Preface

This book takes a complex look at a very simple question: How does the constantly developing array of information and communication technologies (ICTs) fit into the life of design education and practice exemplified by architects and engineers? The book also attempts to answer many other related questions along the way. What is technology? What is ICT? What is design? How are architects and engineers different? How are they the same? How do industrial designers compare to architects and engineers? How does technology differ from art, admired by architects, and science, admired by engineers? How should architectural and engineering students be taught? What should they be taught? That is, is there a unique body of knowledge for each of these disciplines? Why is the design studio such an important and contentious feature of design education? What is the conflict between Herbert Simon and Donald Schön? If the work of architects and engineers exhibits a constant tension between the forces of art and science on one hand and the forces of business and culture on the other hand, how can professionalism mediate these opposing demands? What is complexity theory and how does it possibly relate to design creativity? Is there a place for virtual reality (VR) technologies in visual design? And finally, how does imagination relate to ICTs in the designing worlds of architecture and engineering?

All these questions might suggest that the book is timid about suggesting answers and advancing an argument. That is not the case. All the questions cluster around the definition of the future of design as possessing three unquestionable characteristics. First, design is the production of new visual images representing buildings and products that attempt to satisfy both the economic and the cultural imperatives of society. Secondly, design is firmly grounded in the cultural landscape of the times – in our case the climate of communitarian ethics, exemplified by environmentalism and sustainability as overarching progressive social values. Finally, design is implicated with the latest computerized technologies, from the sheer force of their popularity and their reputation as the magical mode of future life. Of these three characteristics, it is argued that, at its innermost core, design is the creation of visual images, and the other two characteristics exist to serve the process of visualization. Making this assumption, the book posits imagination as the central feature of design. The trouble is, imagination – with the creativity that is said to emanate from it – is a mysterious concept that has defied any satisfactory explanation since the time of Plato and Aristotle. Nevertheless, the book argues that it is indeed Aristotle who offers the most convincing account of imagination as a mental power that links the sensible world and the intelligible world in such a way that it assists logic in making sound judgments about future behaviour. All designers know that the process of design involves both reason and imagination. Aristotle, more than anyone, seems to explain how this is done.

It might seem, at first glance, that this book is attempting to address all the issues faced by all designers. Who, one might ask, is the intended reader? Architects? Engineering designers? Industrial
designers? Or does the book speak mainly to the educators of these disciplines? The faculty, then? Or students too? What about readers from other disciplines? And what about readers from other fields of design – such as interior design, or ICT designers? Finally, what about readers from the well-informed general public? In a way, this book examines issues and suggests arguments that readers from a wide spectrum might find interesting. Anyone who is interested in the design of buildings and products, and at the same time is interested in computerized technologies – and it is easy to see that this is a very broad range of potential readership – is likely to find much to interest them in this book. One of the main reasons to make such an extravagant claim is that the book seriously questions the common assumption that ICTs are not only useful but also valuable for the creation of the visual designs that reside at the core of architecture, engineering design, and industrial design. If you think this assumption is right, this book can show you why I think it is wrong. The remainder of the Prologue offers an outline of each successive chapter of the book.

Chapter 1 begins by presenting a conceptualization of technology that considers both its historical and its cultural dimensions. Careful attention is paid to the philosophical understanding of technology from the time of Plato and Aristotle through the advent of the “new philosophy” of empiricism in the 17th century to the post-positivist science at the beginning of the 21st century. Technology is a fundamental human occupation, closely allied to both art and science, and as such it has always attracted the attention of philosophers. Throughout the book philosophical interpretations of technology, ICT, and design will provide the principal focus on the various features and manifestations of these phenomena. Three particular themes – first, the relationship between rationality and imagination; secondly, the relationship between the Aristotelian theory of teleology, or the intrinsic relationship between essences and ends, and the modern theory of democratic utilitarianism; and thirdly, the apparently unaccountable mystery of artistic and design creativity – are all introduced in Chapter 1, and these recur throughout the rest of the book. Chapter 1 also provides a contemporary cultural conceptualization of technology, highlighting Andrew Feenberg’s argument that technology is neither an exogenous force we cannot control nor a grand and powerful instrument we can use for human profit; instead, states Feenberg, technology is a cultural phenomenon that we can employ politically to make our society more democratic and our environment more healthy and sustainable. Finally, Chapter 1 offers a conceptualization of ICT the foregrounds its cultural context in the globalized “Information Age” of the Internet, cellular telephones, and computer-mediated virtual reality (VR), suggesting that ICT is ultimately the latest embodiment of the ages-old Western dream of transforming the world we are given into the world we desire. It is also noted, however, that in communication systems the transformations of data into information and information into knowledge present a contentious intellectual problem, related in the world of design to the psychological mystery of imaginative creation – the most important recurrent theme in the book.

Chapter 2 presents a conceptualization of design, as it is manifested in the disciplines of architecture and engineering. According to a perusal of the recent literature, three key activities or capabilities appear to characterize the designer of the 21st century. The first – and by far the most important – of these activities, is the ability to create visual designs that will satisfy the needs and demands of clients for new buildings and products. The second requirement for contemporary designers is the ability to perform all tasks by achieving a reasonable and sensitive balance between the economic imperative of the profession and the various socio-cultural and environmental concerns that impinge upon any given project. The third requirement is an active and ongoing commitment to mastering the latest technological developments related to design. Much of Chapter 2 focuses on an attempt to conceptualize the process of design creativity, highlighting the centrality of imagination to the production of visual representations that combine
ideation and materiality. Once again, Aristotle is discussed, especially in relation to the questions of the essence and end of design creativity and the difference between pure creativity and design creativity. Donald Schön’s theory of design as “reflection-in-action” is introduced as a bold contrast to Herbert Simon’s theory of design as rational problem solving. J. P. Guilford’s theory of divergent thinking is also introduced at this point, and the creative process is examined in detail, leading to the conclusion that creativity is ultimately uncanny and uncontrollable – yet it is still absolutely essential to the process of design. Chapter 2 also examines the contemporary assumption that designers, as responsible members of a discipline and a profession, must also embrace and demonstrate social ethics in a robust manner. Such a commitment means assuming the fundamental value of communitarian ethics with its belief in co-operation and striving to achieve a consensus among all the interested parties in any design situation. The principal theme of communitarian ethics is environmentalism with the goal of sustainable development. It is certainly true that both architects and engineers are now expected to exhibit social ethics in all that they do, but the Aristotelian ideal of virtue ethics is also still evoked from time to time in terms of rational thinking, moral habituation, and acting from principles of character. Finally, Chapter 2 examines the belief that designers must familiarize themselves with the latest ICT, pointing out, however, that there is a great difference between the human brain and a computer and that in any human-computer interaction (HCI) humans must adopt the role of master – not partner, as some ICT enthusiasts claim.

Chapter 3 compares and contrasts architects and engineers in order to establish a typology for each occupation, by distinguishing their traditions and temperaments, but also by looking at how each profession resolves the conflict between design as art, with an essence and an end, and design as technology, with a dubious essence and an end ultimately defined, not by designers, but by users. All things considered, there is a tendency for architects to regard their occupation as artistic, while there is a tendency for engineers to regard their work as scientific. Neither profession is, of course, separable from design as technology – that is, the necessary condition of working to satisfy clients and to comply with the complicated requirements of social expectation and governmental laws. Thus, architects are not purely concerned with beauty, and engineers are not purely concerned with truth. Those ideals must be left to artists and to scientists. Both architects and engineers must be practical in their daily work. But does this mean that art and science must be relegated to the idle daydreams of architects and engineers? Certainly not! These professions are both highly intelligent. Chapter 3 examines the long tradition of architecture’s conceptualization of itself, beginning with the writings of Vitruvius in ancient Rome. Vitruvius argues that an architect must possess both *ratiocinatio*, or theoretical knowledge – knowing by thinking (what Aristotle calls *epistēmē*) and *fabrica* or practical knowledge – knowing by making (what Aristotle calls *technē*). Needless to say, theory and practice must collaborate in architecture, but it was theory, with its emphasis on formal beauty, that dominated Western architecture for many centuries, culminating in the Italian Renaissance in the 15th century and the Beaux-Arts tradition lasting from the 17th century to the 19th century in France. In the modern age, however, practice came to dominate theory as function replaced form as architecture developed a social conscience and strove to serve the everyday needs of ordinary people. Nevertheless, Mario Frascari (1988) argues that architects must be, first and foremost, prudential theoretical thinkers, and he advances Giambattista Vico’s 18th century theory of “universal images” to support his argument. According to Vico, universal images provide artists with an epistemological language that rivals the logical thinking of rationality with its universal abstract ideas. Chapter 3 also examines the relationship between theory and practice in engineering, where rationality and utilitarian concerns dominate the discourse – at the expense of imagination. Just the same, it is evident that “engineering thought” involves imagination almost as much as it does rationality, especially given the
fact that, as Kathryn Henderson (1999) observes, the design culture of engineering is highly visual and hand-drawn, suggesting that there is a strong linkage running from imagination to hand to eye. Finally, a comparison of the ways in which architects and engineers perform on psychological testing suggests, according to Mark Gridley (2007), that, as artistic types, architects tend to be introspective, independent, and freely imaginative, while engineers, as scientific types, tend to be logical, open to suggestions from others, and cautiously rationalistic. One thing is certain: architects belong on the humanistic side of the great cultural divide among Western intellectuals identified by C. P. Snow (1959), while engineers belong on the scientific side. They may not always understand each other, but architects and engineers both use rationality and imagination to make their visual designs, and, more and more, they are both being aided by ICT.

Chapter 4 looks at the pedagogy and curriculum development of design education in relation to architecture and engineering. In general there are two competing theories of what and how architectural and engineering students should be taught in the 21st century. Some educators argue that students should be encouraged to develop their individual potential to the maximum, while other educators argue that students should be taught to develop a strong sense of communitarian ethics. Of course, both these ideals may be combined, but, chances are, one or the other will be given official preference. At the same time, some educators believe that traditional chalk-and-talk lectures should instruct students in the important concepts of the discipline, while other educators believe that students should be encouraged to construct the knowledge they need through collaboration with their instructors acting as coaches and their fellow students sharing the experience of learning. In fact, this latter belief, known as the pedagogical paradigm of constructivism, is now generally assumed to be the “correct” approach to teaching design to architectural and engineering students. The origins of constructivism can be traced to the educational theory of John Dewey (1897, 1929, 1938) with its emphasis on acquiring necessary knowledge through the accumulation of unique individual experiences. Dewey’s philosophy of pragmatism may be seen as developing parallel to the philosophy of phenomenology advanced by Edmund Husserl (1913, 1931). Chapter 4 examines the modern history of curriculum development, especially the recent claims of the superiority of the constructivist paradigm, paying special attention to the experiential learning theory of David Kolb (1983) and the studio-based reflective learning theory of Donald Schön (1984, 1988). Two of the strongest critics of constructivist pedagogy, John Sweller (2004) and David Merrill (2002, 2007), are also considered carefully. If there is, as Nigel Cross (2001) argues, such a thing as a discipline of design and “a designerly way of knowing,” the question arises of what its distinctive body of knowledge should be. Engineering educators insist that science should be the foundational knowledge of design, while architectural educators, such as Schön argue that if science is taught, it should be presented to students as a process to experience, not as a product already established. Chapter 4 suggests that it might be best to return to Marco Frascari’s (1988) contention that Vico’s “universal images” might serve as the body of knowledge for architects, with the possibility that a similar vocabulary of past engineering designs might serve the same purpose for engineering students. Chapter 4 then examines the possibility that complexity theory might serve to replace positivism as the paradigm of design education and practice. With its emphasis on autopoiesis complexity theory might offer a theoretical way for creativity to be accounted for in academic circles, and yet the tendency of complexity theory to eliminate individual imagination makes it problematic to design theory. Finally, Chapter 4 reviews the possibility of using ICTs as a means of presenting design curricula as Virtual Learning Environments (VLEs), concluding that e-learning offers much in the way of managing design courses but little in the way of contributing to design pedagogy.
Chapter 5 investigates the pedagogy of the architectural design studio as the prototype of design education. In recent times the design studio has often been associated with the concept of “reflection-in-action” promoted so eloquently by Donald Schön (1984, 1988), but the design studio has actually been a standard feature of architectural education since the 18th century when it was firmly institutionalized in the École des Beaux-Arts in Paris. Since the Beaux-Arts tradition was based on the aesthetic theory of Neoclassicism developed in the Italian Renaissance, it emphasized the essential value of formal qualities. This tradition was challenged in the early 20th century with the Modernist insistence, manifested especially in the Bauhaus School in Germany, that social function is what matters most in architecture. Yet even Bauhaus pedagogy carried on the tradition of the design studio. Schön argues that creativity is the core activity of the design studio, in contrast to analysis and criticism that are consider the core activities of the university as a whole. For Schön creativity is conceptualized as a “reflective conversation with materials” in which design students learn through an engagement with constructivist epistemology, led by professors who coach rather than lecture. Besides creativity, the culture of the design studio also emphasizes rapid communication and broad social relevance. Typically, the design studio is cluttered and highly physical, and it features prominent visual displays of all manner of designs. Design students tend to be serious, highly motivated, and constantly busy. Chapter 5 also considers criticisms of the design studio. Schön has criticized the “technical rationality” of the university model of education, many have criticized the design studio for being overly subjective and therefore isolated within university culture as a whole. This is a dispute that has always raged and probably always will rage. In recent years, however, three other criticisms of studio education have been frequently advanced. The first of these criticisms is the charge that the design studio promotes an elitist conception of the architect as being preoccupied with formal aesthetic concerns at the expense of cultural sensitivity and social justice. Some critics even go so far as to argue that the design studio should be used primarily to indoctrinate students to acquire the values of “progressive” politics in order to “save the planet,” arguing that sustainability is much more important to designers than aesthetics. The second recent criticism of the design studio is that it needs to become much more attuned to the latest advances in ICT, doing away with its traditional reliance on both physical community and material visualizations in order to become non-physical and “paperless” – that is, to shift from material space to cyberspace in a global context. The third criticism brought against the design studio is that its tradition of jury assessment of design projects is too stressful on students. Chapter 5 concludes with a refutation of all these recent criticisms of the design studio.

Chapter 6 both reviews design pedagogy in relation to engineering and introduces the discipline of industrial design in relation to both architecture and engineering. The first chapters tended to examine design in architecture more than in engineering, owing to the fact that the core activity of design is imaginative creativity, but engineers tend to regard their designing work as the application of rational thinking to solve problems. The difference is not simply a matter of artistic architects versus scientific engineers. Instead, the difference should be conceived in terms of imagination versus rationality. As we have seen repeatedly in the first 5 chapters, both imagination and rationality are needed to create successful designs, but we have not yet fully examined how these two mental powers relate to each other and even come to support each other. That will be the topic of Chapter 10 – that is where we are heading, but first it might be useful to recapitulate what we have observed so far, because design concepts tend to slip and slide and appear in more ways than one.

Chapter 6 strives to re-emphasize the importance of Aristotle to design pedagogy and practice by reiterating the fact that design is exactly what Aristotle calls technē or knowing by making – in our terms, technology. Aristotle regards technē as a rational activity, and he defines rationality in the doctrine of the
four causes, particularly the idea that any made thing must have an essence and an end. Modern thinkers, however, often argue that technological inventions are not teleological in a predetermined way; instead the products of technology are often defined by their users, not their makers. Thus, as Herbert Simon (1969, 1996) argues, designs do not have final causes but pragmatic purposes. In this one important manner, then, it might be said that technological designs are not truly rational—at least not in the Aristotelian sense. On the other hand, it might also be said that the designs of architects and engineers are not truly imaginative either, because they are not, as the great modern philosopher R. G. Collingwood (1937) would have it, expressions that are ends in themselves. No doubt many architects and engineers do create their designs “out of thin air,” as Plato criticized poets for doing, and no doubt both architects and engineers are very capable of cherishing certain designs as expressions of their most profound sense of life, but in the end all the designs of architects and engineers are fundamentally utilitarian. Chapter 6 also recounts what we saw earlier about the core reliance of the design process on imagination to deliver the creativity that defines both architecture and engineering. Aristotle calls imagination *phantasia* and he locates it in the human mind between sensation and rationality. Like Plato, Aristotle admits that imagination cannot directly apprehend the reality of ideas, but, unlike Plato, he insists that imagination can sometimes embody ideas. Is this not exactly what the visual creations of designers strive to do? Nevertheless, how to think imaginatively is an extremely difficult skill to teach, and this often troubles engineering faculty very much.

Toward its end Chapter 6 offers a few summative suggestions about engineering pedagogy and practice. First, it seems that engineers need to take imagination much more seriously than they have in the past in order to do justice to what Robert Quinn (1994) calls the “art of engineering” by placing design at the core of engineering education. Secondly, engineers need a body of theoretical knowledge apart from science; something along the lines of Vico’s “universal images” that Marco Frascari (1988) argues should be taken as a body of knowledge by architects. Finally, engineers need to integrate their technical expertise much more with the broad social and cultural demands of communitarian ethics, particularly those relating to environmental sustainability and a wide range of quality of life issues.

Chapter 7 examines and conceptualizes professionalism in relation to the work of designing done by both architects and engineers. As with so much else that we have observed thus far, there is a difference in the history and the professional development of architecture and engineering. The classic definition of professionalism is given by Walter Metzger (1975) as the organization through codification of the ever-increasing body of knowledge of a discipline in an honorable manner, resulting in autonomy or self-regulation and social responsibility. As Adam Unwin (2007) reminds us, however, in recent years society has tended to withdraw its simple trust in professionals and demand that they behave in a more transparent and publicly accountable manner. Such a demand is, of course, in keeping with the current
trend of “progressive” democratic thinking and communitarian ethics, but it has had a disruptive and chilling effect on many practitioners in all professions. Chapter 7 takes a close look at this crisis in the discourse of professionalism.

As far as architecture and engineering are concerned, it is argued that professionalism is a mediating concept that serves to connect the concepts of art and business to each other in a triadic relationship that I call the Mediation Model of Design Professionalism. Thus, professionalism may be seen as a moderating force that allows the creativity of designers to respond to the demands of the marketplace in a socially ethical manner. Much of Chapter 7 is taken up with an historical overview of professionalism in both architecture and engineering in both Britain and America. In the beginning architects were gentleman scholars who worked on commissions from wealthy patrons and disdained any commercial connections with the public. Engineers, on the other hand, rose to prominence as self-made men who used scientific learning to enable them to earn contracts for public works endeavors such as canal and railroad construction. Thus, professionalism meant different things to architect and engineers, though the demand for both occurred in the 19th century with the advent of capitalism and the market economy.

The gentleman architects were being challenged by newly educated architectural students who demanded recognition for their credentials through official registration. The Royal Institute of British Architects, however, resisted registration until well into the 20th century, because it wished to protect the profession from an influx of newly trained practitioners not belonging to the upper social class. The members of the RIBA conceptualized architecture as fine art, not as a business enterprise, and the same thing happened on the East Coast of America under the leadership of Richard Morris Hunt who imported the Beaux-Arts tradition from Paris and established it at Columbia University and MIT. Nevertheless, the modernist movement developing in Chicago under the banner of “form following function” eventually displaced the emphasis on art in architecture and transformed it into a business. Meanwhile, engineers were contented to use their specialized knowledge to elevate them socially into the status of gentlemen. For engineers, then, professionalism was regarded in terms of social status and the public recognition of their expert knowledge.

Finally, Chapter 7 examines how design professionalism is currently changing, particularly in its approach to education. The recent shift to communitarian social ethics throughout the West has meant that the face of architecture is much different than it was just fifty years ago when both professions were almost exclusively composed of white males. Now at least 20% of architects and engineers are female, and the rate of minority participation is increasing all the time. Moreover, because of the recent attack upon professionalism, the education of professions has become much more deliberately instructive – no longer is professionalism passed on exclusively through role modeling. New theorists of design professionals, such as Linda Groat (1992), has argued that architects (and, by implication, engineers) should no longer conceive themselves as technical experts but as “cultivators,” thereby taking on a social identity more in keeping with the times by being responsive to cultural values and ideals more than to economic imperatives in the marketplace. Needless to say, this claim runs contrary to the argument of this chapter that design professionalism allows creativity, social identity, and economic interests to co-operate successfully to everyone’s advantage.

Chapter 8 takes a closer and a longer look at the central theoretical problem of design ontology and epistemology: namely, the rationally unaccountable phenomenon of creativity that we have encountered again and again, in one form or another, in this book. It is universally recognized that creativity is the work of imagination, but there is no saying what that is – at least with any reasonable consensus. Design is usually thought to be a linear process beginning with the rational definition of a problem through
analytical or convergent thinking, but somewhere in the middle of the process the designer’s thinking diverges in order to synthesize a new visual plan that will eventually be materialized as a building or a product. Incidentally, this double thinking – this uncanny amalgam of analysis and synthesis – is what appears to preclude the use of ICT in the actual work of design. In the first place, it is extremely difficult to provide algorithms that can accurately represent the infinite complexity of variables involved with any design project; more importantly, computers are totally lacking in imagination. They can analyze data, and they can even synthesize data within predictable parameters, but they cannot make the brilliant leaps in the dark that characteristically illuminate successful designs. Thus, it might be said that, at least as far as theory is concerned, computers are irrelevant to the design process. What are not irrelevant are the designer and his or her personal imagination.

More than anything, Chapter 8 examines the possibility, put forward by such architectural critics of positivism as Alain Findeli (2002), that complexity theory might be seriously considered as a new paradigm for design pedagogy and practice. Complexity is a concept identified with living organisms and geological processes. Complexity happens in systems that are characterized, paradoxically, by the possession of great internal uncertainty coupled with an absolutely certain external goal for the system as a whole. Biological evolution is the central metaphor of complexity theory. The life goal of an organism is genetically pre-determined, but how the organism develops is also affected by environmental forces that impinge upon it. Moreover, as the organism develops it also affects its environment. Even observers of complex systems are influenced by the systems. In complexity theory there is no such thing as objective research. The most important thing about complex systems, at least as far as design is concerned, is that they exhibit self-organization or autopoiesis.

Here then is the possible argument, one that I have tentatively advanced myself (Wang, 2010): Does the self-organizing principle of autopoiesis offer a rigorous explanation of design creativity? After all, autopoiesis is a respectable academic concept, yet at the same time it requires uncertain components, and it always manages to organize all the disparate elements spontaneously and successfully, so that the whole is greater than the sum of its parts. Is this what happens in the design process? It is tempting to entertain this possibility. But there are serious objections. The first and most important is, as we have already noted, complexity theory does not allow any clearly defined place or function for either the designer or the imagination. This is a real problem, because it is unthinkable to argue that design happens without a central executive and the art that results from imagination. Another problem with complexity theory is that it does not conceptualize tasks as problems with solutions. Instead, there is the system as it now is and the system as it might become. Needless to say, such a vague conceptualization is inadequate to the pedagogical and practical requirements of design.

In addition to examining theoretical matters, Chapter 8 provides a historical sketch of the background of complexity theory, focusing especially on the ground-breaking work of automata researchers in the 1940s, ‘50s, and ‘60s: Shannon and Weaver’s (1949) information model of communication McCulloch and Pitts’ (1943) conception of neural networks, Wiener’s (1948) invention of cybernetics, von Neumann’s (1957) development of artificial intelligence (AI), and Herbert Simon’s promotion of the amalgamation of all these autonoma theories as the technological solution to the postmodern crisis occurring at the interface of various rapid cultural changes The opinions all draw on the 19th century mathematician George Boole’s idea that there are “laws of thought” inherent in the mind and that these laws can assist humans in understanding the reality of the physical universe. This idea has come to be known as symbolic logic, and it strongly inspired many mid-20th century theorists to develop what we know today as ICT and AI. These rationalist conceptualizations of complexity theory all assume that the world consists
of “organized complexity” – all researchers have to do is model that complexity, hopefully with the assistance of more and better computers. So far, this hope has not been realized, and as far as design epistemology is concerned, there is reason to doubt that it will ever be realized.

Chapter 9 examines the possibility of using virtual reality (VR) technology for design pedagogy and practice. This high-tech form of ICT is still in the experimental stage of educational use, and it certainly deserves our attention. VR technology is a means of computer-generated communication in which participants interact in a cyberspace world and thereby experience a sense of presence with each other. Interactivity and mutual presence are defining features of VR. Unlike the Shannon and Weaver (1949) model of communication as transmission of messages that are first encoded and then decoded, VR communication happens at a site in cyberspace that participants can visit at any time to engage with information that is stored there.

VR technology presents a visual world that may or may not resemble the real world. This is a serious problem for those who would use VR technology for educational purposes. In VR intelligent imagination soon degenerates into barbaric fantasy. After all, VR technology is still used almost exclusively for game playing purposes. An even greater educational danger is the fact that VR is programmed by humans who create a fantastic ontology with whatever cause and effect relationships they desire. Thus the VR world cannot ever be taken as a representation of reality without some serious reservations. Moreover, it is absolutely wrong to assume – as many do – that VR is created by computers. VR is a human construction, representing the knowledge (however dubious) of their programmers. In fact, there are two reasons that VR does not adequately represent actual reality. First, unlike the real world, the virtual world is not independent of human control, and secondly, the virtual world cannot begin the capture the subtle complexity of the real world. Ultimately, it must be remember that, unlike, say, an ant colony, a virtual world is not living, and because it is not living it is not capable of self-organization or autopoiesis. In fact, VR technology is totally instrumental, and any tendency to romanticize it as a magical realm where humans and computers creatively interact must be strongly resisted.

Moreover, Chapter 9 has much to say about how VR technology operates. VR technology offers a 3-D computer-generated visual presentation of a virtual community in which users interact on screen by manipulating avatars or idealized visual images of themselves. Avatars provide users with a first-person perspective on the interactivity that happens in the virtual world. Immediately, psychological questions arise in regard to avatars. Watching an idealized image of oneself performing idealized actions inevitably leads to an unrealistic level of self-consciousness – and, usually, self-aggrandizement – in users. Whatever value self-magnification may have in VR game playing, it certainly does not have much use in educational undertakings. Moreover, there is an ethical problem with avatars. They can – and in game playing almost always do – perform immoral acts, especially of violence. Immoral and unethical behavior is, however, totally inappropriate for educational projects. Although there has been little research done on avatars to date, this chapter demonstrates how they might be interpreted by various pedagogical theories, particularly the dominant design pedagogy of constructivism.

This chapter also considers the dangers of using VR technology for design purposes. In the first place, VR technology operates, like all ICT, through the programming of computers with mathematical formulas and algorithms that supposedly model reality, but, as Clive Dym et al. (2009) remind us, such computerized modeling is all but useless to designers, especially in the early stages of the design process. Computers can only do what they are told, and are, as we have observed before in this Prologue, incapable of imaginative creativity. Thus, VR technology, however appealing it may appear to the players of fantasy games, cannot be trusted to present accurate images of reality. Moreover, design relies very
much on the value of the visual images it creates. If these images are not transferrable to reality – that is, if they cannot pass from ideation into materiality – they will be of little use to designers. In the end, the computer-generated images of VR are much more remote from reality – that is, from the human brain and all it knows – than the drawings that designers have made by hand for centuries.

As far as using VR technology for the teaching of design is concerned, there has been little evidence forthcoming to support claims for its effectiveness even from the Immersive Environments Laboratory (IEL) at Pennsylvania University, probably the most advanced program for experimenting with VR technology in relation to architecture. The theory is that VR immersion might help students to develop three-dimensional spatial cognition by experiencing design environments in cyberspace. The assumption here is that virtual reality represents physical reality, but this true only in the most approximate sense. A virtual world is the product of a software manufacturer, dependent entirely on the way it is programmed. The truth is, no virtual world comes close to hand drawn world in the depiction of reality, for the simple reason that pencils held in hands are co-ordinated with eyes, and eyes are a part of the brain, the most accurate sensor and depicter of physical reality. As the sculptor Richard Serra (2011) says, “Drawing is thinking.” By comparison, the act of programming a computer is far removed from any actual creation of visual representations. A rough analogy might be to say that drawing is like making music, while programming a computer is like mixing recordings. Moreover, as Kathryn Henderson (1999) reminds us, designers regard 3-D perspectival representations – like those embodied in VR technologies – as little more than “pretty pictures,” for it is 2-D profiles, sections, and plans that ultimately serve as production drawings. Finally, as Donald Kunze (1988) argues, virtual reality is the realm of fantasy, not imagination. That is, fantasy and VR are non-representational in the strictest sense. Instead, fantasy and virtual reality depict images by spontaneously transforming what Shakespeare calls “airy nothing” into monstrous personal visions that have little to do with academic ontology and epistemology. According to Kunze, this is a good thing, but that is debatable.

Chapter 10 concludes the book by posing a simple question: What good are ICTs to design education and practice? Recall that we began in Chapters 1 and 2 to relate ICTs to design pedagogy and practice by conceptualizing technology in general, ICTs in particular, and the act of design as the core of all technological enterprises. The intervening chapters all pick up, in one way or another, on the one burning question: Do ICTs really improve the design process? Much skepticism about that question is expressed in the book – fairly, I think, and always reasonably. Chapter 10 identifies thinking with imagination as the essence of design, and it starkly argues that computers cannot think in this way. Moreover, the design process concentrates on the production of new visual images, but, once again, computers cannot “see visions.” Therefore, what good are ICTs to design?

For the most part, Chapter 10 articulates and conceptualizes imagination, tracing its historical development from the time of Plato and Aristotle to the present day. There are two very different traditions of imagination. Plato hardly recognizes imagination at all, but Aristotle finds imagination to be necessary to intelligent thought. The different traditions of imagination turn on the question of what imagination does in the mind. Does imagination represent or imitate nature or physical reality? Or does the imagination create something entirely free of any “true” correspondence to actual reality? Plato and Aristotle both state that artistic or imaginative productions are a kind of mimesis or imitation, strongly related to the sensible world. Plato famously detested poets, but his criticism is not that poets imitated or represented nature – instead of creating grand visions that transcend nature, as many of Plato’s followers wanted him to say – but that what poets chose to imitate was not worthy of serious attention. In other words, Plato argues against the depiction of the sensible world of sex and violence, saying that such depictions
are dangerous to young people. This opinion should sound familiar today! Aristotle, on the other hand, argues in the *Poetics* that the depiction of tragic events actually purges and cleanses the soul via the imagination. This opinion too should sound familiar to us, although its modern liberal exponents are currently losing ground to various traditions of religious fundamentalism. The key thing to note here is that the Classical theory of imagination as *mimesis*, expounded by both Plato and Aristotle, ruled Western thinking until the Renaissance in the 15th and 16th centuries and the Romantic Age in the 19th century. Neither Plato nor Aristotle believed that imagination is capable of directly apprehending ideal reality—only reason can do that. The great Romantic poets, though, such as Goethe, Blake, and Wordsworth, asserted that imagination is a “divine power” that allows humanity to see visions of reality unaided by rationality. In order words, the Romantic conceptualization of imagination emphasizes creativity in the mind of the poet. Taken to its extreme, as in the writings of Nietzsche in the late 19th century, imagination is everything. Thinking is imagining in this view— even rationality is a product of imagination.

This Romantic conceptualization of imagination is still very much alive today. As far as design is concerned, the two traditions of imagination appear to fuse. Designers often regard their work as creative—that is, the inspired or at least mental making of visual images. Such is the artistic side of design. The technological, or more practical, side of design is forced to realize that, wherever designs might originate, they still must be representations of materially possible buildings or products. Therefore, it is important to note that the Classical tradition of imagination as the representation of practical reality is actually more important to design than the Romantic notion that imagination is purely mental. Despite the fact that *mimesis* has been out of fashion for at least two hundred years, Chapter 10 takes special note of Aristotle’s views on imagination. Throughout the book Aristotle has haunted us more than any other thinker. After all, it is Aristotle conception of *technē* that is the foundational definition of technology. Plato uses the word *technē* too, and he means more or less the same thing. But, whereas for Plato *technē* is making that is usually contrary to *logos*, or rational thinking, and thinking that is limited to the sensible world, for Aristotle making and rationality go together to achieve the highest knowledge of universal ideas in the intelligible world. Chapter displays the full development of Aristotle’s theory of *fantasia* or rationality, arguing that his theory of imagination emphasizes the centrality of imagination in the mind, acting as an intermediary between physical sensations and rational judgment. This means, that as far as design is concerned, imagination should be regarded as a guide to rational judgment, not simply as a source of wild and fanciful ideas. It is safe to safe that all designers and teachers of design recognize that both rational and creative thinking are integral to the process of design. Chapter 10 shows how Aristotle’s concept of imagination can account for the mentally dual nature of design.

The chapter and the book end an attempt to answer the question, “What good are ICTs to design?” First, the superficial objections to ICT in design are disposed of as being irrelevant—such complaints as their spurious glamour making them seductive to students and their extravagant cost making them impractical. Instead, the final chapter argues that the case against using ICTs in the design process as anything more than marginal tools is very strong. It seems to be undeniable that, more than anything, the activity of design requires the production of visual images that satisfy both economic and cultural demands. It is also certain that in order for this to happen the imagination of the designer must be stimulated to think so as to produce these necessary visual images. So far, so good. The designer has to use imagination in both a representational and a creative way. How is this to be done? The way it has always been done is through the drawing of images by hand. Remember, drawing is thinking—the material objectification of the ideational content of the mind, through the combined efforts of eye and hand. Therefore, in purely theoretical (the best kind!) of terms, can ICTs do what needs to be done to take a partnership role in
design? Do computers have imagination? Can computers see visions in a suddenly spontaneous way? Can computers produce images that are both elegant and practical? No, not really. Then why are so many people determined to think that they can? They must be enchanted with the magic of technology that, like all magic, promises fantastic effects at the expense of rational explanation.

It is hoped that reading the book as a whole will encourage design educators, design practitioners, and design students to contemplate the complexity of their chosen discipline from a perspective that attempts to transcend the ordinary view of the field. Throughout the book it is assumed and argued that the activity of design is as old as humanity and as deserving of respect as any intelligent occupation. Architects and engineers especially have, in a very real sense, made the world we have inherited, the world we live in today, and the world we dream of tomorrow. The fact that they have done so since long before recorded history suggests that they always knew what they were doing, and they could always recognize and respect a new tool when they found one or made one – without being tempted to claim that they could form a partnership with their tools. But this is precisely what many advocates of ICTs are currently claiming should happen next. This book does not believe that claim, and it tries to explain, in some detail, why.

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