KEYWORDS

Design

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Design is ubiquitous and ambiguous. As a quality of the material world, it is everywhere implicated in the construction of everyday objects and experiences. As a term, it is used as both a noun and a verb. As a noun it might refer to (1) aesthetic embellishments, (2) a solution to a problem, or (3) an expressive domain of creative practice. As a verb, it refers to a set of actions that result in the production of an end product: (1) imagining, (2) creating, (3) representing, (4) negotiating, (5) prototyping, (6) fabricating, (7) building, (8) evaluating, and (9) iterating. Given such a range of linguistic usage, how might the term *design* be usefully unpacked for the purposes of thinking about digital media and learning? In short, how can design serve as a catalyst for learning in a digital age?[1]

To begin to address this question, I want to consider the issue of design in light of Henry Jenkins's description of the new skills that are necessary for full engagement in what he calls "participatory culture" (Jenkins et al. 2008). Jenkins and colleagues elaborate this set of skills in light of the question "How does 'media education' need to change in the 21st century?" His discussion of literacy is part of his broader work on the investigation of "convergence culture," which for Jenkins is marked by changes in processes of knowledge creation and in technological infrastructures. The defining characteristic of the 21st century for Jenkins is the increase in opportunities for people to participate in activities of cultural creation. Certain skills, Jenkins and colleagues argue, are necessary for someone to be a fully empowered member of participatory culture. These skills are play, performance, simulation, appropriation, multitasking, distributed cognition, collective intelligence, judgment, transmedia navigation, networking, and negotiation.

While the term *design* is not explicitly identified in his list, the notion of design—as the name given

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to a particular set of skills such as information gathering, creative thinking, improvisation, and tinkering—is fundamental to the broader cultural shift that Jenkins and colleagues are concerned to elaborate. This essay suggests ways in which the activities that are centrally involved in design processes—especially the design of innovative technologies and technological experiences—address and expand upon the list of new literacies that Jenkins and colleagues (and others) argue are the foundation for knowledge creation in the 21st century. I begin by reviewing three dominant meanings of the term *design* (as a noun) as a prelude to setting forth the argument for a fourth sense of design as the means for the reproduction of (techno)culture. I then elucidate some of the key theoretical assertions about the work of design in a technological culture, thus setting the stage for a discussion of the more explicit connection between design (as well as designing and design thinking) and Jenkins and colleagues' list of 21st-century literacies.

The Meanings of Design

In one of the most commonsensical notions of design, the term describes the aesthetic embellishments or nonfunctional aspects of a product or application. The design of a "thing" is, according to this view, separate from the purpose of the object. This notion of design is typically associated with consumer behavior where the quality of design is a matter of taste, of appeal, of fashion, and of fad. The goal of understanding design as a category of "aesthetics" is to learn how to recognize and appreciate the value of elements that constitute the design of the thing.

A second sense of design—as a solution to a problem—is most closely associated with the fields of engineering where the design process is often initiated by the formation of a problem, and the design task is to develop solutions to the puzzle. This notion of design foregrounds practices of problem specification, problem solving, and rationalization. The quality of a design is often determined by appeals to an argument for the fitness of the design solution in terms of how well the proposed design addresses the constraints of the original problem. Design solutions are evaluated, for example, in terms of the efficient use of resources, the conservation of energy, or the economics of materials.

In the fields of applied arts, which include disciplines as diverse as typography and architecture, the term *design* names a domain of creative expression. In these disciplines, design is integral to the manifestation of the art form. Design is the term used to describe the methods of creative practice that define the art form as (and within) a distinct discipline. The shift here is to a focus on the materials of the art form and the practices whereby the materials are shaped, formed, reformed, invented, or remixed.

What is less developed within these three notions of design is a consideration of the cultural significance of the term. Indeed, over the past 20 years, the relationship between design and culture has been taken up in different design disciplines. This has led to the emergence of the field of "design studies," which focuses on elucidating the nature of the discipline of "design" in terms of its key elements: ontological frameworks, methodologies, institutional formations, and cultural manifestations.[2] As a field, design studies is robustly eclectic in involving the participation of thinkers from diverse disciplinary backgrounds. One of the important insights to emerge from discussions within this field is the sense in which design is understood as a key cultural practice. Following this, we should add a fourth sense to the meaning of the term *design*: a practice of cultural reproduction.[3] I am particularly interested in the design studies that investigate situations that result in the creation of innovative technologies. This research identifies the key elements of design processes that inaugurate new technocultural phenomena.

Design and Technocultural Reproduction

The formal process of designing technologies involves the replication of specific elements, such as standards, forms of knowledge, power relations, technical codes, and institutional structures, but it also makes new things possible when the expression of a design may manifest something that has not yet been realized. Designing also involves a full range of expressive practices: storytelling, sketching, sculpting, image making, storyboarding, semantic mapping, composing, ventriloquizing, and wordsmithing (among others).[4]

In engaging in these representational practices, designers manifest "creativity." In studies of creativity in design, researchers assert the importance of a shared cultural context for the expression of novel ideas. Culture, in this sense, provides the broad framework of meaningfulness and novelty (Eckert and Stacey 2000). Csikszentmihalyi (1996)—in his

social model of the creative process—argues that culture (as a widely shared symbolic system) is the *generator* of creativity. He asserts that designers mediate between culture and society (the social context of the design situation) to manifest "creativity." Thus, designers serve as cultural mediators by translating among languages, materials, and people to produce, among other things, "taste," meaning, desire, and coherence (Bourdieu 1984). Through the practices of designing, cultural beliefs are materially reproduced, identities are established, and social relations are codified.[5] In this way culture is both a resource and an outcome of the designing process.

At a base level, the *process* of technological design involves a wide range of expressive practices whereby meanings are created for the technology-under-development.[6] It is not just that technological design involves the creation of new meanings. It is also true that technological innovations inevitably *replicate previous meanings*, at the same time making possible the *expression of new ones*. Communications scholar Klaus Krippendorf (1995) describes the fundamental paradox of the designing process as oscillating between "the aim of making something new and different from what was there before, and the desire to have it make sense, to be recognizable and understandable."[7] As he rightly points out, an innovative design cannot be so novel that it makes no sense at all. To be comprehensible, the innovation must draw on understandings that are already in circulation within the particular technocultures of users, consumers, and participants. At the same time it must perform "novelty" through the creation of new possibilities as expressed in language, desires, dreams, and phantasms of needs.

A doubled logic is at the heart of all technological design: new designs not only replicate previous elements (i.e., codes, standards, conventions), but they also bring new elements into existence through the development of new materials, the creation of new functionality, or the novel combination of prior components. The process of technological creation is reproductive: every technology replicates previous possibilities and makes new ones manifest. Reproduction, as anthropologist Marilyn Strathern (1992) reminds us, involves two processes: (1) of *replication*, when original (parental) material is duplicated; and (2) of *expression*, when the combination of original material takes a shape within a new (reproductive) context.[8] Technocultural formations incorporate elements that are already part of broader cultures. *Innovation* happens when elements are combined in novel ways. This is how technologies can logically manifest multiple and contradictory effects. To embrace this understanding is to forgo the metaphysical debates that posit technology as *either* (1) fully autonomous and completely determining in its effects, *or* (2) a mere tool in the hands of a human operator. Once the binary *either/or* proposition is established as the frame for discussion, all further attempts to think complexly about the nature of technology bog down in an effort to establish a singular essence of technology.[9]

In this sense, what gets designed as an "innovative technology" is not merely an artifact or the instrumentation of scientific knowledge. An innovative technology is better understood as an *assemblage* of materialities, practices, projections, and affordances, each of which contributes something to the overall meaning of the technology. These elements are diverse in kind. Some of the elements that contribute to the meaning of a technology are recognizable as *material* objects, such as physical artifacts, tools, and hardware devices—the things people commonsensically refer to as "technologies." Other significant elements include *infrastructures*, which may be material (e.g., highways and power lines) or intangible and *immaterial* (e.g., codes and technical standards).[10] But equally significant are the social elements that contribute to the overall meaningfulness of a technology, including the social practices through which technologies take shape, the social rituals and habits engendered by new technologies, and the social structures that congeal through the use of machines, products, gadgets and gizmos.[11] Scholars in the field of social studies of science and technology assert that every technology is, at its most fundamental, a sociotechnical construction.[12] Humanists extend this analysis to point out that every technology also involves the expression of cultural understandings in the form of narratives, myths, values, and truth claims. These elements, too, constitute the meaning of a particular technology. So instead of seeing technologies as bounded objects, this approach argues that technologies are better understood as hybrid *socio-technical-cultural assemblages*.[13]

This description of the situation of designing is abstracted from formal studies of the design of innovative technologies. To this description we should add an account of the key infrastructural elements of the design process: agents, representations, social negotiation, and social integration.

Agents

At the more formal end of the scale, the creation of innovative technologies involves the work of a range of participants such as engineers, architects, and scientists, as well as those who are responsible for setting up the structure of the development efforts: funders, clients, policymakers, and standards committees. Although all these participants are engaged in creating the meaning of a new technology, some are designated as creative agents such as "designers" and "innovators." They are instrumental in the process whereby the materiality of the world becomes meaningful both technologically and culturally.[14] In this formulation, the term *designing* identifies a category of practice through which the *materiality* and the *intelligibility* of the technology-under-development are constituted.

Representations

Formal processes of *designing* involve the creation of visual representations, narratives, fictions, prototypes, and speculative proposals for design "solutions." These representations are used in the communication among participants to help them make sense of the designing activities.[15]

Social Negotiation

Because designing involves human actors who represent distinct stakes, narratives, values, and levels of privilege to influence the designing process and eventual outcomes, designers have to negotiate the creation of shared understandings among participants who come from different disciplinary backgrounds, hold divergent assumptions and values, and have particular investments in the innovation process. Designing always involves processes of social negotiation among participants; this is one of the ways that designing activities are implicated in the reproduction of technoculture.

Social Integration

Designing activities also imply processes of social integration, where people with different expertise, investments, and skills are managed and organized to contribute to the overall design effort. Designing is a multidisciplinary endeavor that requires the contribution of many people with differing skill sets. The term *articulation* is useful in part because of its double meaning: articulation is both a *process* (of meaning-making) and a *production*. As a process of meaning construction, articulation describes the practice of forging associations among signifying elements. The meaning of an element is established in part through its semiotic relationship to other elements of the ensemble. The constitutive signifying elements of a formation cohere through specific practices of *articulation*. The *design* of a digital technology, application, or experience requires the involvement of many people who contribute distinct forms of labor: intellectual, artistic, managerial, representational, communicative, physical, emotional, and funereal. Their efforts and labor must be integrated. Tasks require coordination. Communication must be facilitated. Resources must be acquired, maintained, allocated, and dispersed. End users must be identified, recruited, and trained. All these functions—coordination, facilitation, acquisition, maintenance, allocation, recruitment, and dispersion—are *articulatory* practices, the processes whereby the activities of individuals are organized as part of a collective effort identified as "design."

Participants in the designing process are never merely passive receivers of preconceived meanings. They are better understood to be active coproducers of the meanings of technology-under-development. They are, in this sense, key members of what Jenkins and colleagues (2008) refer to as participatory cultures.

Design as a New Liberal Art

The previous section elucidated the process of design primarily through references to studies and analyses of formal design situations. But these elements are also evident when looking at the issue of design at an informal level—the level of the everyday activities of designing that happen within the context of participatory cultures. Here the connection to Jenkins and colleagues' list of literacies is most provocative. In an essay titled "Wicked Problems in Design Thinking," Richard Buchanan—one of the founding figures in the field of design studies—asserts that design is a "new liberal art of technological culture." In making this assertion, Buchanan returns to the work of John Dewey to remind us that Dewey promoted an understanding of technology as "an art of experimental thinking" (Margolin and Buchanan 1998, p. 5). This leads Buchanan to assert that design thinking is of utmost value in complex technological culture. He reframes Dewey's assertion to suggest that design is

the term for the activities whereby technologies are used as experimental thinking materials. Technologies, in this sense, are understood as an expressive medium. People think through and with their tools, and the tools enable new insights and cognitive connections. In this way technologies *collaborate* in the creative process, the process we (i.e., Buchanan and I) call designing. This suggestion lays the groundwork for thinking about design as an important body of knowledge that should be incorporated into basic educational programs—in essence, as a "new liberal art." With this in mind, consider again the list of the skills itemized by Jenkins et al. (2008, p. 4) and that define for him the requirements for robust engagement in participatory culture.

> Play—the capacity to experiment with one's surroundings as a form of problem-solving

While problem-solving is not the only motivation for engaging in designing activities, the identification of a problem and of the constraints that define a problem space are important aspects of design thinking.

> Performance—the ability to adopt alternative identities for the purpose of improvisation and discovery

Designing involves improvisation with materials and stories. Sometimes this activity is referred to as "tinkering." Designing incorporates nonpurposive engagement with potential materials.

> Simulation—the ability to interpret and construct dynamic models of real-world processes

Designing involves the creation of prototypes of new ideas, technologies, applications, and experiences. Sometimes these prototypes take the form of digital simulations; other times these prototypes are worked out in material form. A wide range of tools, including new varieties of digital design applications (Rhino, Maya, Processing) and new visual and multimodal authoring programs (Sophie, Scratch) expand the form factor of prototypes that represent models of real-world processes and objects.

> Appropriation—the ability to meaningfully sample and remix media content

In that design practices enact the logic of technocultural reproduction, previous materials (media content, built forms, functional systems) are borrowed and replicated as elements of a new design. In the process of appropriating previous materials, the meaning of the new design is reworked as a consequence of situating the materials within a new expressive context.

> Multitasking—the ability to scan one's environment and shift focus as needed to salient details

The meanings that designers create are mediated through the production of objects that can be material as well as digital, representational as well as gestural, and theoretical as well as physical. Engineering design researcher Louis Bucciarelli (1994) describes *design* as the place where *two worlds collide*: the object-world and the world of interests of the design participants.[16] In this sense, objects, too, participate in the designing process by evoking knowledge, stimulating discussion and the production of discursive understandings, and manifesting the matter of the world. This requires that the designer have the ability to shift attention rapidly from the world of objects to that of abstractions, from the social world of meaning creation to the various channels through which media flow.

> Distributed Cognition—the ability to interact meaningfully with tools that expand mental capacities

Designing involves the realization of knowledge claims through the use of a range of prototyping tools and through the creation of different kinds of evocative knowledge objects. In engaging with objects, human participants create provisional understandings that are conveyed in story form. Objects must be continually reproduced as meaningful entities and participants throughout the designing process. Through the co-creation of objects, narratives, identities, and dispositions, a set of shared social understandings emerges about the designing process itself.

> Collective Intelligence—the ability to pool knowledge and compare notes with others toward a common goal

Designing is inherently multidisciplinary; it requires the construction of creative and productive relationships among humanists, artists, engineers, and technologists, each of whom has something necessary to contribute to and to *learn from* the experience of collaborative multidisciplinary design and technology development.

Judgment—the ability to evaluate the reliability and credibility of different information sources

As part of the designing activity, designers seek to identify the multiple contexts within which technologies take shape and have effects. This involves a consideration of how all participants in a proposed design—the designers, the users, and the generations yet to be born—are implicated in the materialization and the dematerialization of the technology-under-development. The range of expertise required for the assessment of a design includes not only deep understanding of technical principles and protocols but incisive knowledge about the psychological, social, political, and institutional contexts that make the innovation meaningful, relevant, and effective.

Transmedia Navigation—the ability to follow the flow of stories and information across multiple modalities

Designing involves the production of socio-technical-cultural assemblages. The elements of the assemblage are reworked in the process of designing. Using reverse engineering methods, designers employ a set of techniques for analyzing an existing technology to determine its constitutive parts and pieces and the interdependencies among functional components. By working backward from the construction of a functioning technology, a designer gains useful information for the creation of a novel technological instance. In thinking about the notion of "transmedia navigation," the designer might apply a set of techniques that I call *hermeneutic reverse engineering*.[17] Here what is "reverse engineered" are the elements that contribute to the meaning of a given problem space or technology-under-development. These techniques focus on uncovering the layers of sedimented meaning as well as the meanings that circulate through different media channels.

Networking—the ability to search for, synthesize, and disseminate information

Designing involves practices of cultural analysis for the purposes of explicating what Geertz (1973) called "webs of significance"—the cultural matrix within which something makes sense. The process of cultural analysis uses basic techniques of description, analysis, and elucidation. To *describe* something adequately requires the use of specialized vocabulary and knowledge of diverse cultural vernaculars.[18] The step of *analysis* can involve formal methods of linguistic and grammatical parsing or the decoding of visual symbols or representations. This is the stage where the full range of methods of textual and literacy criticism come into play.[19] The step of *elucidation*—of interpretation—involves the creation of an account of the way in which meaning coheres through the association among various signifying elements. Just as the practices of reverse engineering focus on identifying constitutive components of a functioning technology or system, these steps identify the main "elements of signification" that invest a particular design with meaning.

Negotiation—the ability to travel across diverse communities, discerning and respecting multiple perspectives, and grasping and following alternative norms

At a foundational level, to design a new technology one needs to apprehend it from multiple perspectives: the historical, the social, the cultural, *as well as* the technical, instrumental, and material. Designers must be exposed to multiple knowledge frameworks: (1) the history of technology; (2) the development and use of critical frameworks for assessing technologies in their various forms (media, infrastructure, subcultural practices, devices, and artifacts); and (3) disciplinary approaches that provide skills for the detailed assessment of global technocultural contexts such as international studies, policy studies, and anthropology. This ability to negotiate different frameworks and perspectives is a foundation for the exercise of creativity. As William Mitchell, former director of the MIT Media Lab, writes, the genesis of a "creative act is the escape from one range of assumptions to another" (Mitchell, Inouye, and Blumenthal 2003, p. 31).

Designing, Creativity, and the Technological Imagination

To consider design a new liberal art is to invoke the notion of transdomain creativity: this concept expresses the understanding that creative thinking is central to the development of new ideas in every discipline and domain of human activity, although the practices that yield new and novel ideas within a given discipline/domain may differ. What signifies an idea as novel and creative also differs across domains. For example, in the arts, creativity is manifested in a novel form of aesthetic expression; in business, creativity is realized through entrepreneurial activities;

in the sciences, creativity is demonstrated through elegant proofs and well-formulated hypotheses. Creativity, in this sense, is a cultural construct; the signs of "creativity," of "innovation," and of "novelty" are expressions of cultural (domain-specific) sensibilities. Learning "to be creative" is in part a process of learning what it "means" to be creative in a specific domain.

Incorporating designing activities and design thinking into digital media and learning efforts is not only a strategy for fostering creativity in different disciplinary contexts; it is also a way to train the technological imagination of those who are active within participatory cultures. The education of the designer's technological imagination requires not only multidisciplinary training but also, following the suggestion of Jenkins et al. (2008), the development of new literacies. These new skills do not compete with traditional print-based literacies but build on and complement them. These skills involve learning how to use tools and applications for the production of multimodal forms of expression, techniques for rapid prototyping, processes of iterative experimentation, and skills in social negotiation and integration.[20]

Because the efforts of digital media and learning focus on the use and development of new technologies (for expression, communication, and networking), the explicit development of the technological imagination is an important horizon of learning and pedagogy. Designers work the scene of technological emergence; they hack the present to create the conditions of the future.[21] In this sense, they need to be encouraged to develop a robust imagination about *what could and should* be done differently with technologies that are already in existence. The best of this work will also suggest new technologies to develop. To be fully engaged participants, people need to learn *how* to do things differently with technologies. During the designing process there are many moments when the meanings of a technology-under-development are themselves under construction. Although these moments may be fleeting, each moment of reproduction offers an opportunity to change the way in which technologies are developed, deployed, implemented, and discarded. Designing always offers an opportunity to do something that has not been done before and to create something unique and untried. Designing provides participants with the tools to *exercise* their technological imaginations in the creation of our collective futures.[22] These are the possibilities that animate the designer's imagination and serve as the foundation for the reproduction of technocultures of the future.

Notes

1. This question is suggested by the title of the book *Design as a Catalyst for Learning* (Davis et al. 1997), which reported on the use of design activities in K-12 classrooms.
2. Design researchers Richard Buchanan and Victor Margolin staged a conference called "Discovering Design: Explorations in Design Studies" in 1990 that led to an edited collection of essays in a book of the same name published in 1995. Soon after the journal *Design Issues* was launched. Margolin and Buchanan (1998) followed up with a second edited volume called *The Idea of Design: A Design Issues Reader* that collected key essays that extended the horizon of inquiry in design studies.
3. The term *cultural reproduction* was used by Bourdieu (1984) to describe the way in which cultural values are replicated from one generation to another, usually through educational systems that function (according to Bourdieu) to reproduce the values of a ruling class, thereby ensuring the continuation of relations of oppression and domination.
4. The schematic offered by Galle (1999) of the "generic artifact production process" incorporates many of the elements of a hermeneutic understanding of design as the process of meaning-making. He emphasizes the mediating role of design "representations"—the sketch, the design brief. These symbolic representations play an important role in bringing the artifact into material existence by mediating among "artifact-ideas" and artifact production. Winograd and Flores (1986), in their classic work, *Understanding Computers and Cognition: A New Foundation for Design*, turn to hermeneutical theory for philosophical insights into the process of creating artificial intelligence systems, supporting the assertion that design is a meaning-making activity.
5. For a discussion of the cultural significance of designing, see Julier (2000), as well as Margolin and Buchanan (1998) and Margolin (2002).
6. For example, design philosopher Richard Coyne identifies the use of metaphor in designing practices as a technique that "sets up a distance that is also a space for imaginative thought" (Coyne 1995, p. 307). In this case the creative deployment of an expressive (cultural) form—the metaphor—enables an important epistemological move within the design process. The metaphor creates an epistemological space for creating new possibilities.
7. Although the focus of Krippendorf's (1995) discussion is to elaborate the notion of "product semantics" as a structure for understanding how technologies and artifacts communicate symbolic meanings, his broader point is important for my argument here: that design is the process of meaning-making. I build on Krippendorf's "semantic" emphasis to examine the ways in which

meaning is produced, reproduced, negotiated, and contested in the process of designing.

8. Strathern (1992) is careful to situate this "reproductive model" in a particular Euro-American view of procreation. Nonetheless, she notes that it offers an interesting approach to think about such issues as continuity, change, potentiality, and the future, both as these apply to the intellectual work of anthropology as a discipline and as they identify the key processes of cultural reproduction.
9. As the philosopher of technology Carl Mitchem explains, the formulation of the nature of technology in this way is at root a metaphysical debate: "[A]t some level of abstraction technology does appear to be one and autonomous; all technology is technology with a broad historical trajectory that appears to transcend particular times and places. At another level the diversity of technologies belies any strong unity; unity appears no more than nominal. The root issue, a metaphysical one concerns the different realities present in the different levels of analysis" (Mitchem 1994, p. 110).
10. Star and Bowker (2002) describe the importance of understanding the social and theoretical role of infrastructure in analyzing new media formations. Star, in particular, is a leading theorist of "infrastructure" as an emergent area of research within science and technology studies and new media studies.
11. In their introduction to the *Handbook of New Media*, Lievrouw and Livingstone (2002) succinctly describe a framework for understanding new media technologies (information and communications technology) that acknowledges the rich interweaving of media technology, human action, and social structure.
12. In the introduction to their edited book, *Shaping Technology/Building Society*, Bijker and Law unequivocally state, "[A]ll technologies mirror our societies. They reproduce and embody the complex interplay of professional, technical, economic, and political factors" (Bijker and Law 1992, p. 3). This leads some technology design researchers to argue that what is always being designed is a *sociotechnical system*, never simply a device, an application, or a product.
13. Deleuze and Guattari (1987) elaborate a theory of assemblages in *A Thousand Plateaus*. DeLanda (2006) takes on the task of elucidating how the notion of "assemblage" allows for new insights into the complexity of social arrangements. In contemporary cultural studies, the distinction between the terms *assemblages* and *formation* is nuanced. Early in the development of cultural studies, Williams (1961, 1981) introduced the term *formation* to describe the complex organization of a historically contingent cultural arrangement. This notion was further elaborated as an outcome of "articulations." Hall (1996) used the term *articulation* as the name for a structured totality that is neither inevitable nor unending. According to Hall's account, the unity of a structured totality (i.e., its sensibleness, meaning, and manifestation) is itself a construction, constituted by connections among different elements that make up a formation. Drawing on earlier work by Hall, Slack developed the notion of technology as articulation when she wrote that technology should be studied "as a non-necessary connection of different elements that, when connected in a particular way, form a specific unity" (Slack 1989, p. 331). Slack and Wise (2005) elaborate the relationship between articulation and assemblages in *Culture and Technology: A Primer*.
14. While a growing body of work in engineering design research now explicitly considers cultural questions in the elaboration of theories and philosophy of design, this research has not yet widely influenced the development of curricula in engineering or interactivity design. Sometimes the reference to culture is implicit, as when design researchers discuss designers' use of metaphor and symbols. In other work the notion of culture is prominent, although subtle differences exist in how the term is invoked. In ethnographic studies of design practice, for example, the notion of culture is used in two ways: (1) as the term for the organizational context for the proposed design, as in design for products that have to fit the "culture of BMW" or the "culture of IBM"; or (2) as the context of the working environment of the design groups themselves, as in the "culture of IDEO" or the "culture of PARC." The latter usage of the term draws on an anthropological notion of culture as the set of practices and sensibilities of a bounded social collectivity. A volume of the journal *Design Studies* was devoted to the topic of ethnographic design research. A representative article is Lloyd (2000).
15. Sociologist Andrew Feenberg describes technological designs as "negotiated achievements." He notes that the rationality of a particular design solution—that is, the "rightness" of a design—is an outcome of social interactions that is, at its most fundamental, a process of meaning-making and negotiation. Feenberg elaborates the role that social negotiation plays in the designing process, pointing out that "technological rationality doesn't spring fully formed from the mind of the technologist nor from the results of an experimental manipulation of materials" (Feenberg 1995, p. 4).
16. Bucciarelli describes design as involving "the process of achieving consensus among participants with different 'interests' in the design. . . . [T]hose different interests are not reconcilable in object-world terms" (Bucciarelli 1994, p. 159). Consensus is accomplished, according to Bucciarelli, through the use of a particular rhetoric of the object that renders the object meaningful in deterministic terms. Certain materials or components are said to favor certain conditions; for example, "this circuit board will be happiest in a ventilated environment." As Bucciarelli notes, an important part of the design process is to communicate these understandings of the object-world to others. This rhetorical turn produces closure for the negotiation process: "[W]e know this to be true therefore there is no more need for discussion." Contradictions are settled by the rhetorical strategies of design participants. Bucciarelli suggests that a better way of describing the communicative act of designing

is to use the term *story making*. "Story making is a better metaphor—story making about voltages and currents, tank dimensions and air pressure. . . . This story making is constrained by these mundane concepts and features in that they must behave deterministically in accordance with an accepted set of principles and rules, and there is general consensus not only on what they are (voltage, stress, pressure) but also on how to measure their character in hard, quantitative terms. Nevertheless, there remains much to be constructed of their relationships and interactions in particular circumstances within object worlds. The elements are there, but their synthesis requires rhetorical skill and creative effort" (Bucciarelli 1994, p. 88).

17. The protocols of hermeneutic reverse engineering identify both a set of *research* practices and a *design* methodology. Hermeneutic reverse engineering includes a set of basic steps for the creation of a cultural analysis. Anthropologist Clifford Geertz (1973) aptly noted that the apprehension of culture is a daunting project. What is needed, he argued, is a set of methods to cut the project down to size. To this end, Geertz proposed the notion of "thick description" as a procedure for discovering the frames of meaning within which people live their lives. Although Geertz borrowed the phrase "thick description" from the philosopher Gilbert Ryle, it came to identify Geertz's signature approach to the practice of ethnography. In proposing the notion of "hermeneutic reverse engineering," I draw inspiration from several key theorists of design who advocate the use of methods of cultural analysis for the purposes of creating a more nuanced understanding of the cultural work of designing. Coyne (1995) elucidates a new philosophical framework for designing by drawing insights from Hans-George Gaudier, Martin Heidegger, and Jacques Derrida (among others) to provide a foundation for thinking about the role of language in the design process. Love (2002) identifies hermeneutics as one of the research paradigms that can contribute to the creation of a philosophy of design.
18. This resonates with Tufte's invocation of the practice of "intense seeing," which he defines as "the wide-eyed observing that generates empirical information" (Tufte 2006, p. 9). This practice, common to both art and science, is the first stage of the production of knowledge. Tufte's book explores "how seeing turns into showing."
19. See, for example, Barthes (1970), Abrams (1971), Hawkes (1977), and Belsey (1980).
20. For a fuller discussion of the new skills that are learned through incorporating critical design activities in digital media classrooms, see Anderson and Balsamo (2007).
21. In making this claim, I draw inspiration from both Johnson's (2002) work on "emergence" and Thackara's (2005) consideration of the social purposes of designing.
22. In my forthcoming book (Balsamo, forthcoming) I discuss various design projects where the designers explicitly considered issues of culture throughout the designing process. I examine how the *exercise* of the technological imagination *reproduces* cultural understandings at every turn. I define the technological imagination as a quality of mind that enables people to think *with* technology, to transform what is known into what is possible. This imagination is performative; it improvises within constraints to create something new. People engage the materiality of the world through the exercise of their technological imaginations in order to create the conditions for future world-making. In the active engagement between human beings and technological elements, culture, too, is reworked through the development of new narratives, new myths, new rituals, new modes of expression, and new knowledges that make the innovations meaningful. When people participate in designing activities, their technological imaginations are engaged in a complex process of meaning-making whereby *both* technology and culture are created anew. What gets reproduced is a particular (and historically specific) form of techno-culture. For this reason, I assert that cultivating and shaping the technological imagination is a cultural imperative of the highest order. And, yet, in only a few places in the world can one learn how to engage in practices of technological development that consider *from the outset* the cultural aspects of an intended innovation. Based on an analysis of how imagination unfolds throughout the designing process, I speculate about what would be required to educate and inspire imaginations that are as ingenious in creating *new democratic cultural possibilities* as they are in creating new kinds of technologies and digital media. The horizon I seek is nothing less than the transformation of educational programs and the development of learning strategies adequate to the task of inspiring culturally attuned technological imaginations. The resonance with Mills's (1959) notion of the "sociological imagination" is intentional. Mills defined the sociological imagination as a quality of mind that "enables its possessor to understand the larger historical scene in terms of its meaning for the inner life and external career of a variety of individuals. It enables him to take into account how individuals in the welter of their daily experience, often become falsely conscious of their social positions. . . . For that imagination is the capacity to shift from one perspective to another—from the political to the psychological; the examination of a single family to comparative assessment of the national budgets of the world; from the theological school to the military establishment; from considerations of an oil industry to students of contemporary poetry" (Mills 1959, pp. 5–7). De Lauretis, Huyssen, and Woodward (1980) edited an important volume titled *The Technological Imagination: Theories and Fictions* that explicitly explores the notion of the technological imagination in the history of art and literature. See also Woodward (1980).

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