and software engineering.[39]

The 2013 Computer Science curriculum is very detailed—518 pages, including recommendations and course descriptions. Several of their core principles can apply equally to design (with obvious changes in the disciplines that are named). The principles that also apply to design (somewhat edited by the two of us) are in the list below.[40] (Additions are set in parentheses, in regular type. Deletions are marked by ellipses …). As you read the guidelines, notice how well each translates into a useful, constructive guideline for curricula in design.

The curriculum

- must provide realistic, adoptable recommendations that provide guidance and flexibility, allowing curricular designs that are innovative and track recent developments in the field. The guidelines are … intended as guidance, not as a minimal standard against which to evaluate a program.
- must be relevant to a variety of institutions. Given the wide range of institutions and programs (including 2-year, 3-year, and 4-year programs; liberal arts, technological, and research institutions; and institutions of every size), it is neither possible nor desirable for these guidelines to dictate curricula for computing. Individual programs will need to evaluate their constraints and environments to construct curricula.
- (must manage the) size of the essential knowledge…. While the range of relevant topics has expanded, the size of undergraduate education has not. Thus, (schools) must carefully choose among topics and recommend the essential elements.
- should be designed to prepare graduates to succeed in a rapidly changing field. Curricula must prepare students for lifelong learning and must include professional practice (e.g., communication skills, teamwork, ethics) as components of the undergraduate experience…. Students must learn to integrate theory and practice, to recognize the importance of abstraction, and to appreciate the value of good engineering design.
- should identify the fundamental skills and knowledge that all … graduates should possess while providing the greatest flexibility in selecting topics. To this end, we have introduced three levels of knowledge description: Tier-1 Core, Tier-2 Core, and Elective.

38 The Joint Task Force on Computing Curricula: Association for Computing Machinery/IEEE-Computer Society, *Computer Science Curricula 2013: Curriculum Guidelines for Undergraduate Degree Programs in Computer Science* (New York: ACM and IEEE, 2013), DOI: https://doi.org/10.1145/2534860.

39 The subfield of cybersecurity was added in 2017, but as an addendum. Presumably this will become a part of the formal discipline when the next decade's revisions are completed, sometime in the 2020s. Let this be a warning to those who think any curriculum will last for long.

40 Joint Task Force on Computing Curricula, *Computer Science Curricula 2013*, 21–22.

41 Ibid., 30.

- should provide the greatest flexibility in organizing topics into courses and curricula. Knowledge areas are not intended to describe specific courses. There are many novel, interesting, and effective ways to combine topics from the body of knowledge into courses.
- should be designed to provide students with the flexibility to work across many disciplines. Computing (Design) is a broad field that connects to and draws from many disciplines, including mathematics, electrical engineering, psychology, statistics, fine arts, linguistics, and physical and life sciences.

The Power of Tiers in the Curriculum

We believe the notion of a tiered curriculum is useful, and perhaps should be adopted within design. Here are how those tiers are defined and used in computer science:[41]

- A Core Tier-1 topic should be a required part of every … curriculum. While Core Tier-2 and elective topics are important, the Core Tier-1 topics are those with widespread consensus for inclusion in every program. While most Core Tier-1 topics will typically be covered in introductory courses, others may be covered in later courses.
- Core Tier-2 topics are generally essential in an undergraduate … degree. Requiring the vast majority of them is a minimum expectation, and if a program prefers to cover all of the Core Tier-2 topics, we encourage them to do so. That said … programs can allow students to focus in certain areas in which some Core Tier-2 topics are not required.

Conclusions from the Case Studies

It is interesting to contrast the lack of cohesion reported by CUMULUS for interaction design curricula within design schools with the clarity and precision of the HCI curricula for computer scientists. Why this difference?

One answer is the maturation of the fields. Computer science is a far more mature discipline despite the fact that, in years, it is far younger. Computer science has a solid base in academia, something lacking in the design profession. Many designers were trained in art schools as practitioners and have very little understanding of academia, rigor, the need for evidence, and so on. Instead, teaching has primarily been through mentorship, which basically means teaching via opinions of the instructors. Computer science, on the other hand, has its roots in engineering (mostly electrical engineering) and, to a lesser extent, applied mathematics.

Design Education: Considerations

The Role of Experiential Learning: Learning by Doing

Design is a discipline of making and of doing. Accordingly, the design project plays an important role in training. We recommend devoting a large portion of each year's curriculum to design projects (this is, of course, a common practice in most design schools). Projects can be selected to fit the specialization of the student. Many projects will be long, continuing ones, so students will join a project that has already been going on. In the early years of education, students enter as apprentices, learning not only the skills of design, but how teams function; learning followership is just as important as leadership, although often neglected in design project courses. Toward the end of the education, students should be allowed to select projects of most relevance to their specialization and also to assume positions of leadership, guiding the younger students.

Note that just sending students off to do projects does not produce the desired results. The traditional process of mentoring, guiding, and critiquing throughout the process is essential. Projects also have to be selected or refined to ensure that they cover the concepts being stressed within the class.

The project is also essential for motivational purposes. Students enter design programs in order to build and create, so getting them involved on day 1 is a great motivator. Moreover, the issues faced with the projects will also demonstrate to the student the relevance of the other parts of the curriculum.

The Role of Academic Courses

Since the 1950s, design has accumulated numerous principles, rules, guidelines, and heuristics, some supported by evidence, some simply stated as obvious axioms. More recently, multiple research journals and conferences have emphasized the importance of rigor in establishing these guidelines, with evidence collected in statistically appropriate ways.

Courses designed to help create and grow a systematic body of knowledge for design, developing principles and theories that aid in understanding, that can be generalized to a wide range of issues, and that are supported by evidence, are essential if the field is to keep up with changes in the world. These changes include the development of new technologies, new cultural distinctions, different business models for industry, and more and more, concern for ethical issues. The designs of many objects are deleterious to the world's environment, in the mining and harvesting of the materials, in waste products and use of energy during manufacture and shipping, and then in deleterious impact upon the environment in their disposal. Many designs are more expensive than need be, use more energy than might be needed and in general are not sensitive to the major societal issues facing the world.

These points are not new. Numerous courses, books, and writings have addressed these issues. Our favorite is one of the earliest, Victor Papanek, whose first sentences of his 1971 book deserve repeating:

> "There are professions more harmful than industrial design, but only a very few of them. And possibly only one profession is phonier. Advertising design, in persuading people to buy things they don't need, with money they don't have, in order to impress others who don't care, is probably the phoniest field in existence today. Industrial design, by concocting the tawdry idiocies hawked by advertisers, comes a close second."[42]

We would only change one word from this statement: delete "industrial" because today, the complaint can be made of the work of all subfields of design.

Yes, we need more academic classes—and in this ever changing, environmentally challenged world, we must address ethics, fairness, sustainability, and preservation of the environment.

42 **Papanek, preface to *Design for the Real World*, ix.**

Curriculum Recommendations for Design

The Degree Structure in Design

As design has evolved from its origins in schools of art and architecture, it has followed the normal academic tradition of offering degrees at three levels: bachelor, master, and doctor. However, a wide variety of labels have been associated with these degrees: A (Arts), FA (Fine Arts), S (Science), Des (Design), PhD (Doctor of Philosophy).

Prefaced by B (Bachelor's) or M (Master's) and often made more specific by a postfix "in X," where X can be almost any specialty, such as industrial design, graphic design, and more, the distinction between the BA/MA and BS/MS degrees reflects the degree of concentration upon the major subject: A implies broader coverage of general education and S more focus upon the major.

The type of degree awarded to designers varies quite radically. At the Bachelor's and Master's levels the most common degrees are labelled BA-MA, BS-MS, BFA-MFA, and BDes-MDes. In the United States, the frequent use of BFA and MFA titles appears to be a holdover from the days when design was taught in art schools and departments. Almost everyone uses the PhD for the doctoral degree, although some also use DDes.

The distinction between a DDes and a PhD is not clear. We had thought that the DDes (Doctor of Design) was used for practitioners, where the final thesis requirement was either waived or was a practical project whereas in PhD studies, the final thesis for a PhD is meant to be a publishable piece of work that represents new knowledge that can be applied by others.

However, in conversation with colleagues from many institutions, the distinction was not shared by everyone, although one online description about the related distinction in engineering between the EngD and the PhD degrees supports it:

> "The biggest difference between the Doctor of Engineering and Doctor of Philosophy degrees is that the EngD is a professional degree, while the PhD is a research degree. A traditional Doctor of Philosophy in Engineering focuses on engineering theory and scholarship, heavily emphasizing original research work that can take years.
>
> "A professional doctorate, sometimes called an applied doctorate, focuses on developing specialized skills for practical application in the engineering workforce."[43]

43 Krystle Dodge, "Professional Vs Research Focus," *DegreeQuery* (online), accessed January 21, 2020, https://www.degreequery.com/what-is-the-benefit-of-an-eng-d-degree-vs-a-traditional-ph-d-degree/.

Why Not Call Our Degrees "Design" (Des)?

We believe that the continual use of the Fine Arts label in the United States (and elsewhere) in both the undergraduate degree (BFA) and the master's degree (MFA) is inappropriate, helping to blur the distinction between design and art. Design is not art: art is not design. Designers are developing concepts for others, whether it be a product, service, organizational chart, or new way of dealing with the world's societal issues. In many instances, there are important aesthetic requirements for the designs, especially within industrial and graphic design. However, many of the newer areas of design—of services, organizational structures, hospital procedures, and more—have no art or aesthetic component (in the usual sense).

We strongly believe that designers should receive their own degree, not one borrowed from the fine arts. We recommend that design schools all use the degree title that represents design, not art: Bachelor and Master of Design—BDes and MDes—both of which are existing, established degree titles, used by many universities around the world. We recommend the policy adopted by Carnegie Mellon University's design program:

> "We have recently changed our undergraduate degree designation from a BFA (Bachelor of Fine Arts) to a BDes (Bachelor of Design). Design programs around the world are moving to this distinction, which acknowledges that design has become a discipline that is separate and distinct from fine art. Just as architecture offers a bachelor's in architecture (BArch), design degrees are designated at the undergraduate level as a BDes, the master's level as MDes (Master of Design) and the professional doctorate as Doctor of Design (DDes). The academic accreditation of the BDes is the same as the BFA with the same number of credits awarded."[44]

Should a Designer Have an Undergraduate Degree in Design?

> "It is unfortunate that almost all schools or departments of design in the United States require an undergraduate degree in the same field as that in which the student hopes to do graduate work. We chose a different way, because of our passionate belief that the true design needs of the world must be carried out by cross-disciplinary teams. Hence, for graduate work we did not require four or five previous years of study in industrial design, architecture, or some other design area but preferred taking our young people from the field of behavioral sciences. This added meaning to their work."[45]

Is it necessary—or even desirable—for a designer to have an undergraduate degree in design? Victor Papanek did not think so; we agree with him.

Many disciplines in universities focus on analysis—on a deep understanding of the phenomena of interest. Design, however, is a field of synthesis, of creating things—some tangible, some not. The act of creation automatically cuts across many of the existing disciplines of the university, and because we are creating for the benefit of people, organizations, and society, we must also be knowledgeable about these issues. Because modern, 21st century design requires a broad knowledge of many topics, we recommend that undergraduates devote most of their time to other subjects, doing a major outside of design in whatever area they are interested in. And yes, do minor in design. The combination of a degree in a traditional university subject—which provides a broad general education plus an in-depth education in a non-design topic—coupled with a minor in design produces a more powerful, insightful designer for the design thinking arena than those who have had four years of design studies with no depth in any other discipline. We are also pleased to note that an increasing number of design programs welcome such people.

The minor in design—or for that matter, single courses designed for those not majoring in design—can also be of great value for those who do not wish to become designers. Courses and minors have the virtue of educating non-designers in the power, methods, and various disciplines of design, which means that when they embark upon their career, they are

44 "Undergraduate Programs," Carnegie Mellon Design, Carnegie Mellon University, accessed January 22, 2020, https://design.cmu.edu/content/undergraduate-programs.

45 Papanek, *Design for the Real World*, 301.

better equipped to work together with design teams, or if they move into managerial roles in industry, to recommend the hiring of designers and the use of design firms.

We find further encouragement in this from our analogous professions. Many leading business schools (Harvard, most notably) have declined to offer a bachelor's degree, in favor of an MBA whose student population is carefully composed from a balanced mix of BAs and BSs from other fields who have several years of practical experience under their belts.

The Design Curriculum

We define practitioner knowledge as knowing both what needs to be done and how to do it. These tend to be skills that are essential to the doing/making part of design.

Academic knowledge is defined as the underlying rationales and principles for the activities of the designer. Some of this may be based upon science, some may be pre-science, but still guided by evidence. Some may be rules of thumb (heuristics) developed over a period of time by practitioners, with some backing in evidence. And some may be the beliefs of the practitioner, which have not been demonstrated through evidence, so their status as appropriate ways to proceed is still unknown.

Note that design is not alone in training those who wish to be practitioners with practical skills as well as imparting an academic breadth of knowledge to those who need this more abstract and general education for the paths they wish to pursue. Thus, in schools of business, the MBA degree is considered a practical, terminal degree, where students primarily learn the practical considerations of a wide variety of topics. Those who wish a PhD in business follow a rather different path, one that does not include getting an MBA and, moreover, one that does not require the same courses as those used by MBA students. There are similar distinctions in the training of lawyers, journalists, physicians, artists, musicians, and those in theater and media. Psychology is both an experimental, academic program and a practice (clinical and counseling, for example), and quite often the students in one track have few classes in common with the other. In all these disciplines there are continual tensions between the two types of training for the two different outcomes, with continual debates and revisions of the curricula.

We believe that designers need both practitioner knowledge, so that they can accomplish things, and academic knowledge to give them a deep, generalizable knowledge base to guide their activities. We resist the temptation to classify one type of knowledge as superior to the other. Both are important.

No single set of suggestions for a curriculum will work for all schools or students. Therefore, what we describe here is a basic philosophy of approach plus several examples of how a curriculum might be structured. Basically, we suggest that all students engage in a common, foundational set of courses, followed by a specialization, which is where they would spend most of their time. Some students might wish to take two specializations. Indeed, some schools might wish to require that all students do two specializations, or perhaps a major and a minor specialization.

We recommend a core curriculum that consist of both forms of knowledge. Note that the bullet points represent concepts that need to be covered. They do not necessarily match with courses. Some concepts might require several courses, some might be covered much more rapidly, probably best if integrated into other course material or projects.

Common Skills for All Designers

Consider the four design challenge groups (A–D) and the corresponding sample scenarios with which we opened this paper:

A Performance challenges
B Systemic challenges
C Contextual challenges
D Global challenges: dealing with complex sociotechnical systems

Designers do have special, unique skills that inform their work. One is the ability to use sketching both as a means of thinking and as a way of communicating ideas to others. Sketching is of great importance even for those who work in groups C and D, for which drawing and sketching are not normally done (but are invaluable as both tools for thinking and for communicating ideas and suggestions).

The Human-Centered Designer also spends considerable time studying the relevant human behavior and culture in order to better understand the true underlying needs, not just the symptoms. More and more, research is conducted as part of a community-driven co-design process. This means that many ideas will come directly from the community being addressed, which helps enlist the support of the community (especially in groups C and D), and also feeds into a more accurate assessment of the true needs, competencies, and requirements for all four groups. Thus, although the fundamental principles of our design methods might stay the same, the way they are applied could be completely reframed, with the community being served taking the lead while designers and subject matter experts serve as coaches, guides, and mentors. Traditional HCD approaches, with their emphasis on designer skills, will almost definitely have to be transformed into community-driven, bottom up collaborations with the expert knowledge in all domains: a community-driven form of co-design.[46] Teaching the capacity to reconfigure traditional design practices should be an integral part of foundational design education—after all, questioning everything is an important attribute of the creative designer."

Be people focused, solve the correct problem, prototype, and iterate. These are all common themes in design, but not in most other disciplines. Sometimes it is best to first conduct research to understand the people and issues. Sometimes it is best to start simply by making *something* (drawings, skits, prototypes) with the full understanding that it is apt to be very wrong, but nonetheless that its faults and difficulties can oftentimes present the quickest way to get the information required to rapidly converge upon an appropriate direction—a process known as research through design.[47] At the beginning,

46 Sanders and Stappers, "Co-creation and the New Landscapes of Design," 5–18; Iskander, "Design Thinking Is Fundamentally Conservative and Preserves the Status Quo," online.

47 John Zimmerman, Jodi Forlizzi, and Shelley Evenson, "Research through Design as a Method for Interaction Design Research in HCI," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (New York: ACM, 2007), 493–502, DOI: https://doi.org/10.1145/1240624.1240704.

one doesn't necessarily know what to look for, or what questions to ask. That initial deployment starts providing answers to those initial concerns.

In many ways, one might consider the following four components a recipe for design thinking: the use of drawing as a way of thinking; the emphasis upon people; the use of incomplete, perhaps faulty prototypes as probes to get more information; and the deliberate intention to make multiple prototypes in search of an answer that is good enough for deployment. (Not perfect—good enough.) These approaches are often quite foreign to people in other disciplines. And of course, there is also making sure that the end-product is not only effective, but pleasurable, delightful, and understandable. And when errors or other failures occur (and they invariably will), making sure that it is easy for people to understand what has happened and what they should do.

What, then, is common to all the design disciplines? To us, it is the way design tackles problems. We hesitate to call this "design thinking," because the term has become trivialized and distorted through its overuse in the popular press and in industry. Nonetheless, the kind of thinking that leads to designing is indeed special, including what Nigel Cross calls our designerly ways of knowing.[48] We include human-centered design in the practices that come under the heading of design thinking, because it focuses upon the development of devices, services, communications, and other things for the use and enjoyment by people. This is different from most engineering (and even computer science) design, where people and society are seldom considered. For us, the human being, which implies human society and culture, is paramount—which is why we are surprised that so few design curricula include substantive training in human behavior, human factors and ergonomics, societal issues, safety, and ethics. All are of critical importance in the design of things used by people and society.

Note that in the list of design methods we provide, each bullet point is a "module" of knowledge, not a separate course. Modules are probably best acquired within the broader context of instruction in general and/or within projects. Although the list below appears to be long, we do not believe it need be lengthy, assuming a thoughtful balance of explicit teaching and hands-on learning.

Most of the module topics should be tailored for students of design. Thus, many of the technical topics are best taught by professors within the design department. (To avoid perpetuating our previous criticism of developing and teaching coursework without drawing upon existing bodies of knowledge, we propose a "bootstrapping" approach to growing this faculty in the sections that follow.)

Statistics and experimental methods provide a good example of how and why things work—or don't. Almost every department in the social and behavioral sciences offers a course in statistics, and each one is tailored to the specific requirements of its discipline. They would never consider having their students take the general statistics courses offered by the university, because even though each field uses the tools with rigor, they do so in different ways. Design should primarily be concerned with statistics as an applied field, and the way the tools are applied will vary considerably depending on

48 Cross, "Designerly Ways of Knowing," 49–55; Nigel Cross, *Designerly Ways of Knowing* (London: Springer, 2006); Rivka Oxman, "Educating the Designerly Thinker," *Design Studies* 20, no. 2 (1999): 105–22, DOI: https://doi.org/10.1016/S0142-694X(98)00029-5.

the context. Unfortunately, design departments that offer statistics often teach the methods used in psychology, which are quite inappropriate for use within an applied discipline where the concern is with "good enough" and large effect sizes, rather than the small differences that may be important theoretically, but often have only a negligible impact on the world.

- Design Methods
  - Human Centered Design principles
  - Co-design, community-driven design, co-creation and their variants
  - The role of designers in developing strategy and as managers, mentors, and facilitators
- Creativity—individual and team
- Leadership—team composition and management
  - Project experience (essential to hone the skills and to train both followership (years 1 and 2) and leadership (years 2 and 3)
- Design research (applied; rapid ethnography)
  - Quantitative methods
  - Qualitative methods
- Core principles of business
  - Finance—income statements, balance sheets, and cash flow
  - Data-driven decision making and justification
  - Sales and marketing
  - Operations, distribution, supply chain management
  - Patents and intellectual property
  - Business models—their relation to profits, losses, margins and one-time and continuing costs and incomes over an n-year period
  - How to present to executives
- Basic principles of academic research, and how to apply the findings of others
  - Rigorous thinking and debate based upon evidence
  - Skills to develop rapid prototyping
  - Computational methods: big data, basic programming, and computational thinking
- Thinking by sketching and by making
- Experimental methods and statistics
  - Simple probability theory and an understanding of variability, measurement methods, and statistical significance
  - Obtaining large effects, using smaller sample sizes and simpler tests
  - Biases, and methods to counteract or mitigate experimenter bias, human sampling biases, order effects of presentation, etc.
  - The pros and cons of A/B testing
  - Ethical concerns in running experiments
- Ethics
  - The designer's responsibilities toward societal good, the world's major societal issues, the environment, local communities
  - The ethics of what we are designing: impact upon people, the environment, health, and safety
  - Respectful treatment of individual and group identity (gender, race, country of origin, religious beliefs, etc.)

  - Balancing the designer's ethical considerations with systems of policy, profit, law
- The real world
  - World history
  - Culture
  - Human psychology, sociology, and anthropology
  - Basic human factors and ergonomics
  - Human interaction

A Family of Curricula

Copying from the recommendations of computer science, we propose the development of a family of curricula. Schools and departments can select parts of the family that are most appropriate to their focus and their student bodies.

Specialization Skills

Students focus on their specializations toward the end of their studies, with the concentration on the specialization continually increasing.

Two Tiers of a Curriculum

Tier 1 represents those courses that are fundamental to all specialties and approaches. Tier 1 topics might be required of all students.

Tier 2 courses are more advanced, mostly of interest to people in the general specialties. Here is where each school can configure combinations of required and optional course that best fit the needs and interests of the students, while also assuming the appropriate amount of academic (and practical) rigor.

The Doctoral Degree (PhD)

Having a PhD is the core requirement for becoming a faculty member at one of the top research universities in the world (and for those aspiring to be on that list). It requires understanding the nature of research and of academic scholarship—in other words, understanding the role of evidence and the importance of citing the works of others; knowing the history of other work on the topic; and presenting appropriate argumentation and discussion both of one's present work and that of others. Basic statistics and a knowledge of appropriate experiment design and comparison conditions are essential to ensure that there are no biases in the judgments.

As we consider the formation of doctoral students within the system of design education, we should also consider the evolutionary state of design schools and their eventual role in fostering further curricular development.

The PhD Degree in Business

The Carnegie report argued that the business school of 1959 needed to "bootstrap" itself into producing a cadre of PhDs who could carry the field forward. While the field urgently required a professoriate with a firm grasp of both science and pedagogy, teaching needed to be tightly coupled to an

49 Pierson, *The Education of American Businessmen*, 299–301.

innate understanding of the working professional. In this, it recognized that much of the core MBA material was foundational for the PhD, and that commingling the two educational paths would both connect the academic with the practitioner and allow students with an unrecognized inclination towards the PhD to discover that and shift tracks.

At the time, Stanford was cited as a leading example of a tight connection with significant overlap—PhD students took all core MBA classes. Further into its own evolution, Harvard had begun with the broad overlap model and by 1957 revised both PhD and MBA curricula to feature a smaller, more precisely targeted overlap, as the faculty had refined their understanding of the balance that would best serve both practitioner and academic.

Pierson hypothesized that a continued iteration of the curricula by successive generations of academics would result in a research-focused, practice-advancing professoriate.[49] Today, we know of no credible doctorate-granting business school without a clearly defined separate MBA and PhD tracks that have been connected through the cultural expectation that no research is complete without a discussion of managerial implications, and no class is complete without a grounding in theory.

We interpret the above evolution as an extended, iterative design effort, with a heavy reliance on experiential user research, treating the faculty as lead users, and incorporating participatory design that draws from the practitioner community. The result is a robust system of both curriculum and culture.

The PhD Degree in Design

Like business, with its distinction between the training of practitioners (with the terminal degree being the MBA) and academic scholars (with the terminal degree being the PhD), design also has two different target occupations.

Traditionally, design departments and schools prepared students for life in the world of commerce as practitioners. A small number of these students would then return to academics as professors of the discipline, usually acting as mentors and supervisors of training in the craft. The basic degree for undergraduates varied across the world, but typically had one of three titles: BFA, BA, or BS (Bachelor of either Fine Arts, Arts, or Science). For those who did advanced study, the terminal degree in the field was essentially the same, substituting master (M) for bachelor (B): MFA, MA, MS.

Today it is common for design schools to require their professors to have a PhD. This has resulted in many debates about what a PhD in design stands for, especially as they are being granted by departments that have no or just a few PhD professors—which means that those responsible for granting and certifying the degree have very little understanding of the traditional academic requirements for the PhD.

The requirement that designers in academia have the PhD poses a paradox. If there are very few designers who have the PhD and even fewer schools currently offering the degree, who is to train the new design PhDs? Given that most designers are not trained in scholarship and the type of research citation, argumentation, and evidence-based reasoning required, the new crop of PhDs are apt to lower academic standards and lead to the sort of rubbish (to use an unkind word) that is sent to journals for publication. This criticism probably also applies to a number of existing designers who have PhDs. See the long, 9-page editorial by Nigel Cross, Emeritus Editor-in Chief of *Design Studies*, one of design's highest quality journals, complaining about the number of submissions that he is forced to reject without even sending them out for review because it falls so far below the required academic standards.[50] Cross points out

> "The fact that we still have to keep pointing out basic weaknesses in submitted papers suggests that education and training in design research is still weak. In those cases where the study being reported is based on PhD work, these criticisms of lack of awareness of the breadth and depth of the field and of basic research skills are actually an indictment of some of the standards of current doctoral supervision in design."[51]

Unfortunately, we agree.

Consider the wide range of faculty training in the Industrial Design Engineering department at Delft University of Technology (TU Delft, the Netherlands), which we believe to be one of the very best design programs in the world. We suspect that one of the reasons for its success it that it started with faculty and staff from a wide range of disciplines, most of which included considerable emphasis upon the role of evidence, experimental design, and statistical analyses. In their article on their School for this issue of the journal *She Ji*, Ena Voûte, P. J. Stappers, and colleagues stated:[52]

> "At its inception, most of the teaching staff was teaching based on their industrial experience and design practice, but research has since become an important component of staff expertise. In the past, engineering schools had traditionally placed emphasis on problem-solving and solution-building in industry and society, rather than on writing academic papers. But since the 80s, a growing body of research has emerged, first on design methods, and then on supporting disciplines such as perception, management and manufacturing, and human factors. The number of people pursuing a PhD at the school grew. Most of the candidates in those early years had already gained research experience in other disciplines—in psychology, marketing, mechanical engineering, or physics, for example—but rarely in design. From around 2000, there was a steep rise in the number of candidates who had a design degree. This had an influence on research topics, journal types and other research dissemination platforms, and also on the way research was carried out."

We believe that because the PhD degrees of the Delft faculty come from so many well-established academic arenas, the students who receive design PhDs from Delft will have learned traditional academic rigor. Few design programs have the same wide range of faculty training and skills as TU Delft. We believe this to be at the heart of the issue we are addressing in this article.

Bootstrapping the Training of PhDs

Perhaps what is required is that we consciously bootstrap the PhD in Design by making the MDes an entrance requirement, and perhaps also requiring practical experience to ensure that any tacit knowledge formation is

50 Nigel Cross, "Editing Design Studies—And How to Improve the Likelihood of Your Paper Being Published," *Design Studies* 63 (July, 2019): A1–A9, DOI: https://doi.org/10.1016/j.destud.2019.06.001.

51 Ibid, A9.

52 Ena Voûte, Pieter Jan Stappers, Elisa Giaccardi et al., "Innovating a Large Design Education Program at a University of Technology," *She Ji: The Journal of Design, Economics, and Innovation* 6, no. 1 (2020): 50–66, DOI: https://doi.org/10.1016/j.sheji.2019.12.001.

53 Cross, "Editing Design Studies."

complete. We could bring the doctoral student into a mix of faculty advisors from design and other fields. We could consciously iterate both curriculum and culture, impressing upon our students that we are educating them through a transformation from design practitioners to design scientists, and that they, in turn, must teach their students to be more thoughtful practitioners or better scientists than they themselves are.

Design education for the PhD will have to become broader, incorporating more history, philosophy, and ethics as well as economics, business, and technology. The role of evidence and the rigor that is required to make reasoned claims and arguments has to be taught. People who learn these methods and techniques (and embrace the need for their application) are not likely to fall under the criticisms Cross lists in *Design Studies*.[53] Note that none of these requirements are technically difficult, but they do require a change in mindset for those who have only encountered design taught as a craft.

If Design Education Should Change, How Should We Go about It?

What should design do? We suggest an approach based on our experience in traditional universities and departments. One of us (DN) has two degrees in electrical engineering from two different universities and a PhD in mathematical/experimental psychology, and he has been an instructor or professor in all these disciplines as well as a professor of computer science, cognitive science, and design. The other one of us (MM) has an undergraduate degree in physics and an MBA, and has worked in many design firms, becoming an executive of two of the best-known design consultancies in the world and CEO of a third firm at the cutting edge of practice and professional education. Neither of us had traditional design training, which makes us exceptional for the traditional designer, but surprisingly commonplace among many new designers.

Rather than trying to define a single best aspirational model for curriculum, faculty composition, degree structure, or relationship between practice and academia, we should instead pursue a model that is evolutionary, diverse, experimental, and iterative. We can draw upon the frameworks developed by the earlier reports for fields such as business and medicine to inform and moderate our efforts.

Convene a Powerful Study Group

We have already examined the role of the Ford and the Carnegie Foundation reports on the transformation of management schools, but they are not the only examples supporting the power of a dedicated study group to transform education within a profession. Medicine followed a similar route. In the first decade of the 20th century, the Carnegie Foundation engaged Abraham Flexner to write a study on medical education. Flexner's 1910 report led to the radical renewal of medical education in the United States and Canada. The influence of this report was such that it also led to major improvements in the United Kingdom and Europe. This was the beginning of modern medical education.

At the detailed level of curriculum revision, the two largest computer science organizations in the United States, the Association for Computing Machinery (ACM) and the IEEE Computer Society, drew together a large group of academics and practitioners from a wide range of disparate sub-fields. They take their time to develop recommendations—work on the 2013 report that began in 2010—and they continually rethink and revise the suggestions they make. The first set of recommendations was published in 1968 by the ACM, and the first joint recommendations by ACM and the IEEE computer society were published in 2001. Revisions follow a (roughly) 10-year cycle, with special recommendations for the sub-disciplines also appearing at intermediate intervals. This group is also large—the steering committee for the 2013 report thanks more than 100 contributors.

A similar effort is required for design.

Whatever the sponsoring group, we should follow good design principles and ensure that all stakeholders are represented:

- All disciplines and sub-disciplines of design,
- Practitioners, academics, and students,
- Representatives from design schools and departments, and
- Representatives from design firms, industry partners, and societies.

Conclusions

Design education began by following and enhancing its roots as a rich and noble history of craft. With time, the requirements and opportunities for design have expanded dramatically. Its origin was in the creation of physical artifacts, but even these needs have changed through the introduction of new and exotic materials, new manufacturing techniques, powerful new tools, today's emphasis on electronic media and distribution, and even through virtual displays and presentation. Work patterns have also changed, moving from a studio in one location presided over by master designers to a distributed collective, where the design team might be scattered all over the world, sometimes employed by the same firm, sometimes hired temporarily, only for a particular job. In addition, the areas tackled by designers have greatly expanded as the creative and problem-finding-and-solving aspect of the profession has grown to encompass societal issues in a vast array of forms and emerging in countless different contexts—from redesigning procedures or organizations to tackling climate change.

Design education is struggling to keep up with these changes. One sign of this is the lack of designers in high-level positions within organizations and government. Almost every profession has installed high-level people in positions of authority: medicine, engineering, social sciences, and the humanities. Why is this? One possibility is that to achieve these ranks, the person must have a broad, informed knowledge of a wide variety of topics and areas, must understand rigorous argumentation and the value of evidence, and must put the needs of the organization—or society—above the needs and views of any single profession. Here, design has largely been unsuccessful.

As we discuss in this article, professions such as engineering, medicine, and business once faced similar issues. By careful study of themselves, they were able to reach consensus upon major changes in how they conducted their education. We believe now is the time for design to do the same.

We need to convene a high-level group of people from across the many disciplines of design, as well as educators and thinkers from outside of design, to provide a template and platform for design education. The template must be powerful and flexible, allowing different institutions to adapt the recommendations to their particular needs and clientele. But within that flexibility, it must also insist on a broad base for education and understanding of modern societal issues, modern ethical concerns, and in general the modern world. The experience of other disciplines shows that the process from the formation of study groups through successful implementation (often with numerous iterations) can take decades. In other words, we need to start immediately.

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References

Alexander, Christopher. *The Timeless Way of Building*. New York: Oxford University Press, 1979.

Bennis, Warren G., and James O'Toole. "How Business Schools Lost Their Way." *Harvard Business Review* 83, no. 5 (2005): 96–104. https://hbr.org/2005/05/how-business-schools-lost-their-way.

Boyer, Ernest L. *Scholarship Reconsidered: Priorities of the Professoriate*. Princeton: Carnegie Foundation for the Advancement of Teaching, 1990.

Bürdek, Bernhard E. *Design: History, Theory, and Practice of Product Design*. Translated by Meredith Dale, Susan Richer, and Nina Hausmann. Boston, MA: Birkhauser-Publishers for Architecture, 2005.

Cavanaugh, Jamie. "A Matrix of Competencies for Interaction Design." *DesignHigher* (online), March 14, 2018. https://www.designhigher.com/competencies-for-interaction-design/.

Cross, Nigel. "Designerly Ways of Knowing: Design Discipline Versus Design Science." *Design Issues* 17, no. 3 (2001): 49–55. DOI: https://doi.org/10.1162/074793601750357196.

Cross, Nigel. *Designerly Ways of Knowing*. London: Springer, 2006.

Cross, Nigel. "Editing Design Studies—And How to Improve the Likelihood of Your Paper Being Published." *Design Studies* 63 (July, 2019): A1–A9. DOI: https://doi.org/10.1016/j.destud.2019.06.001.

Dodge, Krystle. "Professional Vs Research Focus." *DegreeQuery* (online), accessed January 21, 2020. https://www.degreequery.com/what-is-the-benefit-of-an-eng-d-degree-vs-a-traditional-ph-d-degree/.

Flexner, Abraham. *Medical Education in the United States and Canada: A Report to the Carnegie Foundation for the Advancement of Teaching*. New York: The Carnegie Foundation for the Advancement of Teaching, 1910.

Friedman, Ken. "Design Education Today: Challenges, Opportunities, Failures." Chatterjee Global/150th anniversary Commemorative Lecture, College of Design, Architecture, Art and Planning, the University of Cincinnati, October 3, 2019. https://www.academia.edu/40519668.

Friedman, Ken, Yongqi Lou, Don Norman, Pieter Jan Stappers, Ena Voûte, and Patrick Whitney. "DesignX: A Future Path for Design." *jnd.org* (online), December 2, 2014. http://www.jnd.org/dn.mss/designx_a_future_pa.html.

Gordon, Robert Aaron, and James Edwin Howell. *Higher Education for Business*. New York: Columbia University Press, 1959.

Iskander, Natasha. "Design Thinking Is Fundamentally Conservative and Preserves the Status Quo." *Harvard Business Review* (online), September 5, 2018. https://hbr.org/2018/09/design-thinking-is-fundamentally-conservative-and-preserves-the-status-quo.

Kolko, Jon. *How I Teach: Reflecting on Fifteen Years in Design Education*. Austin: Brown Bear, 2017.

Kolko, Jon. "The Divisiveness of Design Thinking." *interactions* 25, no. 3 (2018): 28–34. DOI: https://doi.org/10.1145/3194313.

Myerson, Jeremy. "Scaling Down: Why Designers Need to Reverse Their Thinking." *She Ji: The Journal of Design, Economics, and Innovation* 2, no. 4 (2016): 288–99. DOI: https://doi.org/10.1016/j.sheji.2017.06.001.

National Transportation Safety Board. *Marine Accident Report NTSB/MAR-19/01: Collision between US Navy Destroyer John S McCain and Tanker Alnic MC, Singapore Strait, 5 Miles Northeast of Horsburgh Lighthouse, August 21, 2017*. June 19, 2019. https://www.ntsb.gov/investigations/AccidentReports/Reports/MAR1901.pdf.

National Transportation Safety Bureau. "Safety Recommendation Report: Assumptions Used in the Safety Assessment Process and the Effects of Multiple Alerts and Indications on Pilot Performance." September 19, 2019. https://www.ntsb.gov/investigations/AccidentReports/Reports/ASR1901.pdf.

Norman, Don. "Why DesignX? Designers and Complex Systems." *core77* (online), December 6, 2014. http://www.core77.com/posts/27986/why-designx-designers-and-complex-systems-27986.

Norman, Don, and Scott Klemmer. "State of Design: How Design Education Must Change." *LinkedIn Pulse*, March 25, 2014. https://www.linkedin.com/pulse/20140325102438-12181762-state-of-design-how-design-education-must-change/?trk=mp-author-card.

Norman, Donald A., and Pieter Jan Stappers. "DesignX: Complex Sociotechnical Systems." *She Ji: The Journal of Design, Economics, and Innovation* 1, no. 2 (2015): 83–106. DOI: https://doi.org/10.1016/j.sheji.2016.01.002.

Norman, Donald A. "When You Come to a Fork in the Road, Take It: The Future of Design." *She Ji: The Journal of Design, Economics, and Innovation* 2, no. 4 (2016): 343–48. DOI: https://doi.org/10.1016/j.sheji.2017.07.003.

Norman, Don. "The 'Science' in the Science of Design." Forword to *The Psychology of Design: Creating Consumer Appeal*, edited by Rajeev Batra, Colleen M. Seifert, and Diann Brei, xiv–xvi. New York: Routledge, 2016.

Norman, Don. "Why We Need So Much More Than the Bauhaus." *bauhaus now* 1, no. 1 (2018): 18–21. Available at https://jnd.org/then_and_now_the_bauhaus_and_21st_century_design/.

Norman, Don, and Eli Spencer. "Community-Based, Human-Centered Design." *jnd.org* (online), January 1, 2019. https://jnd.org/community-based-human-centered-design/.

Oxman, Rivka. "Educating the Designerly Thinker." *Design Studies* 20, no. 2 (1999): 105–22. DOI: https://doi.org/10.1016/S0142-694X(98)00029-5.

Papanek, Victor J. *Design for the Real World: Human Ecology and Social Change.* New York: Van Nostrand Reinhold Co., 1984. First published 1971.

Pierson, Frank Cook. *The Education of American Businessmen: A Study of University-College Programs in Business Administration*. New York: McGraw-Hill, 1959.

Sanders, Elizabeth B.-N., and Pieter Jan Stappers. "Co-creation and the New Landscapes of Design." *CoDesign* 4, no. 1 (2008): 5–18. DOI: https://doi.org/10.1080/15710880701875068.

Schlemmer, Oskar, and Heimo Kuchling. *Der Mensch: Unterricht am Bauhaus, Nachgelassene Aufzeichnungen*, Neue BauhausbüCher. Mainz: F. Kupferberg, 1969.

Schön, Donald A. *The Reflective Practitioner: How Professionals Think in Action*. New York: Basic Books, 1983.

Schön, Donald A. *Educating the Reflective Practitioner: Toward a New Design for Teaching and Learning in the Professions*. San Francisco: Jossey-Bass, 1987.

Simon, Herbert A. *The Sciences of the Artificial*, 3rd ed. Cambridge, MA: MIT Press, 1996.

Stahnisch, Frank W., and Marja Verhoef. "The Flexner Report of 1910 and Its Impact on Complementary and Alternative Medicine and Psychiatry in North America in the 20th Century." *Evidence-Based Complementary and Alternative Medicine* 2012, article no. 647896 (2012): 1–11. DOI: https://doi.org/10.1155/2012/647896.

The Joint Task Force on Computing Curricula: Association for Computing Machinery/IEEE-Computer Society. *Computer Science Curricula 2013: Curriculum Guidelines for Undergraduate Degree Programs in Computer Science*. New York: ACM and IEEE, 2013. DOI: https://doi.org/10.1145/2534860.

Thomas, Frank, and Ollie Johnson. *The Illusion of Life: Disney Animation*. New York: Disney Editions, 1981.

United Nations. "United Nations: Sustainable Development Goals." Accessed January 17, 2020. https://www.un.org/sustainabledevelopment/sustainable-development-goals/.

Voûte, Ena, Pieter Jan Stappers, Elisa Giaccardi, Sylvia Mooij, Annemiek van Boeijen. "Innovating a Large Design Education Program at a University of Technology." *She Ji: The Journal of Design, Economics, and Innovation* 6, no. 1 (2020): 50–66. DOI: https://doi.org/10.1016/j.sheji.2019.12.001.

Westcott, Michael. "Design-Driven Companies Outperform S&P by 228% over Ten Years—The 'DMI Design Value Index.'" *dmi:Dialog* (blog), last updated March 10, 2014. https://www.dmi.org/blogpost/1093220/182956/.

Wick, Rainer K. *Teaching at the Bauhaus*. Berlin: Hatje Cantz, 2000.

Zimmerman, John, Jodi Forlizzi, and Shelley Evenson. "Research through Design as a Method for Interaction Design Research in HCI." In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 493–502. New York: ACM, 2007. DOI: https://doi.org/10.1145/1240624.1240704.