Ben Shneiderman, University of Maryland
Catherine Plaisant, University of Maryland
Maxine Cohen, Nova Southeastern University
Steven Jacobs, Northern Arizona University
Niklas Elmqvist, University of Maryland
Nicholoas Diakopoulos, University of Maryland

Grand Challenges for HCI Researchers

The remarkable impact of human-computer interaction research and user experience design compels researchers, practitioners, and journalists to ask: What is the next big thing?

Therefore, it may be useful for our community to lay out grand challenges that steer the direction of future research, design, and commercial development. As HCI researchers, we are profoundly aware of the immense problems of our age: Growing human populations consume natural resources, flourishing cities require housing and transportation, families demand education and safety, and rising expectations from patients put pressure on healthcare and social systems. National priorities include economic development, political participation, civil rights, and achieving the delicate balance between appropriate security and excessive surveillance while pursuing open government policies that limit corruption and prevent waste. The U.S. National Academy of Engineering's Grand Challenges [1] provide a thoughtful list and international efforts such as the UN Sustainable Development Goals [2] suggest additional challenges.

While addressing these problems, researchers, designers, and developers who recognize the aspirations of individuals, their desire for self-determination, and their hopes to contribute to their communities are more likely to deliver constructive products and services. These forward-looking innovators will manifest their sensitivity to individual and community norms, respect individual differences, and observe ethical codes of conduct.

With these considerations in mind, the authors of *Designing the User Interface: Strategies for Effective Human-Computer Interaction* (6th Ed) [3] described 16 grand challenges for researchers, designers, and developers:

1. Develop a handbook of human needs. Abraham Maslow's hierarchy of needs from the 1940s provides some guidance, establishing a foundation of survival and safety, embracing love and esteem, and supporting self-actualization that realizes personal potentials. However, a contemporary and detailed handbook of human needs would help in the refining of designs and invention of new tools or services.

2. Shift from user experience to community experience. User experience designers have cleverly invented interfaces and processes that support work, communication, and fun. Now there is an opportunity to shift to community experience design, social media participation, game theoretic mechanisms, and motivational strategies to engage growing communities in constructive ways. Successful examples, such as Wikipedia or citizen science projects, show what is possible, but the common outcome of community experience design is insufficient response, raising the question of how to make more consistently successful outcomes. This shift is mirrored in the theory shift from emphasis on micro-HCI to macro-HCI.

3. Refine theories of persuasion. Theories of persuasion could lead to more rapid progress in smoking cessation, obesity reduction, medication compliance, and cancer prevention. A periodic table of persuasion strategies would chart the micro-structure of motivation for designers who create applications for individuals, friends and family, colleagues and neighbors, and citizens and markets.

4. Encourage resource conservation. The needs of a growing population will have to be trimmed by efficient strategies for reducing the use of water, energy, and natural resources while increasing production from renewable sources. User interfaces and community engagement will play key roles in providing feedback that encourages winning strategies.

5. Shape the learning health system. A grand opportunity for HCI researchers and designers is to help shape massive healthcare systems that support patients seeking wellness, clinicians delivering care, and providers eager to reduce costs while increasing the quality of care. Macro-HCI thinking and big data analytic tools could provide insights at every level that could be shared with relevant stakeholders, but producing meaningful changes in such massive systems remains a challenge. Bottom-up strategies could propel patient and clinician participation, while top-down governance is needed to set policies, cope with malicious actors, and guide continuous improvement.

6. Advance the design of medical devices. Researchers have been rapidly developing medical devices that go far beyond current hearing aids, pacemakers, body sensors, and data-recording tools. As implanted insulin pumps, vision-restoration systems, prosthetic limbs, brain-computer interfaces, and nanodevices mature, user interfaces to monitor performance, log activity, and enable appropriate controls will be required.

7. Support successful aging strategies. The growing population of older adults want to maintain their health and independence while aging in place. They could benefit from interfaces that collect data from sensors, encourage healthy diet and exercise, promote social connectedness, and enable balanced involvement from caregivers. How might the growing Internet of Things help older adults improve quality of life?

8. Promote lifelong learning. Traditional educational systems are expanding to include online learning (massive open online courses, or MOOCs), professional just-in-time training, learning through games, and many kinds of social learning. Developing best practices for a range of ages, motivations, and cultures will help to make these systems more reliably successful for large numbers of diverse users.

9. Stimulate rapid interface learning. Multilayer user interfaces enable new users to become experts with basic features; then users can control their progress to advanced features as needed. Multilayer user interfaces also simplify design for diverse users and users with disabilities.

10. Engineer new business models. As existing business models give way to new ones, user interfaces play a key role in ensuring the success of peer-to-peer sales of products and services such as taxi rides, vacation-home rentals, and task completion. Closer business-to-consumer connections and lower barriers to consumer-to-consumer collaboration also promise new possibilities if the user experience can be designed to promote trust, conflict resolution, and open feedback from consumer reviews.

11. Design novel input and output devices. As user input continues to shift from keyboards to gestures, speech, and body movement, users will need reliable mechanisms to express their intentions. Expansion of tactile and tangible environments provides fresh possibilities. Still and video cameras, 3D scanners, and sensors will accelerate the capacity to record, analyze, and share rich data streams. Similarly, as output display diversity expands, tiny haptic feedback devices, ambient sound generators, projected displays, and large public displays will challenge designers to provide information rates and content appropriately adjusted to current tasks. Transparent glasses, immersive goggles, and ambient devices offer new possibilities along the spectrum of private to public presentation. 3D printing and novel fabrication methods will enable the production of physical items such as jewelry, foods, and larger objects such as chairs, cars, and building-construction components.

12. Accelerate analytic clarity. The big data movement is generating a high volume and a variety of data whose analysis could lead to a better understanding of invisible processes in business, community growth/decay, learning, and public health. Supported by well-integrated visual interfaces and statistical techniques, this better understanding could result in more confident and bolder decisions that improve individual, community, and planetary welfare.

13. Amplify empathy, compassion, and caring. Human relationships flow more smoothly when empathy is expressed for others in appropriate situations. Similarly, compassionate and caring actions make life better for individuals, families, and communities. Understanding and encouraging such behaviors could mean more hope-filled and satisfying lives for many.

14. Secure cyberspace. Criminal activity and privacy violations threaten to undermine user participation in every form of transaction, participation, political engagement, and tool usage. Designing for usable privacy and security will help ensure that benefits are retained, intrusions minimized, and expectations of safety realized.

15. Encourage reflection, calmness, and mindfulness. Novel interfaces that encourage reflection on past experiences and intended actions with a calm and mindful attitude could enhance life experiences, creative processes, and self-awareness. Reflection about life's challenges, the needs of less fortunate people, end-of-life decisions, and the digital afterlife, while difficult, could lead to comforting clarity.

16. Clarify responsibility and accountability. Interfaces that clarify users' responsibility for their actions by making decisions and their outcomes visible and sometimes public could promote more appropriate behaviors with less overt bias or deception. While machine autonomy is seen as a goal by some designers, in many contexts the preferred approach may be to ensure human control while increasing the level of automation. Similarly, algorithmic accountability interfaces would allow users to better understand underlying computational processes in search, recommender, and other algorithms, giving users the potential to better control their actions.

Undoubtedly, other opportunities and unexpected developments in HCI research will occur. Conducting research on these complex sociotechnical systems requires fresh thinking as well. The traditional controlled experimental approaches associated with micro-HCI research will need to be complemented by rigorous and repeated in-depth case studies, which are part of macro-HCI research. Addressing these problems will require improved interdisciplinary methods that emerge from science, engineering, and design.

This essay is adapted from Designing the User Interface: Effective Strategies for Human-Computer Interaction, *6th Edition, Pearson, 2016 [3].*

Endnotes

1. http://www.engineeringchallenges.org/
2. http://www.un.org/sustainabledevelopment/sustainable-development-goals/
3. https://www.pearsonhighered.com/program/Shneiderman-Designing-the-User-Interface-Strategies-for-Effective-Human-Computer-Interaction-6th-Edition/PGM327860.html

Ben Shneiderman is a professor in the CS Department, founding director of the Human-Computer Interaction Laboratory, and member of the Institute for Advanced Computer Studies at the University of Maryland, College Park.
→ ben@cs.umd.edu

Catherine Plaisant is a senior research scientist at the University of Maryland Institute for Advanced Computer Studies and associate director of research of the Human-Computer Interaction Lab.
→ plaisant@cs.umd.edu

Maxine Cohen is a professor in the Graduate School of Engineering and Computing at Nova Southeastern University.
→ cohenm@nova.edu

Steven Jacobs is a lecturer in computer science in Northern Arizona University's School of Informatics, Computing, and Cyber Systems.
→ steven.jacobs@nau.edu

Niklas Elmqvist is an associate professor in the iSchool and director of the Human-Computer Interaction Laboratory at the University of Maryland, College Park.
→ elm@umd.edu

Nicholas Diakopoulos is an assistant professor at the University of Maryland, College Park College of Journalism.
→ nicholas.diakopoulos@gmail.com

DOI: 10.1145/2977645