# Do-It-Yourself Information Technology: Role Hybridization and the Design–Use Interface

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**Information technology designers and users are generally treated as interacting yet distinct groups. Although approaches such as participatory design attempt to bring these groups together, such efforts are viewed as temporary and restricted to a specific knowledge domain where users can share key information and insights with designers. The author explores case studies that point to a different situation, role hybridization. Role hybridization focuses on the ability of individuals to shift from one knowledge domain to another, thus allowing for simultaneous membership within two otherwise distinct social worlds. While some studies focus on the ability of designers to act as users, this study focuses on the opposite situation, users who become designers. Interview and participant observation data is used to explore hybrid user–designers in two case studies: frog dissection simulations used in K-12 biology education and human anatomy simulations used in medical education. Hybrid users as designers are one part of a larger design–use interface, illustrating the mutually constructive relationship between the activities of information technology design and use. Users as designers also challenge the traditional power relationship between designers and users, leading to a novel and exciting form of user-centered design.**

## Introduction

How can users participate in design? User-centered design, which emphasizes the need for information technology (IT) designers to learn from users to develop software suited to their needs, has become an increasingly common approach in the literature (Benoit, 2004; Bergman, Beyth-Maron, & Nachmias, 2003; Large, Beheshti, & Rahman, 2002; Ma, 2002; Petrelli et al., 2004; Wildemuth, 2004; Xie & Wolfram, 2002; Yang, 2001). Although this approach does involve users, it reinforces a division between designers and users; consequently, it serves to reinforce a power dynamic that makes users dependent on designers' interest in listening to users' articulation of their wants and needs. In contrast, in this article empirical data is used to argue that IT designers and users are not always necessarily distinct groups, by documenting cases of hybrid user–designers who cross from one role to another or even simultaneously occupy both roles. These examples demonstrate the mutually constructive relationship between design and use as well as the potential to destabilize the traditional power dichotomy between designers and users of information technologies.

To begin, the background of role-hybridization and the user–designer hybrid in the literature is given. Next, the research design and analytic framework are explained. Research findings are then provided for the two case studies: cyberfrogs used to teach frog dissection to K-12 biology students and cybercadavers used to teach gross anatomy to medical students. The discussion section begins with a comparison of the two case studies, and then continues by situating this study within the literature discussed in the background section. Finally, the conclusions of the study include applications of this research to the development of a notion of the design–use interface and the practical implications of this research for the relationship between designers and users.

## Background: Role Hybridization and the User–Designer Hybrid

Role-hybridization is a concept that dates back to the work of Joseph Ben-David and Randall Collins (1966) on the development of psychology. According to Ben-David and Collins, the field of psychology emerged as a specialty when practitioners and students from physiology moved to the field of philosophy, bringing their empirical methodologies to that field and creating the field of psychology. In this case, role hybridization led to not only a new scientific field, but also to a shift in the power relations among fields, because it was the empirical approach of physiologists that allowed them to wrestle control of the study of the human mind from philosophers.

In a study of the information processes of interdisciplinary scientists, Palmer (1999) finds that although not all

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members of interdisciplinary research centers cross disciplinary boundaries, some scientists do operate simultaneously in multiple fields. In particular, she explains that team leaders "attempt to keep a range of domains within their intellectual grasp" (p. 250). Palmer's study illustrates the varying degrees of role hybridization possible.

In an example that begins to transcend science and enter into the domain of practice, Epstein (1996) explores the push for expertise among AIDS activists, which led some AIDS activists to pursue careers in medicine to legitimize their knowledge. The attempt by activists to legitimize their knowledge resulted in significant changes in AIDS research and treatment as well as broader transformations in the physician–patient relationship in general. Thus, much like Ben-David and Collins (1966), Epstein found that role hybridization could result in a shift in power relations among social groups.

This study applies the concept of role hybridization to the field of information technology by focusing on hybrid IT user–designers, who go from being consumers of applied computing hardware and software to becoming producers. Christina Lindsay (2003) has documented one example of hybrid IT user–designers. Radio Shack first released the TRS-80 in 1977, but subsequently abandoned the technology only a few years later. Yet, Lindsay found that the TRS-80 still has an enthusiastic group of users almost 20 years after its demise as a commercial product. Over the past two decades, users have begun to fill the roles left vacant by the demise of the TRS-80 as a commercial product such as "designers, producers, marketers, distributors, and technical support" (p. 29). As a result, the TRS-80 has remained a dynamic technology despite its abandonment by its original designers. Lindsay's study of the TRS-80 and its enthusiastic and active users is very similar to the literature on technological appropriation, which focuses on the role that users can play in designing unexpected modifications and new uses for existing technologies (Eglash, Croissant, Di Chiro, & Fouche, 2004; Hess, 1995).

An opposite strategy can also yield role hybrids. For example, Beyer and Holtzblatt (1995) give the typical example of designers who choose to adopt the role of user to understand better the needs of users. Heidorn, Mehra, and Lokhaiser (2002) put this immersion strategy into practice in their study of the ecosystem monitoring program ForestWatch in 2000, and found that it can be a useful strategy for creating an intersection between design and use. While Lindsay (2003) found users who adopted the role of designers, the immersion approach results in designers taking the position of users, demonstrating that there are multiple ways to create role hybrids.

In his study of the design process, Steve Woolgar (1991) and his colleagues (Cooper, Hine, Rachel, & Woolgar, 1995; Grint & Woolgar, 1997) argue for a notion of "configuring the user" (Grint & Woolgar, 1997, p. 72). They define "configure" here as "to define, enable, and constrain" (p. 74) the user such that some readings of a technology by the user are more likely than others. Woolgar tells anecdotal stories about a company where he conducted participant observation: Clear lines were drawn between designers and users, and individuals within the company were assumed not to be able to play the role of a naive user. Based on this case study, he argues that there are clear boundaries drawn between designers within the company and users outside the company, and that these boundaries play a huge role in the understanding of design and use on the part of the designers.

Others, such as Bowers and Pycock (1993) and Mackay, Carne, Beynon-Davies, and Tudhope (2000) apply symmetry to Woolgar's notion of configuring the user, and argue that just as designers configure users, users also configure designers. Mackay and his colleagues explain that in their case study of software design and use, the software is being produced for internal consumption, thus the boundary of inside and outside the company does not match the standard dichotomy of designers and users. Not only are users inside the company, but they are more powerful in their study than are the designers. Thus, it is dangerous to assume either (a) that there is an inside or outside distinction between designers and users, or (b) that there is a constant power dichotomy in place. Such contrasting examples clearly make the design–use interface a more interesting problem than had been initially assumed.

Lucy Suchman (1999) applies the feminist epistemology of Donna Haraway (1991) and others to develop a more nuanced understanding of the design–use interface as a two-way meeting place between designers and users, who cannot be fully separated by a false dichotomy. Suchman argues that viewing design as a process of developing distinct and discrete devices is a limited perspective because it does not allow for a richer understanding of the social relationships, "including both contests and alliances" (1999, p. 258) that influence the development of new technologies. She argues that this myth is underwritten by "the designer/user opposition" (p. 258), which prevents a more sophisticated understanding of the relationships among individuals involved in the design and use of technologies.

In this article I expand upon the work of Ben-David and Collins (1966), Palmer (1999), and Epstein (1996), taking the concept of role-hybridization to the domain of IT design and use. The study differs from the literature on user-centered design and the immersion strategy because it focuses on users who become designers, a process which acts to destabilize the traditional power relations between designers and users. Points of contrast with the study by Lindsay include case studies of wider relevance and an increased emphasis on the political implications of users as designers.

## Research Design and Analytic Framework

The data is taken from two case studies: frog dissection simulations used in K-12 biology education (cyberfrogs) and human anatomy simulations used in medical schools (cybercadavers). These case studies involved ethnographic research on the designers and users of cyberfrog and cybercadaver software, including 61 semistructured


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interviews, 105 hours of participant observation in design laboratories, educational settings, and conferences, and analysis of 20 relevant software products. Following the research protocol, which was approved by the relevant Institutional Review Board, simulation designers were given the option to be identified or to remain anonymous, and thus the use or protection of names in this article reflects this choice. The data analysis is based on grounded theory, such that data were coded according to salient categories that emerged from the interviews, participant observation, and software analysis (Strauss & Corbin, 1998).

The data are interpreted within the context of symbolic interactionism, the theoretical tradition that is responsible for the methodology of grounded theory. Specifically, one of the offshoots of symbolic interactionism, the social world perspective, is used here to understand the relationships among the individuals and groups included in this study (Strauss, 1978, 1984). A social world can be defined as "a set of common or joint activities or concerns bound together by a network of communication" (Kling & Gerson, 1978, p. 26). In contrast to the cultures studied by traditional anthropologists, social worlds are often non-geographically bounded communities, including social worlds of scholars (Covi, 1996; Kling & Covi, 1995; Martens, 2001) and Internet-based social worlds (Fitzpatrick, Kaplan, & Mansfield, 1996; Kazmer, 2002; Kazmer & Haythornwaite, 2001; Kling, 1996; Mark & Poltrock, 2003; Tolone, Kaplan, & Fitzpatrick, 1995). Originating from the sociology of work, this theory focuses on disciplines, specialties, and controversies (Clarke & Star, 2003).

This study also relies on another concept originating within the tradition of symbolic interactionism, boundary objects. Boundary objects, developed by Susan Leigh Star and James R. Griesemer (1989; Star, 1989), bridge social worlds by residing within the boundaries shared by social worlds. Boundary objects are highly portable, and can be understood by members of different social worlds. The boundary object framework is illustrated by the Venn diagram in Figure 1, illustrating how boundary objects emerge from the meeting point of two or more intersecting social worlds (Fleischmann, in press).

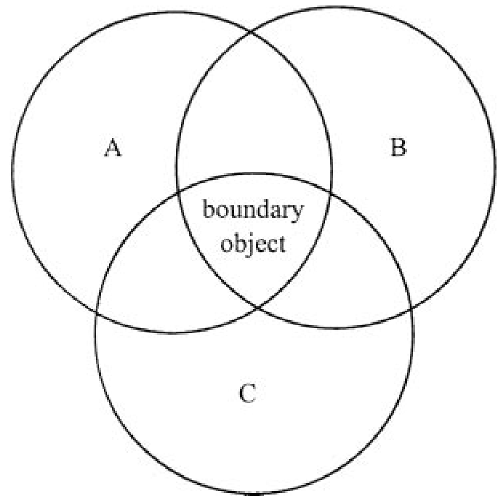


FIG. 1. Boundary object at the intersection of social worlds.

## Research Findings I: Hybrid Cyberfrog User–Designers

For the cyberfrog case study, three social worlds intersect to create frog dissection simulations as boundary objects: biology education, animal advocacy, and simulation design (see Figure 2). While the relationship between biology educators and animal advocates is a particularly contentious one that goes back to the origins of the educational use of animals and the animal advocacy movement, the relationships of these two social worlds with the social world of simulation design are a more recent phenomenon that had led to the development of cyberfrogs.

Biology educators teaching at the K-12 level have relied heavily upon animal dissection as a pedagogical methodology for over 60 years, leading animal dissection to attain a status as a rite of passage for middle and high school students (Orlans, 1993). Frog dissection is the most common form of animal dissection, such that in 1969, nine million frogs were shipped to educational institutions in the United States, while in the late 1980s, 75 to 80% of high school students participated in frog dissection (Orlans, 1988). Traditionally, biology educators have staunchly defended the activity of dissection in the face of increasing opposition within some circles, and they have emphasized the hands-on aspect of dissection. However, the development and refinement of cyberfrogs has led some biology educators to consider them as alternatives and in some cases, to embrace the environmental and technological dimensions of cyberfrogs.

Animal advocacy has a history in this country dating back over 100 years. Opposition to animal dissection and

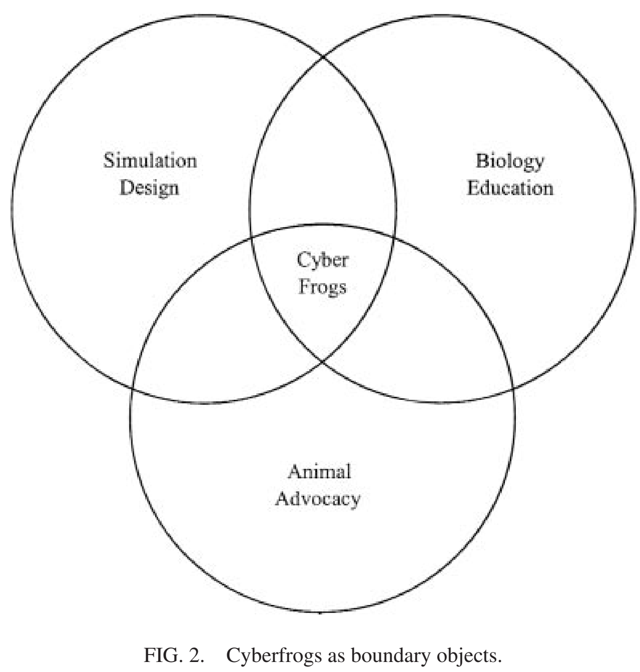


FIG. 2. Cyberfrogs as boundary objects.


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vivisection has traditionally been a major issue for animal advocates, yet prior to the development of cyberfrogs, animal advocates had very few alternatives to advocate, and thus primarily focused on efforts to eliminate dissection from the curriculum. As a result, animal advocacy groups were branded with a stereotype as opposing science, technology, and progress in general. Yet, cyberfrogs have allowed them to take a different approach, arguing for the use of cyberfrogs in place of frog dissection. Here, they have been able to largely turn the tables on traditionalists who defended animal dissection; now, animal advocates are able to cast themselves as advocates not only of animals but also of science, technology, and progress, as illustrated by the names of some animal advocacy organizations and subgroups (Fleischmann 2003). Cyberfrogs have brought animal advocates closer to both biology educators and simulation designers.

Simulation design as a commercial field has largely focused on developing products that can garner widespread interest and, in the case of private firms, generate profit. Simulation designers produce products for a wide range of purposes, including research, education, and entertainment. Educational computer simulation designers often focus on the K-12 market because of the large potential audience for their products. In the case of cyberfrogs, the large number of students who participate in dissection, as well as the increasing barriers to dissection in K-12 such as the cost of purchasing specimens and the potential security and liability issues involved with giving students scalpels has opened up a sizeable potential market for cyberfrogs. Animal advocates have served an important role in promoting the use of cyberfrogs (Fleischmann, 2003), and biology educators have increasingly warmed to the use of cyberfrogs as well. The lack of interest in tapping this market among larger software manufacturers has left the competition for market share to relatively small simulation design firms as well as some interdisciplinary academic teams.

The relationship between simulation designers and animal advocates is characterized by an intersection of shared values (Fleischmann, 2003). Simulation designers and animal advocates, meeting primarily at conferences, developed a common ground to further their respective core values. Thus, this intersection arose as a result of collaboration.

In contrast, the divide between the social worlds of simulation design and biology education has been bridged by hybrids who move between these social worlds, or who simultaneously occupy both social worlds. Dissection simulation design requires a combination of technical expertise and biological knowledge. In particular, many simulations are intended to be knowledge-based simulations capable of supplementing or replacing not only the frog but also the textbook and teacher as well. There are two main approaches for generating this combination: using teams or partnerships that include individuals with technical expertise and individuals with biological knowledge, and a reliance on hybrid expertise on the part of individuals or groups who have knowledge in both domains.

The software products studied in this project fall into both categories. Particularly good examples of the team or partnership model include Digital Frog International (DFI; Puslinch, Ontario, Canada) and Neotek (Pittsburgh, PA). Neotek is an extreme case of a partnership approach, because it is the company with the clearest distinction between software development and biological content. Neotek's founder, John Urbanic, is a technical guru whose outstanding achievement was the development of a new method of rendering three-dimensional (3-D) data. In founding Neotek, he decided to keep the company lean, choosing not to hire content experts on staff, but instead to develop partnerships with experts in various fields and in different geographical locations. This corporate structure has kept the company small yet profitable. The style of software developed at Neotek seems to exemplify this kind of partnership and to explain how it can work in this case—the software is a collection of still 3-D images, in the case of their Frog Dissection Laboratory, of a prosected frog specimen. Since Neotek's software is merely a simulation of the frog itself, without incorporating as much expertise in terms of the procedures and underlying physiology that are incorporated in many other frog dissection simulations, Neotek's geographically distant collection of loose partnerships and collaborations may work better for this company than it would for some of its competitors.

Digital Frog International began as a partnership between a technologically gifted physics major (Simon Clark) and a veterinary student. The company has since relied on a division of labor between technologically oriented and scientifically oriented team members. Interestingly, DFI also includes more than just these two types of expertise: the president of DFI, Celia Clark, combines pedagogical expertise and technical writing proficiency, along with a talent for marketing. In contrast to Neotek, DFI is a self-sufficient software company with clear demarcations in terms of the roles and expertise of the individual designers.

The other cyberfrog companies appear to rely more heavily on hybrid expertise. The Schneider & Morse Group (Sylvania, OH), ScienceWorks (Burlington, NC), and Froguts (Tampa, FL) all fit best into this category. The Schneider & Morse Group is one company that relies heavily on hybrids. The Schneider & Morse Group is a subset of the team at the Medical University of Ohio that designed the human anatomy simulation, Anatomy Revealed. The team responsible for ProDissector overlapped significantly with the Anatomy Revealed designers; however, only one of the anatomists involved in Anatomy Revealed is part of the Schneider & Morse Group (Dennis Morse). While there was a clear division of labor and split expertise in the design of ProDissector, the primary individuals, Roy Schneider and Dennis Morse, are hybrids. Schneider, in particular, is both a medical illustrator with expertise in both anatomy and computer animation. His hybrid expertise led him to develop the original idea that led to both Anatomy Revealed and Prodissector, using sliders to melt the individual anatomical layers and make them transparent. This methodology is quite distinct from the ways of looking into the body generally employed by either anatomists or simulation designers. Thus, the concept upon which ProDissector is based is distinctly hybrid.

ScienceWorks is a particularly excellent example of a multiple-employee company composed of hybrids. The four founders of ScienceWorks, whose first joint project was DissectionWorks: Frog, are all both biology teachers and simulation designers. They all began as biology teachers with a side interest in educational simulation, and as they devoted increasing time and effort to developing educational simulations for their school district, they decided that they could go into business for themselves. After founding ScienceWorks, three of the partners have since retired from teaching, yet their collective teaching experience has helped them significantly in developing DissectionWorks and their other educational simulations, as well as in marketing their software to teachers. Interestingly, the division of labor for ScienceWorks is less clear than Digital Frog International or even the Schneider & Morse Group, perhaps due to their highly hybrid backgrounds. These partners now have difficulty identifying with a particular social world, either biology education or simulation design, making them compelling examples of role hybridization.

The designers of ScienceWorks have found that their hybrid background can be very helpful not only in designing software but also in marketing it. Jim Moose explains:

> One thing that helped us as a company, when we first started, was that people understood that we were teachers. We were doing something that was actively going in the classroom. You know, we weren't just some manufacturer who was trying to sell a product. We were more than that. And I think we're still more than that (personal communication, October 14, 2002).

Thus, their hybrid background is an effective tool in establishing their credibility to teachers. The creators of ScienceWorks are able to mobilize their backgrounds as former science teachers to create familiarity and identification among biology educators, yet at the same time, their technological skills make their cybercadaver possible. Another important consideration for hybrid designer–teachers is their ability to develop software based on authoring tools. ScienceWorks co-founder Dick Shaw explains, "Finding the correct development software enables people who don't necessarily have a background in computer expertise to produce these kinds of products" (personal communication, October 10, 2002). Thus, technological developments have served to facilitate role hybridization by lowering the barriers to participating in software design. The important considerations among hybrid designers seem to be their ability to mobilize their teaching expertise in marketing their products and their ability to use authoring tools to apply their educational expertise to software design.

Froguts (http://www.froguts.com/) is the brainchild of science teacher and educational simulation designer Richard Hill. Hill developed the software while simultaneously pursuing a master's degree in educational technology and teaching at a high school in Florida. Hill's dual roles here illustrate another extreme case of role hybridization that leads to a split identification rather than steadfast allegiance to a specific identity. Froguts was useful to him in both domains, both as a part of his academic pursuits in educational technology and as a tool, which he could use for the biology portion of his integrated science classes. The popularity of Froguts is evidence that even one individual can develop a useful and successful educational simulation, as long as the individual has a hybrid background in the domains of simulation design and biology education.


FIG. 3. Spectrum of hybridity of frog dissection simulation design companies.

The simulation design companies included in this study vary widely according to the degree of biology educator–simulation designer hybridity of employees. As illustrated in Figure 3, the companies span the spectrum from a minor degree of hybridity to almost total hybridity. Interestingly, based on this sample, company size does not necessarily seem to be related to the degree of hybridity. The two smallest companies, Neotek and Froguts, are found at the opposite ends of the spectrum, while the three larger companies, while varying in terms of hybridity, are all situated between these extremes.

## Research Findings II: Hybrid Cybercadaver User–Designers

As in the case of cyberfrogs, three social worlds overlap to create cybercadavers as boundary objects: gross anatomy instruction, educational administration, and simulation design (see Figure 4). Interestingly, however, for this case

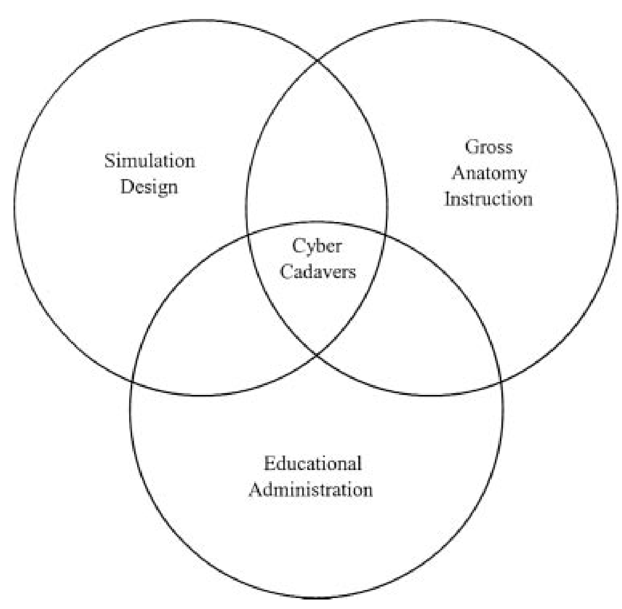


FIG. 4. Cybercadavers as boundary objects.


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study, hybrids were found at all three intersections of the social worlds. Also, cybercadaver design teams tend, in general, to be larger and more hybrid than cyberfrog design teams.

Gross anatomy instruction in modern American medical history has traditionally relied on cadaver dissection as a pedagogical activity. Cadaver dissection not only serves as an exercise for learning anatomy, it also has traditionally served as a rite of passage for future doctors, initiating them into the medical profession. Yet, because the field of gross anatomy is currently a relatively static field, the number of qualified gross anatomy instructors is on the decline, and anatomy departments are increasingly understaffed. Because of reductions in staff as well as curricular changes related to the influence of educational administrators, gross anatomy instructors are now adopting additional approaches to teaching gross anatomy, including the use of cybercadavers (Fleischmann, 2004).

While gross anatomy instructors are in charge of the basics of the gross anatomy course, educational administrators are charged with allocating time among various subject areas. Recently, educational administration implemented a variety of sweeping reforms that have directly influenced gross anatomy instruction, including the integrated curriculum and problem-based learning. Gross anatomy instructors are not always pleased by these changes, which have led to a severe reduction in the time devoted to their subject material. As a result, there often tends to be friction between educational administrators and gross anatomy instructors (Fleischmann, in press).

In the medical field, simulation designers aim to create products that can make medical education more efficient and effective. These products tend to be produced for internal, rather than external, consumption, due to specialization within specific medical schools and the smaller market overall for medical education-related simulations as compared with products that target K-12 education. However, medical schools typically have much more significant resources than K-12 schools, and thus simulation designers who focus on the medical field are able to produce more complex and technologically sophisticated products (Fleischmann, 2004).

The cybercadaver designers include hybrids that unite all three social worlds; hence, it is useful to consider the individuals at each of these intersections. Seven of the study participants are both simulation designers and anatomy instructors. Primarily, they were anatomy instructors who had a secondary interest in software design and applied this interest to their work to create teaching tools that could assist them in teaching gross anatomy. It is interesting to compare the routes that these hybrids took in uniting these different interests to create cybercadavers that span simulation design and anatomical instruction.

Norm Eizenberg is the head of the design team that created An@tomedia. This cybercadaver was the culmination of 25 years of work as a gross anatomy instructor at the University of Melbourne in developing a comprehensive and clinically relevant anatomy curriculum. According to Eizenberg (personal communication, August 25, 2003), when he asked students, "Should the curriculum determine the textbook or should the textbook determine the curriculum?" the student response was, "We want the curriculum to be a good curriculum, and we want the textbooks to reflect that, and if there aren't textbooks there, we want you to write it." So, he set out to create a clinically oriented textbook based on applying general principles. During this process, the textbook turned into an anatomy simulation, and the result was An@tomedia.

The design team for Anatomy Revealed was a combination of educational software designers and gross anatomy instructors. The project grew out of collaboration between Roy Schneider and his colleagues at the Medical College of Ohio (MCO)'s Center for Creative Instruction and three gross anatomy instructors at MCO: Dennis Morse, Mark Hankin, and Carol Bennett-Clarke. In interviews, both Morse and Hankin, like Norm Eizenberg, explained that they aimed to create an educational tool that would facilitate their teaching. Medical illustrator Roy Schneider had the initial idea for the mechanism for teaching anatomy by making the parts of the body transparent, so Drs. Morse, Hankin, and Bennett-Clarke served primarily as anatomical and medical experts as well as playing an important role in evaluating and providing feedback for the design of Anatomy Revealed's user interface.

Gary Nieder is both an anatomy instructor at Wright State University with a PhD in anatomy and the designer of the QTVR Anatomical Resource Web site (http://www.anatomy.wright.edu/qtvr/). Nieder created the anatomical resources using his laboratory specimens and QuickTime VR. The primary purpose of the Web site was to serve as a resource during gross anatomy lectures, to allow him and other gross anatomy instructors to use 3-D models as learning aids outside of the anatomy laboratory. One interesting issue raised by Nieder was the difficulty of being involved in simulation design as a faculty member. Creating educational simulation learning tools became one more responsibility added to his busy schedule. Also, he explained that it is difficult to receive recognition for the effort that he has put into technology development. As he explained, the main problem is, "How do we evaluate and quantify what we're doing?" (personal communication, August 7, 2003). Since aspects of academia such as promotion and tenure are typically based on research in the form of articles, chapters, or books, as well as teaching and service, it is difficult to determine where software design fits into this system, and the lack of recognition for their efforts seems to be a significant problem for academics involved in software development, including cybercadaver design.

David Morton, who received a PhD in anatomy from the University of Utah, worked on anatomical simulation to facilitate his teaching of gross anatomy and to complete his degree requirements. Initially, his goal was to write a paper version of a dissection manual for his master's thesis work, but his students urged him to work on a computer-based dissection guide. So, he used Macromedia Flash to develop a dissection aid for medical students. Morton explained that


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since gross anatomy knowledge has remained relatively static for the past 50 years, one potential way to train more anatomy PhDs is for them to do research on dissection simulation, rather than gross anatomy itself. Thus, an increase in simulation designer–anatomy instructors may increase the number of trained gross anatomy instructors.

Peter Abrahams of Cambridge University and collaborator Hanno Boon of the University of Pretoria have worked on cybercadavers as part of large hybrid teams. Abrahams (personal communication, August 5, 2003) argues that cybercadaver design teams need to have individuals with different domains of expertise because, "You can't be an expert at all of those things." Through such collaboration, he argues, anatomy instructors with no simulation design expertise and simulation designers with no anatomical instruction expertise can work together to create useful tools for the classroom.

Another study participant was a different type of hybrid, spanning the social worlds of simulation design and educational administration. This informant is the head of a cybercadaver design team that also includes software designers and a medical illustrator. The goal of this project was to improve both the effectiveness and efficiency of gross anatomy instruction. Interestingly, for this team, gross anatomy instructors, as well as students, are viewed primarily as users rather than being more actively involved in the design process.

Richard Drake, an anatomy professor at the University of Cincinnati, is both an anatomy instructor and an educational administrator. His role combines both administrative control over the gross anatomy program and hands-on involvement in gross anatomy instruction. Drake is primarily a user of cybercadavers, and is largely skeptical of their utility, at least in their present form.

## Discussion

Although cyberfrogs and cybercadavers are both biomedical simulations used to teach anatomy, there are significant differences in the teams generally involved in creating them. While some individuals or teams have been involved in designing both, the examples of Anatomy Revealed and ProDissector are particularly instructive. Anatomy Revealed was created first, by a design team that included three gross anatomy instructors. When members of this group decided to create the spin-off cyberfrog ProDissector, only one anatomist participated in the design of ProDissector, and the team did not include anyone with particular expertise in frog anatomy. In general, the teams of cybercadaver designers generally include a gross anatomy instructor, while cyberfrogs may be designed without initial input from biology teachers. Thus, it seems more important to have credibility in gross anatomy knowledge when designing a cybercadaver, while cyberfrog designers seem to be more able to rely on textbooks for their knowledge of frog anatomy. One aspect of this difference is that anatomical expertise is expected to travel in one direction, such that experts in human anatomy may be more likely to be assumed to have expertise in animal anatomy than the inverse. Another difference is that, perhaps because of the more important role of gross anatomy in medical education than frog dissection in biology education, gross anatomy knowledge enjoys a privileged position in the hierarchy of biomedical knowledge.

Cybercadaver design teams, as a result, seem to be larger and more hybrid than cyberfrog design teams. Although, for example, Rick Hill was able to create a cyberfrog on his own, cybercadaver design teams seem to be more diverse and grandiose. An example is the Visible Human Project, a huge multi-million dollar project funded by the National Library of Medicine. The Visible Human Project either directly or indirectly has spawned a wide range of cybercadavers, while there is no corresponding project for cyberfrogs. Cyberfrog endeavors instead tend to be more independent and individualized, relying more on hybrid individuals than hybrid teams. Thus, there are notable differences in the hybridity of cyberfrog design teams and cybercadaver design teams.

The user–designer hybrids found in this study differ from the immersion approach (Beyer & Holtzblatt, 1995; Heidorn et al., 2002) in that this study found cases primarily of users becoming designers rather than the opposite, and also that the role-hybridization was more permanent and transformative than that of the immersion approach. Because the progression from designer to user is generally seen as a downgrade in social status while moving from "only" being a user to becoming a designer (even using less technologically sophisticated approaches) is viewed as upward movement, there is an incentive for users-as-designers to stay that way, unlike designers-as-users who are happy to go back to their day jobs. Yet, the user–designer hybrids identified in this study also differ significantly from those found by Lindsay (2003) and the literature on technological appropriation. Instead of users redesigning existing technologies, in these case studies users play a role in the initial design of the technology by crossing the boundary between IT user and IT designer prior to the initial development of the particular technology in question. Biology educators or gross anatomy instructors became involved in the early stages of design projects, and actually designed new cyberfrogs and cybercadavers.

The proactive role of hybrid user–designers in this study appears to have more in common with the role hybridization identified by Ben-David and Collins (1966). In the case of cyberfrogs and cybercadavers, the hybrid identity precedes the development of the particular technology, rather than the converse. Lindsay's study had the opposite finding, that users can play a role in the redesign of a technology after it has already been created. In this study, it is not the users that trail or "shadow," using Lindsay's (2003) terminology, but instead these hybrid user–designers play a foundational role in the development of cyberfrogs and cybercadavers, again mirroring the findings of Ben-David and Collins.

This study has found that the concept of role hybridization can be fruitfully applied to the study of IT design and use. These case studies illustrate that it is possible for users to become designers, thus challenging the traditional separation of designers and users as well as the assumption


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that to play a role in design, users must still be dependent on designers to facilitate their involvement. The following conclusion section will explore in more detail the implications of these findings for the design–use interface.

There are also some limitations to this study. First, the study involves only two specific technologies, both of which are types of educational software. It is not clear to what extent these findings may apply to other forms of IT. For this reason, the study focuses solely on demonstrating that IT user–designer hybrids are possible, and exploring their implications within these case studies. Also, the perspective of social worlds as applied here may not capture the full range of communication and interaction among individuals, as well as the full range of membership within the social worlds. It is important that the social worlds be viewed as artificial constructs which are useful only insofar as they lead to a better understanding of the types of interactions that occur among designers and users of these technologies, with dynamic and gradual requirements for membership following the similar concept of communities of practice (Lave & Wenger, 1991). Another study of these technologies might draw the lines separating the social worlds differently; however, the underlying notion of role hybridization within IT design and use would remain.

Like any successful scientific study, this research raises more questions than it answers. One area for further investigation is to explore why this situation arose in these cases, and why it does not arise in other cases. Similarly, since both of these case studies are within the domain of educational software design and use, it would be useful to determine if any similar findings can be found in other areas of IT design and use. The effectiveness of user–designer hybrids, including the educational and commercial success of the software that they produce, is an issue that is only partially explored here and elsewhere (Fleischmann, 2004), and certainly merits additional attention. Finally, what is the impact of role hybridization on communication behaviors and working styles on different individuals and groups?

## Conclusions

What can be viewed at the macro level as the sociotechnical interface, or the interaction between technology and society (Danziger & Kraemer, 1986), can be viewed at the micro level as the design–use interface, or the interaction between designers and users. In this article, the concept of the design–use interface is introduced as an alternative to the dichotomy that Suchman (1999) deconstructs and rejects. The user–designer hybrids identified here and elsewhere (Lindsay, 2003) play an important role in further challenging the dichotomy between designers and users, because these individuals permeate and even thrive at the so-called boundary between designers and users. Following Mackay et al. (2000), design and use are involved in a mutually constitutive relationship that makes malleable the previously inflexible boundary between designers and users. The technological landscape of design and use is complex, and requires a more complex model than a simple dichotomy. Instead, viewing the design–use interface as a dynamic meeting place holds the promise of allowing for a more-nuanced analysis with more attention paid to the social worlds of designers and users as well as user–designer hybrids and meeting places of designers and users.

The practical significance of the IT user–designer hybrids documented in this study is tied to the power relations among designers and users of information technologies. In the cases of both cyberfrogs and cybercadavers, educators were able to enter into the design field in a variety of different ways and to a range of degrees, allowing them to change from users to designers and to play a critical role in the development of new technologies. In terms of the power dynamic between designers and users, in Beyer and Holtzblatt's study (1995) the designer as user is primarily a role-playing activity—the designer merely acts as a user. It is a very different thing indeed for users, who have a rich understanding of their own information needs and preferences based on specialized knowledge (Haraway, 1991) built up over many years, to become designers in their own right.

The political implications of this study are parallel to those of Lindsay (2003) and the larger literature on technological appropriation, yet they go further than those studies. While studies of technological appropriation focus on the potential for users to participate in the redesign of technologies, giving them more control of the technologies that they use and thus making users less dependent on users, it is easier and more powerful to enter on the ground floor, as the technologies are being designed, rather than after the fact. Thus, if the literature on technological appropriation demonstrates the potential for empowering IT users relative to IT designers, this study carries this idea even further to a more fundamental stage in the design process.

Here, parallels can be drawn to the work of Epstein (1996), who found that the push for legitimate expertise among AIDS activists resulted in significant changes not only within the field of AIDS research and treatment but also for the physician–patient relationship in general. Similarly, the hybrid user–designers identified in this study, who carry their expertise as IT users into new roles or careers as IT designers, redefine the static dichotomy of separate and different designers and users, a dichotomy which is by no means separate but equal. By tearing down the wall between designers and users, the end result is an increased potential for empowering users and ensuring that information technologies are truly beneficial to society.

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