**Introduction**

One of this chapter’s authors stayed in a new hotel on the outskirts of London. When she entered her room, she encountered three wall-mounted light switches in a row, but with no indication of which lights they operated. In fact, the mapping of switches to lights was so peculiar that she was more often than not surprised by the light that came on when she pressed a particular switch. One might conclude that the author had a serious problem, but she prefers to attribute her difficulty to poor design.

When these kinds of technology design issues surface in health care, they are more than just an annoyance. Poorly designed technology can lead to errors, lower productivity, or even the removal of the system ([**Alexander & Staggers, 2009**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib04)). Unfortunately, as more and more kinds of increasingly complex health information technology applications are integrated, the problem becomes even worse ([**Johnson, 2006**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib32)). However, nurses are very creative and, if at all possible, will design workarounds that allow them to circumvent troublesome technology. However, workarounds are only a Band-Aid; they are not a long-term solution.

In his classic book *The Psychology of Everyday Things*, Norman ([**1988**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib45)) argued that life would be a lot simpler if people who built the things that others encounter (such as light switches) paid more attention to how they would be used. At least one everyday thing meets Norman’s criteria for good design: the scythe. Even people who have never encountered one will pick up a scythe in the manner needed to use it because the design makes only one way feasible. The scythe’s design fits perfectly with its intended use and a human user. Would it not be great if all technology were so well fit to human use? In fact, this is not such a far-fetched idea. Scientists and engineers are making excellent strides in understanding human–technology interface problems and proposing solutions to them.

As you read through this chapter, reflect on the everyday items you use. What makes them easy or difficult to use? Is it evident that the developer thought about how they would be used to facilitate their design and function? Next, turn your attention to the technologies you use. Is it evident that the developer thought about how the technology would be used to facilitate its design and function? Think about your smartphone. How easy is it to hold your smartphone? Is it intuitive and easy to access and use? What improvements would you make? Does the electronic health record (EHR) system you use support your workflow and patient needs? Do you use workarounds to avoid items that you feel should not be there or are not needed at the time of entry? Do you think that the developer understood you, as the user, or did not realize how their technology tool would be used? By the end of this chapter, you should be able to critically examine the human–technology interfaces currently available in health care and describe models, strategies, and exemplars for improving interfaces during the analysis, design, and evaluation phases of the development life cycle.

**The Human–Technology Interface**

What is the [**human–technology interface**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss324)? Broadly speaking, anytime a human uses technology, some type of hardware or software enables and supports the interaction. It is this hardware and software that defines the interface. The array of light switches described previously was actually an interface (although not a great one) between the lighting technology in the room and the human user.

In today’s healthcare settings, one encounters a wide variety of human–technology interfaces. Those who work in hospitals may use bar-coded identification cards to log their arrival time into a human resources management system. Using the same cards, they might log into their patients’ EHR, access their patient’s drugs from a drug administration system, and even administer the drugs using bar-coding technology. Other examples of human–technology interfaces one might encounter include a defibrillator, a patient-controlled analgesia (PCA) pump, any number of physiologic monitoring systems, electronic thermometers, and telephones and pagers. According to Rice and Tahir ([**2014**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib48)),

*[R]ecent studies have found that rapid implementation of new medical technology—electronic health records, patient monitoring devices, surgical robots and other tools—can lead to adverse patient events when it is not thoughtfully integrated into workflow. The right processes require understanding the devices and the users. Testing in controlled environments often does not adequately consider the “human factor,” or how people interact with technology in high-pressure, real-life situations. (p. 12)*

The human interfaces for each of these technologies are different and can even differ among different brands or versions of the same device. For example, to enter data into an EHR, one might use a keyboard, a light pen, a touch screen, or voice. Healthcare technologies may present information via computer screen, printer, or smartphone. Patient data might be displayed in the form of text, images (e.g., the results of a brain scan), or even sound (an echocardiogram); in addition, the information may be arrayed or presented differently, based on roles and preferences. Some human–technology interfaces mimic face-to-face human encounters. For example, faculty members are increasingly using videoconferencing technology to communicate with their students. Similarly, telehealth allows nurses to use telecommunication and videoconferencing software to communicate more effectively and more frequently with patients at home by using the technology to monitor patients’ vital signs, supervise their wound care, or demonstrate a procedure. According to Gephart and Effken ([**2013**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib23)), “The National eHealth Collaborative Technical Expert Panel recommends fully integrating patient-generated data (e.g., home monitoring of daily weights, blood glucose, or blood pressure readings) into the clinical workflow of healthcare providers” (para. 3). Telehealth technology has fostered other virtual interfaces, such as system-wide intensive care units in which intensivists and specially trained nurses monitor critically ill patients in intensive care units, some of whom may be in rural locations. Sometimes telehealth interfaces allow patients to interact with a virtual clinician (actually a computer program) that asks questions, provides social support, and tailors education to identify patient needs based on the answers to screening questions. These human–technology interfaces have been remarkably successful; sometimes patients even prefer them to live clinicians.

Human–technology interfaces may present information using text, numbers, images, icons, or sound. Auditory, visual, or even tactile alarms may alert users to important information. Users may interact with (or control) the technology via keyboards, digital pens, voice activation, or even touch.

A small, but growing, number of clinical and educational interfaces rely heavily on tactile input. For example, many students learn to access an intravenous site using virtual technology. Other, more sophisticated virtual reality applications help physicians learn to do endoscopies or practice complex surgical procedures in a safe environment. Still others allow drug researchers to design new medications by combining virtual molecules (here, the tactile response is quite different for molecules that can be joined from those that cannot). In each of these training environments, accurately depicting tactile sensations is critical. For example, feeling the kind and amount of pressure required to penetrate the desired tissues, but not others, is essential to a realistic and effective learning experience.

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The growing use of large databases for research has led to the design of novel human–technology interfaces that help researchers visualize and understand patterns in the data that generate new knowledge or lead to new questions. Many of these interfaces now incorporate multidimensional visualizations, in addition to scatter plots, histograms, or cluster representations ([**Vincent, Hastings-Tolsma, & Effken, 2010**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#page227)). Some designers, such as Quinn (the founder of the Design Rhythmics Sonification Research Laboratory at the University of New Hampshire) and Meeker ([**2000**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib46)), use variations in sound to help researchers hear the patterns in large datasets. In Quinn and Meeker’s ([**2000**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib46)) “climate symphony,” different musical instruments, tones, pitches, and phrases are mapped onto variables, such as the amounts and relative concentrations of minerals, to help researchers detect patterns in ice core data covering more than 110,000 years. Climate patterns take centuries to emerge and can be difficult to detect. The music allows the entire 110,000 years to be condensed into just a few minutes, making detection of patterns and changes much easier.

The human–technology interface is ubiquitous in health care and takes many forms. A look at the quality of these interfaces follows. Be warned: It is not always a pretty picture.

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**The Human–Technology Interface Problem**

In *The Human Factor*, Vicente ([**2004**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib55)) cited the many safety problems in health care identified by the Institute of Medicine’s ([**1999**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib30)) report and noted how the technology (defined broadly) used often does not fit well with human characteristics. As a case in point, Vicente described his own studies of nurses’ PCA pump errors. Nurses made the errors, in large part, because of the complexity of the user interface, which required as many as 27 steps to program the device. Vicente and his colleagues developed a PCA in which programming required no more than 12 steps. Nurses who used it in laboratory experiments made fewer errors, programmed drug delivery faster, and reported lower cognitive workloads compared to the commercial device. Further evidence that human–technology interfaces do not work as well as they might is evident in the following events.

Doyle ([**2005**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib16)) reported that when a bar-coding medication system interfered with their workflow, nurses devised [**workarounds**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss781), such as removing the armband from the patient and attaching it to the bed, because the bar-code reader failed to interpret bar codes when the bracelet curved tightly around a small arm. Koppel et al. ([**2005**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#page226)) reported that a widely used computer-based provider order entry (CPOE) system meant to decrease medication errors actually facilitated 22 types of errors because the information needed to order medications was fragmented across as many as 20 screens, available medication dosages differed from those the physicians expected, and allergy alerts were triggered only after an order was written.

Han et al. ([**2005**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib27)) reported increased mortality among children admitted to Children’s Hospital in Pittsburgh after CPOE implementation. Three reasons were cited for this unexpected outcome. First, CPOE changed the workflow in the emergency room. Before CPOE, orders were written for critical time-sensitive treatment based on radio communication with the incoming transport team before the child arrived. After CPOE implementation, orders could not be written until the patient arrived and was registered in the system (a policy that was later changed). Second, entering an order required as many as 10 clicks and took as long as 2 minutes; moreover, computer screens sometimes froze or response time was slow. Third, when the team changed its workflow to accommodate CPOE, face-to-face contact among team members diminished. Despite the problems with study methods identified by some of the informatics community, there certainly were serious human–technology interface problems.

In 2005, a *Washington Post* article reported that Cedars-Sinai Medical Center in Los Angeles had shut down a $34 million system after 3 months because of the medical staff’s rebellion. Reasons for the rebellion included the additional time it took to complete the structured information forms, failure of the system to recognize misspellings (as nurses had previously done), and intrusive and interruptive automated alerts ([**Connolly, 2005**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib12)). Even though physicians actually responded appropriately to the alerts, modifying or canceling 35% of the orders that triggered them, designers had not found the right balance of helpful-to-interruptive alerts. The system simply did not fit the clinicians’ workflow.

Such unintended consequences ([**Ash, Berg, & Coiera, 2004**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib06)) or unpredictable outcomes ([**Aarts, Doorewaard, & Berg, 2004**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib01)) of healthcare information systems may be attributed, in part, to a flawed implementation process, but there were clearly also [**human–technology interaction**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss323) issues. That is, the technology was not well matched to the users and the context of care. In the pediatric case, a system developed for medical–surgical units was implemented in a critical care unit.

Human–technology interface problems are the major cause of as many as 87% of all patient monitoring incidents ([**Walsh & Beatty, 2002**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib58)). It is not always that the technology itself is faulty. In fact, the technology may perform flawlessly, but the interface design may lead the human user to make errors ([**Vicente, 2004**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib55)).

Rice and Tahir ([**2014**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib48)) reported on two errors that remind us we still have a long way to go to ensure patient safety: In 2011, a pop-up box on a digital blood glucose reader was misread and the patient was given too much insulin, sending her into a diabetic coma; in 2013, a patient did not receive his psychiatric medicine for almost 3 weeks because the pharmacy’s computer system was set to automatically discontinue orders for certain drugs, and there was no alert built in to notify the team providing care to this patient that the drug was suspended. The real issue is that the healthcare personnel–technology interfaces continue to cause these adverse events and near-misses. It is important to remember that it is not only a technology or human interface issue. Many of these problems occur when new technology is introduced or existing technology is modified. In addition, we must examine how the technology tools are tested, how the human users are prepared for their use, and how the tools are integrated into the care delivery process ([**Rice & Tahir, 2014**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib48)).

**Improving the Human–Technology Interface**

Much can be learned from the related fields of cognitive engineering, [**human factors**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss318), and [**ergonomics**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss234) ([**Figures 11-1**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch011-fig001) and [**11-2**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch011-fig002)) about how to make interfaces more compatible with their human users and the context of care. Each of these areas of study is multidisciplinary and integrates knowledge from multiple disciplines (e.g., computer science, engineering, cognitive engineering, psychology, and sociology).

**Figure 11-1** Human Factors and Ergonomics

**Figure 11-2** Human Factors and Ergonomics, Continued

These areas are also concerned with health issues arising from computer and other technology use. Longo and Reese ([**2014**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib38)) reminded us that

*Nearly 20 years ago, the American Optometric Association termed computer vision syndrome (CVS) as the complex of eye and vision problems related to near work experienced while using a computer. CVS symptoms reflect the current broad diagnosis of* *asthenopia (ICD-9, 368.13) [2017 ICD-10-CM H53.149] also referred to as eyestrain. Symptoms include: fatigue, blurred distal or proximal vision, headache, dry or irritated eyes, neck and/or backaches, blurred near vision and diplopia (double vision). (p. 8)*

Longo and Reese described how to prevent computer vision syndrome. One of the best ways to help your eyes is to remember to look 20 feet away from your screen every 20 minutes for a minimum of 20 seconds. With the increased smartphone use, we are seeing neck issues caused by the tilt of the head (with the chin on the chest) while looking down at the smartphone or other handheld device. You should hold your phone up so that you are keeping your neck and eyes aligned properly with the device’s screen for more comfortable viewing and interactions. We must all be aware of our posture and how our work areas are set up when using our computers, smartphones, tablets, and any other devices that consume a great deal of our time during our work or personal hours.

Effken ([**2016**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib19)) proposed the ecological approach to interface design to help us realize a more meaningful EHR. This approach borrowed from a small field of psychology, ecological psychology, which “emerged after the 3-Mile Island nuclear fiasco to allow complex processes (like nuclear power plants) to be more easily and safely controlled by operators. Ecological displays subsequently have enhanced the control of airplanes, bottling plants—and even nuclear power plants. In the 1990s, the approach began to be extended to the complexities of healthcare” (Effken, para. 2). Ecological displays help the user identify deviations from normal physical or physiological processes. According to Effken,

*Given the current pressure to achieve meaningful use of the EHR and the availability of new, more flexible technology, this seems like an ideal time for informaticists (and nurse informaticists, in particular) to consider seriously how the ecological approach might be applied to make the meaning of the EHR’s data more transparent to clinician and patient users, as well as to make clear the value proposition of various treatments. (para. 8)*

It is evident that users and clinicians need the technology and interfaces necessary to quickly comprehend the multiple discrete data that are contained in distinct parts of the EHR. “Because these are exactly the kind of complex problems that they were developed to solve, the analysis and design approaches derived from ecological psychology are worth examining further as we attempt to derive a more meaningful EHR” ([**Effken, 2016**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib19), para. 8).

Over the years, three axioms have evolved for developing effective [**human–computer interactions**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss321) ([**Staggers, 2003**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib51)): (1) Users must be an early and continuous focus during interface design; (2) the design process should be iterative, allowing for evaluation and correction of identified problems; and (3) formal evaluation should take place using rigorous experimental or qualitative methods. These axioms still apply today and, even after all of these years, are often not followed.

**Axiom 1: Users Must Be an Early and Continuous Focus During Interface Design**

Rubin ([**1994**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib49)) used the term *user-centered design* to describe the process of designing products (e.g., human–technology interfaces) so that users can carry out the tasks needed to achieve their goals with “minimal effort and maximal efficiency” (p. 10). Thus, in user-centered design, the end user is emphasized. This is still a focus of human–technology interface design today.

Vicente ([**2004**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib55)) argued that technology should fit human requirements at five levels of analysis (physical, psychological, team, organizational, and political). Physical characteristics of the technology (e.g., size, shape, or location) should conform to the user’s size, grasp, and available space. Information should be presented in ways that are consistent with known human psychological capabilities (e.g., the number of items that can be remembered is seven plus or minus two). In addition, systems should conform to the communication, workflow, and authority structures of work teams; to organizational factors, such as culture and staffing levels; and even to political factors, such as budget constraints, laws, or regulations.

A number of analysis tools and techniques have been developed to help designers better understand the task and user environment for which they are designing. Discussed next are task analysis, cognitive task analysis, and cognitive work analysis (CWA).

[**Task analysis**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss690) examines how a task must be accomplished. Generally, analysts describe the task in terms of inputs needed for the task, outputs (what is achieved by the task), and any constraints on actors’ choices on carrying out the task. Analysts then lay out the sequence of temporally ordered actions that must be carried out to complete the task in flowcharts ([**Vicente, 1999**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib56)). A worker’s tasks must be analyzed. Task analysis is very useful in defining what users must do and which functions might be distributed between the user and technology ([**U.S. Department of Health and Human Services, 2013**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib54)). [**Cognitive task analysis**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss116) usually starts by identifying, through interviews or questionnaires, the particular task and its typicality and frequency. Analysts then may review the written materials that describe the job or are used for training and determine, through structured interviews or by observing experts perform the task, which knowledge is involved and how that knowledge might be represented. Cognitive task analysis can be used to develop training programs. Zupanc and colleagues ([**2015**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib63)) reported on the use of cognitive task analysis techniques to develop a framework from which a colonoscopy training program could be designed. “Task analysis methods (observation, a think-aloud protocol and cued-recall) and subsequent expert review were employed to identify the competency components exhibited by practicing endoscopists with the aim of providing a basis for future instructional design” (Zupanc et al., p. 10). The resulting colonoscopy competency framework consisted of “twenty-seven competency components grouped into six categories: clinical knowledge; colonoscope handling; situation awareness; heuristics and strategies; clinical reasoning; and intra and inter-personal” (Zupanc et al., p. 10).

[**Cognitive work analysis**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss118) was developed specifically for the analysis of complex, high-technology work domains, such as nuclear power plants, intensive care units, and emergency departments, where workers need considerable flexibility in responding to external demands ([**Burns & Hajdukiewicz, 2004**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib09); [**Vicente, 1999**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib56)). A complete CWA includes five types of analysis: (1) work domain, (2) control tasks, (3) strategies, (4) social–organizational, and (5) worker competencies. The work domain analysis describes the functions of the system and identifies the information that users need to accomplish their task goals. The control task analysis investigates the control structures through which the user interacts with or controls the system. It also identifies which variables and relations among variables discovered in the work domain analysis are relevant for particular situations so that context-sensitive interfaces can present the right information (e.g., prompts or alerts) at the right time. The strategies analysis looks at how work is actually done by users to facilitate the design of appropriate human–computer dialogues. The social–organizational analysis identifies the responsibilities of various users (e.g., doctors, nurses, clerks, or therapists) so that the system can support collaboration, communication, and a viable organizational structure. Finally, the worker competencies analysis identifies design constraints related to the users themselves ([**Effken, 2002**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib20)).

Specialized tools are available for the first three types of CWA ([**Vicente, 1999**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib56)). Analysts typically borrow tools (e.g., ethnography) from the social sciences for the two remaining types. Hajdukiewicz, Vicente, Doyle, Milgram, and Burns ([**2001**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib26)) used CWA to model an operating room environment. Effken ([**2002**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib20)) and Effken et al. ([**2001**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib18)) used CWA to analyze the information needs for an oxygenation management display for an ICU. Other examples of the application of CWA in health care are described by Burns and Hajdukiewicz ([**2004**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib09)) in their chapter on medical systems (pp. 201–238). Ashoon et al. ([**2014**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib07)) used team CWA to reveal the interactions of the healthcare team in the context of work models in a birthing unit. They felt that team CWA enhances CWA in complex environments, such as health care, that require effective teamwork because it reveals additional constraints relevant to the workings of the team. The information gleaned about the teamwork could be used for systems design applications.

**Axiom 2: The Design Process Should Be Iterative, Allowing for Evaluation and Correction of Identified Problems**

Today, both principles and techniques for developing human–technology interfaces that people can use with minimal stress and maximal efficiency are available. An excellent place to start is with Norman’s ([**1988**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib45), pp. 188–189) principles:

1. Use both knowledge in the world and knowledge in the head. In other words, pay attention not only to the environment or to the user, but to both, and to how they relate. By using both, the problem actually may be simplified.
2. Simplify the structure of tasks. For example, reduce the number of steps or even computer screens needed to accomplish the goal.
3. Make things visible: Bridge the [**gulf of execution**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss286) and the [**gulf of evaluation**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss285). Users need to be able to see how to use the technology to accomplish a goal (e.g., which buttons does one press and in which order to program this PCA?); if they do, then designers have bridged the gulf of execution. They also need to be able to see the effects of their actions on the technology (e.g., if a nurse practitioner prescribes a drug to treat a certain condition, the actual patient response may not be perfectly clear). This bridges the gulf of evaluation.
4. Get the mappings right. Here, the term [**mapping**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss415) is used to describe how environmental facts (e.g., the order of light switches or variables in a physiologic monitoring display) are accurately depicted by the information presentation.
5. Exploit the power of constraints, both natural and artificial. Because of where the eyes are located in the head, humans have to turn their heads to see what is happening behind them; however, that is not true of all animals. As the location of one’s eyes constrains what one can see, so also do physical elements, social factors, and even organizational policy constrain the way tasks are accomplished. By taking these constraints into account when designing technology, it can be made easier for humans use.
6. Design for error. Mistakes happen. Technology should eliminate predictable errors and be sufficiently flexible to allow humans to identify and recover from unpredictable errors.
7. When all else fails, standardize. To get a feel for this principle, think how difficult it is to change from a Macintosh to a Windows environment or from the iPhone operating system to Android.

Kirlik and Maruyama ([**2004**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib34)) described a real-world human–technology interface that follows Norman’s principles. In their classic analogy, the authors observed how a busy expert short-order cook strategically managed to grill many hamburgers at the same time, but each to the customer’s desired level of doneness. The cook put those burgers that were to be well-done on the back and far right portion of the grill, those to be medium well-done in the center of the grill, and those to be rare at the front of the grill, but farther to the left. The cook moved all burgers to the left as grilling proceeded and turned them over during their travel across the grill. Everything the cook needed to know was available in this simple interface. As a human–technology interface, the grill layout was elegant. The interface used knowledge housed both in the environment and in the expert cook’s head; also, things were clearly visible, both in the position of the burgers and in the way they were moved. The process was clearly and effectively standardized, with built-in constraints. What might it take to create such an intuitive human–technology interface in health care?

Several useful books have been written about effective interface design (e.g., [**Burns & Hajdukiewicz, 2004**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib09); [**Cooper, 1995**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib13); [**Mandel, 1997**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib40); [**McKay, 2013**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib42); [**Wigdor & Wixon, 2011**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib61)). In addition, a growing body of research is exploring new ways to present clinical data that might facilitate clinicians’ problem identification and accurate treatment ([**Agency for Healthcare Research and Quality, 2010**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib02)). Just as in other industries, health care is learning that big data can provide big insights if it can be visualized, accessed, and meaningful ([**Intel IT Center, 2013**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib31)). Often, designers use graphical objects to show how variables relate. The first to do so were likely Cole and Stewart ([**1993**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib11)), who used changes in the lengths of the sides and area of a four-sided object to show the relationship of respiratory rate to tidal volume. Other researchers have demonstrated that histograms and polygon displays are better than numeric displays for detecting changes in patients’ physiologic variables ([**Gurushanthaiah, Weinger, & Englund, 1995**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib25)). When Horn, Popow, and Unterasinger ([**2001**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib28)) presented physiologic data via a single circular object with 12 sectors (where each sector represented a different variable), nurses reported that it was easy to recognize abnormal conditions, but difficult to comprehend the patient’s overall status. This kind of graphical object approach has been most widely used in anesthesiology, where a number of researchers have shown improved clinician [**situational awareness**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss647) or problem detection time by mapping physiologic variables onto display objects that have meaningful shapes, such as using a bellows-like object to represent ventilation ([**Agutter et al., 2003**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib03); [**Blike, Surgenor, Whallen, & Jensen, 2000**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib08); [**Michels, Gravenstein, & Westenskow, 1997**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib43); [**Zhang et al., 2002**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib62)).

Effken ([**2006**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib21)) compared a prototype display that represented physiologic data in a structured pictorial format with two bar graph displays. The first bar graph display and the prototype both presented data in the order that experts were observed to use them. The second bar graph display presented the data in the way that nurses collected them. In an experiment in which resident physicians and novice nurses used simulated drugs to treat observed oxygenation management problems using each display, residents’ performance was improved with the displays ordered as experts used them, but nurses’ performance was not improved. Instead, nurses performed better when the variables were ordered as they were used to collecting them, demonstrating the importance of understanding user roles and the tasks they need to accomplish.

Data also need to be represented in ways other than visually. Gaver ([**1993**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib22)) proposed that because ordinary sounds map onto familiar events, they could be used as icons to facilitate easier technology navigation and use and to provide continuous background information about how a system is functioning. In health care, auditory displays have been used to provide clinicians with information about patients’ vital signs (e.g., in pulse oximetry), such as by altering volume or tone when a significant change occurs ([**Sanderson, 2006**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib50)).

Admittedly, auditory displays are probably more useful for quieter areas of the hospital, such as the operating room. Perhaps that is why researchers have most frequently applied the approach in anesthesiology. For example, Loeb and Fitch ([**2002**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib37)) reported that anesthesiologists detected critical events more quickly when auditory information about heart rate, blood pressure, and respiratory parameters was added to a visual display. Auditory tones also have been combined as [**earcons**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss207) to represent relationships among data elements, such as the relationship of systolic to diastolic blood pressure ([**Watson & Gill, 2004**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib59)).

**Axiom 3: Formal Evaluation Should Take Place Using Rigorous Experimental or Qualitative Methods**

Perhaps one of the highest accolades that any interface can achieve is to say that it is transparent. An interface becomes transparent when it is so easy to use that users no longer think about it, but only about the task at hand. For example, a transparent clinical interface would enable clinicians to focus on patient decisions rather than on how to access or combine patient data from multiple sources. In [**Figure 11-3**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch011-fig003), instead of the nurse interacting with the computer, the nurse and the patient interact through the technology interface. The more transparent the interface, the easier the interaction should be.

**Figure 11-3** Nurse–Patient Interaction Framework in Which the Technology Supports the Interaction

Modified from Staggers, N., & Parks, P. L. (1993). Description and initial applications of the Staggers & Parks nurse–computer interaction framework. *Computers in Nursing, 11*, 282–290. Reprinted by permission of AMIA.

[**Usability**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss743) is a term that denotes the ease with which people can use an interface to achieve a particular goal. Usability of a new human–technology interface needs to be evaluated early and often throughout its development. Typical usability indicators include ease of use, ease of learning, satisfaction with using, efficiency of use, error tolerance, and fit of the system to the task ([**Staggers, 2003**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib51)). Some of the more commonly used approaches to usability evaluation are discussed next.

**Surveys of Potential or Actual Users**

Chernecky, Macklin, and Waller ([**2006**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib10)) assessed cancer patients’ preferences for website design. Participants were asked their preferences for a number of design characteristics, such as display color, menu buttons, text, photo size, icon metaphor, and layout, by selecting on a computer screen their preferences for each item from two or three options.

**Focus Groups**

Typically used at the very start of the design process, focus groups can help the designer better understand users’ responses to potential interface designs and to content that might be included in the interface.

**Cognitive Walkthrough**

In a [**cognitive walkthrough**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss117), evaluators assess a paper mockup, working prototype, or completed interface by observing the steps users are likely to take to use the interface to accomplish typical tasks. This analysis helps designers determine how understandable and easy to learn the interface is likely to be for these users and the typical tasks ([**Wharton, Rieman, Lewis, & Polson, 1994**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib60)).

**Heuristic Evaluation**

A [**heuristic evaluation**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss309) has become the most popular of what are called “discount usability evaluation” methods. The objective of a heuristic evaluation is to detect problems early in the design process, when they can be most easily and economically corrected. The methods are termed “discount” because they typically are easy to do, involve fewer than 10 experts (often experts in relevant fields such as human–computer technology or cognitive engineering), and are much less expensive than other methods. They are called “heuristic” because evaluators assess the degree to which the design complies with recognized usability rules of thumb or principles (the heuristics), such as those proposed by Nielsen ([**1994**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib44)) and available on his website (www.useit.com/papers/heuristic/heuristic\_list.html).

For example, McDaniel and colleagues ([**2002**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib41)) conducted a usability test of an interactive computer-based program to encourage smoking cessation by low-income women. As part of the initial evaluation, healthcare professionals familiar with the intended users reviewed the design and layout of the program. The usability test revealed several problems with the decision rules used to tailor content to users that were corrected before implementation.

**Formal Usability Test**

Formal usability tests typically use either experimental or observational studies of actual users using the interface to accomplish real-world tasks. A number of researchers use these methods. For example, Staggers, Kobus, and Brown ([**2007**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib52)) conducted a usability study of a prototype electronic medication administration record. Participants were asked to add, modify, or discontinue medications using the system. The time they needed to complete the task, their accuracy in the task, and their satisfaction with the prototype were assessed (the last criterion through a questionnaire). Although satisfaction was high, the evaluation also revealed design flaws that could be corrected before implementation.

**Field Study**

In a [**field study**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/37_glossary.xhtml#gloss260), end users evaluate a prototype in the actual work setting just before its general release. For example, Thompson, Lozano, and Christakis ([**2007**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib53)) evaluated the use of touch-screen computer kiosks containing child health–promoting information in several low-income, urban community settings through an online questionnaire that could be completed after the kiosk was used. Most users found the kiosk easy to use and the information it provided easy to understand. Researchers also gained a better understanding of the characteristics of the likely users (e.g., 26% had never used the Internet and 48% had less than a high school education) and the information most often accessed (television and media use, and smoke exposure).

Dykes and her colleagues ([**2006**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#page225)) used a field test to investigate the feasibility of using digital pen and paper technology to record vital signs as a way to bridge an organization from a paper to an electronic health record. In general, satisfaction with the tool increased with use, and the devices conformed well to nurses’ workflow. However, 8% of the vital sign entries were recorded inaccurately because of inaccurate handwriting recognition, entries outside the recording box, or inaccurate data entry (the data entered were not valid values). The number of modifications needed in the tool and the time that would be required to make those changes ruled out using the digital pen and paper as a bridging technology.

Ideally, every healthcare setting would have a usability laboratory of its own to test new software and technology in its own setting before actual implementation. However, this can be expensive, especially for small organizations. Kushniruk and Borycki ([**2006**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib36)) developed a low-cost rapid usability engineering method for creating a portable usability laboratory consisting of video cameras and other technology that one can take out of the laboratory into hospitals and other locations to test the technology on site using as close to a real world environment as possible. This is a much more cost-effective and efficient solution and makes it possible to test all technologies before their implementation.

**A Framework for Evaluation**

Ammenwerth, Iller, and Mahler ([**2006**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib05)) proposed a fit between individuals, tasks, and technology (FITT) model that suggests that each of these factors be considered in designing and evaluating human–technology interfaces. It is not enough to consider only the user and technology characteristics; the tasks that the technology supports must be considered as well. The FITT model builds on DeLone and McLean’s ([**1992**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib15)) information success model, Davis’s ([**1993**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib14)) technology acceptance model, and Goodhue and Thompson’s ([**1995**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib24)) task technology fit model. A notable strength of the FITT model is that it encourages the evaluator to examine the fit between the various pairs of components: user and technology, task and technology, and user and task.

Johnson and Turley ([**2006**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib32)) compared how doctors and nurses describe patient information and found that doctors emphasized diagnosis, treatment, and management, whereas the nurses emphasized functional issues. Although both physicians and nurses share some patient information, how they thought about patients differed. For that reason, an EHR needs to present information (even the same information) to the two groups in different ways.

Hyun, Johnson, Stetson, and Bakken ([**2009**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib29)) used a combination of two models (technology acceptance model and task–technology fit model) to design and evaluate an electronic documentation system for nurses. To facilitate the design, they employed multiple methods, including brainstorming of experts, to identify design requirements. To evaluate how well the prototype design fit both task and user, nurses were asked to carry out specific tasks using the prototype in a laboratory setting, and then complete a questionnaire on ease of use, usefulness, and fit of the technology with their documentation tasks. Because the researchers engaged nurses at each step of the design process, the result was a more useful and usable system.

**Future of the Human–Technology Interface**

Increased attention to improving the human–technology interface through human factors approaches has already led to significant improvements in one area of health care: anesthesiology. Anesthesia machines that once had hoses that would fit into any delivery port now have hoses that can only be plugged into the proper port. Anesthesiologists have also been actively working with engineers to improve the computer interface through which they monitor their patients’ status and are among the leaders in investigating the use of audio techniques as an alternative way to help anesthesiologists maintain their situational awareness. As a result of these efforts, anesthesia-related deaths dropped from 2 in 20,000 to 1 in 200,000 in less than 10 years ([**Vicente, 2004**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib55)). It is hoped that continued emphasis on human factors ([**Vicente, 2004**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib55)) and user-centered design ([**Rubin, 1994**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib49)) by informatics professionals and human–computer interactions experts will have equally successful effects on other parts of the healthcare system. The increased amount of informatics research in this area is encouraging, but there is a long way to go.

A systematic review of clinical technology design evaluation studies ([**Alexander & Staggers, 2009**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib04)) found 50 nursing studies. Of those, nearly half (24) evaluated effectiveness, fewer (16) evaluated satisfaction, and still fewer (10) evaluated efficiency. The evaluations were not systematic—that is, there was no attempt to evaluate the same system in different environments or with different users. Most evaluations were done in a laboratory, rather than in the setting where the system would be used. The authors argued for a broader range of studies that use an expanded set of outcome measures. For example, instead of looking at user satisfaction, evaluators should dig deeper into the design factors that led to the satisfaction or dissatisfaction. In addition, performance measures, such as diagnostic accuracy, errors, and correct treatment, should be used.

Rackspace, Brauer, and Barth ([**2013**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib47)) reported on a social study of the human cloud formed in part by data collected from wearable technologies; they focused on assessing attitudes and “exploring how cloud computing is enabling this new generation of smart devices” (p. 2). Today, smartphones, glasses, clothing, watches, cameras, and monitors for health or patient tracking, to name but a few devices, are available to this purpose.

The additional technologies that are entering our lives on a daily basis can enhance or challenge our ability to complete both our activities of daily living and our professional tasks. As our home monitoring and patient technologies increase, the user’s (patient’s or nurse’s) ability to use the technology is paramount. No matter who is using the technology, the human–technology interface addresses the user’s ability and the technology’s functionality to complete the task demands (see [**Figure 11-4**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch011-fig004)).

**Figure 11-4** Human Technology Interface and Task Completion

As our technologies continue to evolve, we are creating more design issues. The proliferation of smart devices and wearable technology brings new concerns related to human–technology interfaces. According to Madden ([**2013**](https://digitalbookshelf-jigsaw.southuniversity.edu/books/9781284142990/epub/EPUB/xhtml/20_Chapter11.xhtml#ch11-bib39)), wearable technologies are adding another wrinkle into the design process—namely, human behavior. How will someone use this technology? How will individuals behave with it on their person? How will they wear it? How and when will they enable and use it? Will others be able to detect the technologies (that is, will someone be able to wear Google Glass and take pictures or videos of other people’s actions), and will users be able to seamlessly move among all of the capabilities of his or her wearable technologies? The human–technology interface must address these issues. There is a long way to go.

**Summary**

There are at least three messages the reader should take away from the discussion in this chapter. First, if there is to be significant improvement in quality and safety outcomes in the United States through the use of information technology, the designs for human–technology interfaces must be radically improved so that the technology better fits human and task requirements. However, that improvement will be possible only if clinicians identify and report problems, rather than simply creating workarounds. That means that each clinician has a responsibility to participate in the design process and to report designs that do not work.

Second, a number of useful tools are currently available for the analysis, design, and evaluation phases of development life cycles. They should be used routinely by informatics professionals to ensure that technology better fits both task and user requirements.

Third, focusing on interface improvement using these tools has had a huge impact on patient safety in the area of anesthesiology and medication administration. With increased attention from informatics professionals and engineers, the same kind of improvement should be possible in other areas regardless of the technologies actually employed there. In the ideal world, one can envision that every human–technology interface will be designed to enhance users’ workflow, will be as easy to use as banking ATMs, and will be fully tested before its implementation in a setting that mirrors the setting where it will be used.

THOUGHT-PROVOKING QUESTIONS

1. You are a member of a team that has been asked to evaluate a prototype smartphone-based application for calculating drug dosages. Based on what you know about usability testing, which kind of test (or tests) might you do and why?
2. Is there a human–technology interface that you have encountered that you think needs improvement? If you were to design a replacement, which analysis techniques would you choose? Why?
3. Which type of functionality and interoperability would you want from your smartphone, watch, clothing, glasses, camera, and monitor? Provide a detailed response.

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