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Design Trade-Offs for Quality of Life

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Exploring Design Trade-Offs for Quality of Life in Human-Centered Design

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Insights

- A QoL framework must explore innovative sociotechnical environments contributing to creativity and enjoyment.
- Efficiency and productivity of digital technologies does not necessarily increase QoL.
- Design problems have no "correct" solutions; the success of a solution is a question of stakeholder value and interests.
- Design trade-offs widen rather than narrow design spaces and show there are no decontextualized sweet spots for wicked problems.

To understand, foster, nurture, and support *Quality of Life (QoL)* is one of the most challenging design problems of the digital age. QoL is a broad concept without a precise, generally accepted definition. It is not out in the world to be discovered, but rather is an objective achieved by *design*. Design is choice: It is an argumentative process with no optimal solutions. In design, *trade-offs* are universal and unavoidable because there are no best solutions or decontextualized sweet spots independent of specific goals, objectives, and values.

Grounded in ideas and research activities from a broad spectrum of disciplines, this article explores requirements and components to create a framework for QoL with an emphasis on specific design trade-offs. Its insights and arguments are summarized in requirements for the design of sociotechnical environments to address future challenges for *human-centered design (HCD)* grounded in a QoL perspective.

The first phase of research and development in HCD was focused on concerns about *usability* and *usefulness*. As hardware and software for many applications became readily available, new concerns emerged, including design methodologies such

as *participatory design*, giving all stakeholders a voice, incorporating requirements and insights from *different disciplines*, and taking advantage of a deeper differentiation of human thinking. Frameworks grounded in QoL perspectives should incorporate the findings and practices of these earlier foundations, but also need to take into account new requirements derived from additional disciplines, including behavioral economics and social psychology [1], creative practices and end-user development [2], social production [3], and new agendas for theory and practice in computing [4].

QoL as a concept transcends the domain of information and communications technology (ICT). For example, the QoL objectives articulated in the Europe 2020 strategy (http://ec.europa.eu/europe2020/) include: democratizing societies, supporting employment and social inclusion, improving healthcare, and supporting energy and environmental sustainability. Here, I analyze the driving forces for articulating and exploring challenges for QoL derived from a focus on ICT, complementing other approaches such as value-sensitive design [5] and positive computing [6].

ICT has made tremendous progress over the past few decades, but its development and adoption have not necessarily led to an improvement in QoL. Given the fundamental, ubiquitous, and global impact of digital technologies, it is time to move beyond analytical post-analyses of risks and benefits to explore the realization that more efficiency and productivity do not necessarily increase QoL for all of us.

The arguments here are grounded in the problem domains our research has addressed over the years, including human-computer interaction, end-user development, lifelong learning, creativity, urban planning, cognitive disabilities, and energy sustainability. These are also the problem domains for which we have designed, developed, and analyzed *sociotechnical environments* [7]. Based on our emphasis on *design*, we have focused particularly on identifying *design trade-offs* as the most basic characteristic of design; this article attempts to create frames of reference (illustrated with examples drawn from different areas) for exploring and understanding the implications of design trade-offs associated with QoL.

QUALITY OF LIFE: A FUNDAMENTAL OBJECTIVE FOR HUMAN-CENTERED DESIGN

QoL represents a fundamental objective for societies in the 21st century. Does it mean being happier? Having more leisure time? Enjoying good health? Having a high standard of living?

Accepting QoL as an important concept does not imply that people will agree which objectives will be desirable or should be avoided. We have questioned a vision [8] that many people regard as highly desirable: an "effortless world" representing the old dream of humankind to return to the Garden of Eden or Paradise (places where peace, prosperity, and happiness can be found) and live a life of abundance free of all work and pain and in which all desires would be satisfied immediately without any effort. However, when all wishes get fulfilled, how would that change the nature of wishing? Human beings value things and relationships they must make an effort to obtain and in which they find purpose, enjoyment, and flow states through *personally meaningful tasks* [9].

In order to gain *empirical evidence* about how people think about QoL, we collected initial data with questionnaires and interviews from different constituencies by asking them how specific systems and gadgets (including e-mail, smartphones, Facebook, Twitter, Wikipedia, Uber, and Airbnb) have impacted their lives. Their answers clearly indicated the numerous trade-offs, for example: "These systems connect me with large numbers of people but isolate me from my surroundings" and "I enjoy the opportunity to participate, but too many demands create a participation overload."

Figure 1 attempts to create an initial framework for QoL, illustrating its different aspects. In order to identify more specific frames of reference and design requirements, we will 1) argue that QoL is best explored by analyzing design trade-offs, 2) mention briefly some current global developments, and 3) describe in some detail some illustrative trade-offs (see sidebars).

DESIGN AND DESIGN TRADE-OFFS

Every positive value has its price in negative terms ... the genius of Einstein leads to Hiroshima. —Pablo Picasso

In contrast to the natural sciences that study how things are, *design* is concerned with how things ought to be [10]. Design problems can be differentiated into *tame problems*, whose solutions are straightforward, and *wicked* (or *ill-defined*) *problems* that have no definitive formulation, no stopping rule, and no boundaries. The most interesting challenges for ICT and HCD are wicked problems with no correct solutions or right answers (as is the case in the natural sciences), implying that the aim of design in these contexts is not to find truth, but rather to identify satisfying solutions.

The huge variety of objectives, problems, value systems, and people's needs and preferences makes *design trade-offs* the most basic characteristic of design. A trade-off is a situation that involves losing one quality or aspect of something in return for gaining

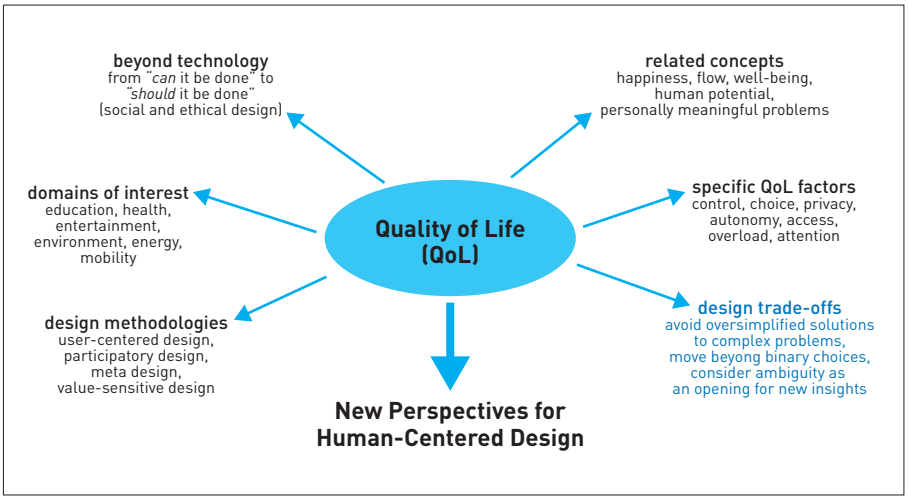

Figure 1. Components of a framework for QoL.

Domain	Choice 1	Choice 2	Balance / Synthesis	Analysis and Details
uncover unknown alternatives and limiting factors	problem framing	problem solving	iterative design; integration of problem framing and solving	[10] and brief analysis here
airplanes and cars	self-driving cars	advanced driver-assistance systems	mobility for all	[11] and Figure 2
exposure to information	personalization	privacy and serendipity	context awareness; beyond "more is more"	[12] and Sidebar 1
control, involvement, and participation	prescriptiveness and curriculum; consumer cultures	permissiveness and interest-driven learning; cultures of participation	meta-design; libertarian paternalism; different levels of engagement	[1] and Sidebar 2

Table 1. Examples of design trade-offs.

another quality or aspect. The concept of a Faustian bargain—selling your soul to the devil to gain unlimited knowledge—is used as a metaphor for getting something you want in exchange for sacrificing something else (e.g., people accept new technologies and are excited about them without being aware of their negative impacts).

Identifying, articulating, and assessing design trade-offs represents a unique challenge in designing for QoL. The value and the contribution of analyzing design trade-offs is grounded in the following objectives:

- Avoiding oversimplified solutions that result from ignoring important facets of complex problems
- Uncovering unknown alternatives and identifying the truly limiting factors that underlie problems
- Transcending one-sided views and groupthink by overcoming the hype or underestimation associated with many technological developments
- Considering ambiguity as an opening for insight and reflections, rather than a bug to be fixed
- Appreciating the complexity and richness of human experience
- Providing evidence that there are no decontextualized sweet spots by identifying interesting syntheses and meaningful compromises between opposing objectives.

Table 1 enumerates a few of the major design trade-offs related to the contents of this article.

There is widespread agreement among scientists, designers, and decision makers that the formulation of a problem already contains half its solution. If we misstate the problem, we may preclude a satisfying solution. The overemphasis on problem solving compared with problem framing is nicely illustrated by an example

SIDEBAR 1. DESIGN TRADE-OFF: PERSONALIZATION VS. SERENDIPITY

The growth of technology has provided the foundations for more information being available at people's fingertips and has offered more opportunities for participation and collaboration. In contrast to technological developments, the growth in human capabilities is limited: Our neurons do not fire faster, our memory does not increase in capacity, and we do not learn or think faster as time progresses. The mismatch between these developments has caused and contributed to information overload, participation overload, collaboration overload, and choice overload. Information overload exists for people in the following contexts: 1) keeping track of what is going on in the world at large or in the circle of one's friends (by paying attention to e-mails, blogs, Facebook postings, and tweets), 2) needing infinite resources for learning something (including the Web, Wikipedia, TED lectures, MOOCs), and 3) coping with high-functionality environments (including digital cameras, word-processing systems, drawing applications, and programming environments).

Information consumes the attention of its recipients. Hence, a wealth of information creates a poverty of attention and requires strategies and support environments to allocate efficiently among the overabundance of information sources to which we pay attention. No person can afford to pay attention to more than a fraction of new things produced. Because of the scarcity of attention, people must be selective. The challenge is not to create sociotechnical environments based on anyone having access to information "anytime and anywhere" but rather to create *context-aware systems* that focus on "the 'right' information, at the 'right' time, in the 'right' place, in the 'right' way, to the 'right' person" [12].

System developments to reduce the information overload problem include developing techniques for personalization and making information relevant to the task at hand, for example: search engines, context-aware applications, adaptive and adaptable components, personalized learning environments (based on learning analytics), recommender systems, and personalized news streams—all help people to find the needle in the haystack.

The design trade-off associated with a strong emphasis on personalization is that serendipitous encounters (e.g., giving people something that they want without asking; encountering interesting ideas, things, events, people by chance) and opposing opinions and worldviews are suppressed.

The promises associated with a strong emphasis on personalization are accompanied by *pitfalls*. Systems tailoring their services (including news and search results) to people's inferred personal preferences and tastes may cause recipients to get trapped in *filter bubbles* (representing a unique universe of information computed by algorithms) [16], which suppress serendipitous encounters, opposing opinions, and different worldviews. Filter bubbles may lead to groupthink with a loss of individual creativity and independent thinking, as well as a tendency to minimize conflict and reach a consensus decision without critical evaluation of alternative ideas or viewpoints. To transcend these contradictory objectives requires finding an adequate balance between personalization and serendipity by designing interaction mechanisms that allow users to select their own personal, situation- and time-dependent *best mixes* of these design trade-offs—providing another example that there are no decontextualized sweet spots.

In our research we have developed *context-aware information delivery systems* [12] to explore a mix between personalization and serendipitous information delivery. Supporting users to incrementally learn more useful operations in high-functionality environments (including software reuse libraries, MS Office, apps on smartphones, MOOCs, etc.), our systems (based on user and task models) differentiated between personally meaningful and personally irrelevant information.

described by Herbert Simon of the importance "to uncover unknown alternatives and identify the truly limiting factors that underlie problems":

A few years ago, the State Department was troubled by the congestion that affected its incoming communication lines whenever there was a crisis abroad. The teletypes, unable to output messages as rapidly as they were received, would fall many hours behind. Important messages to Washington were seriously delayed in transmission.

Since printing capacity was identified as the limiting factor, it was proposed to remedy the situation by substituting line printers for the teletypes, thereby increasing output by several orders of magnitude. No one asked about the next link in the chain: the capacity of officers at the country desks to process the messages that would come off the line printers. A deeper analysis would have shown that the real bottleneck in the process was the time and attention of the human decision makers who had to use the incoming information. Identification of the bottleneck would have generated in turn a more sophisticated design problem: How can incoming messages during a crisis be filtered in such a way that important information will have priority and will come to the attention of the decision makers, while unimportant information will be shunted aside until the crisis is passed? [10]

This is not an isolated example. The lessons learned here can be applied to the design trade-offs between personalization and serendipity (Sidebar 1) and to the relationship of self-driving cars and mobility for all (Figure 2). Like any useful tool, the car has purposes to which it is ideally suited. It is particularly well suited to low-density areas; it can also be very useful in dense cities as a taxi. But those with an interest in promoting cars succeeded in casting transportation problems not as a problem of moving people but rather as a problem of accommodating cars everywhere—even to the point of rebuilding cities for cars, thereby diminishing alternative transportation choices.

While there is no simple recipe for how to identify the truly limiting resources or the "real" design problem, an emphasis on 1) the identification of relevant design trade-offs, 2) the involvement of all stakeholders to bring as many voices to the table as possible, 3) the analysis of errors and breakdowns, and 4) the iterative design by building inspiring prototypes (creating objects to think with) will all contribute to emphasize problem framing in order to avoid developing solutions to the wrong problem. Figure 2 illustrates an important contribution of a design trade-off analysis: It widens the design space. The truly limiting factor (as described in the printing example above) is not self-driving cars, but rather explorations for creating a framework for "mobility for all" in the 21st century [11].

SELECTED MAJOR CURRENT DEVELOPMENTS THAT IMPACT QUALITY OF LIFE

To illustrate the necessity for a comprehensive QoL framework, two current examples of major developments, including the design trade-offs associated with them, will be briefly discussed and analyzed.

Self-driving cars and mobility for all. Ten years ago, self-driving cars seemed to be more a topic for science fiction than a near-term reality. As rapid progress is made at the technological level ("it can be done soon"), the design trade-offs associated with the social and ethical levels ("should we do it") (Figure 1) take center stage. The *proponents* of self-driving cars [13] argue: 1) independence for people who cannot drive (based on impairments such as age or blindness), 2) fewer accidents (no more drunk driving, no more distracted driving), 3) fewer cars (based on the reduced need for owning a car), 4) better use of existing cars (more than 90 percent of all cars are not driven at a particular moment), and 5) spending more time on personally preferred activities (e.g., reading a book or sleeping instead of driving). The arguments of the *opponents* are centered on: 1) loss of control (many people find driving fun and engaging), 2) loss of jobs behind the wheel (trucks, taxis) and in the car industry (as substantially fewer cars are needed), and 3) unclear responsibilities if something goes wrong. Beyond the two endpoints of "no technological support" and "complete automation" (these challenges have been pursued with aircraft for some time [14]), numerous *driver-assistant systems* have been developed and more are becoming available in today's cars, including adaptive cruise control, collision-avoidance systems, parking assistants, and car-to-car communication.

Exploring the impact of self-driving cars on QoL, the question remains whether the truly limiting factors have been identified. Exploring the future of mobility provides an opportunity for a paradigm change, from a focus on the automobile to the consideration of many more options and design trade-offs [11]. There are major stakeholders who have a vital interest in shaping and influencing this future: car manufacturers, information technology companies, environmental groups, and politicians, to name a few. Figure 2 provides an overview of the multifaceted dimensions of the transformative changes that should be considered in exploring "mobility for all" rather than "self-driving cars" as the core problem [11].

The sharing economy. The sharing economy [3] has emerged as an alternative model in several domains (e.g., Uber and Lyft in transportation, Airbnb in accommodation) by providing consumers with alternative, convenient, and cost-efficient access to resources and services. Many stakeholders stress the *positive* impact of the sharing economy on QoL: Consumers see it as a way to (sometimes) get cheaper and more readily available services; drivers and renters earn some additional money; and the companies supporting these services have become some

Those with an interest in promoting cars succeeded in casting transportation problems not as a problem of moving people but rather as a problem of accommodating cars everywhere.

of the most economically valued ones. Others experience the *negative* impact of the sharing economy: Taxi companies and hotels are driven out of business; professional drivers and hotel employees lose their jobs; taxes are not paid; and safety may be at risk. The sharing economy is facilitated and supported by ICT developments; researchers and practitioners in HCD and related fields will be responsible for shaping these developments that ultimately impact the QoL of many people. Figure 3 illustrates the multifaceted developments associated with a shared economy (many of which are related to the concepts associated with mobility for all, documented in Figure 2).

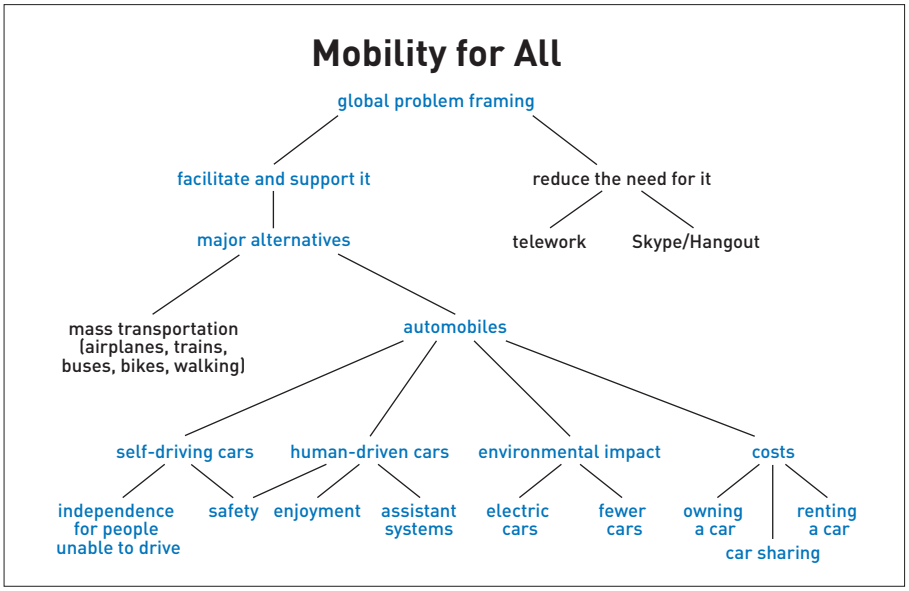

Figure 2. The multifaceted dimensions of mobility for all (the nodes in black are not further elaborated).

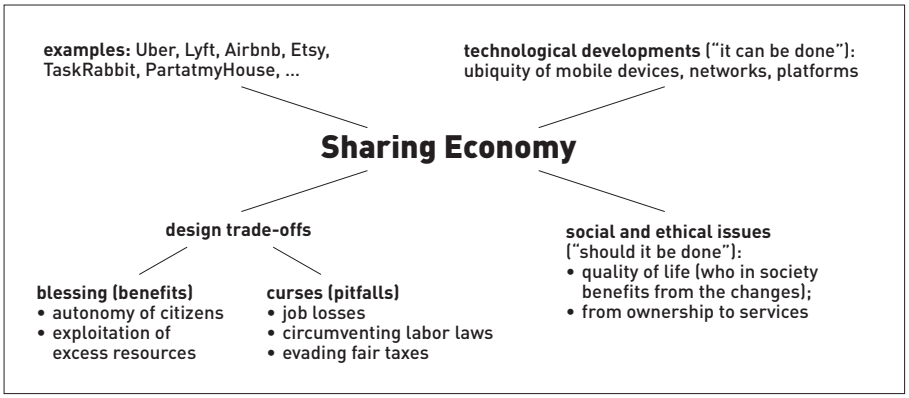

Figure 3. The multifaceted dimensions of the sharing economy.

A RESEARCH AGENDA FOR THE FUTURE

The previous sections of this article have explored QoL as a transformative framework for HCD grounded in a number of fundamental requirements, including to avoid oversimplified solutions that result from ignoring important facets of complex problems (relying on one-sided approaches instead of considering design trade-offs), and to explore a continuum of richer sets of choices by identifying the most adequate balanced approach (by exploiting the strengths and avoiding the weaknesses of the endpoints defining the trade-offs).

The following sections briefly describe a small number of objectives for a research agenda exploring QoL as a transformative framework for human-centered design.

Questioning the "more is more" philosophy of life. Digital technologies have accelerated the production and consumption of information. This information comes about from humans acting as bloggers, producers of movies, and participants in social networks; and from sensors embedded in the cyber-physical systems surrounding us [15]. "More is more" has its attractions and rewards and has been embraced by many people. For example: more slides in a presentation; more Facebook friends, Twitter followers, and LinkedIn connections; more students in a MOOC; more publications and a higher H-Index; more apps on our smartphones; and more "new version" messages from the companies whose systems we use.

An alternative for a QoL framework includes developments that shield people from unwanted information and help them to focus their lives on their interests, passions, and dreams by exploring the design requirement "less is more." This approach will emphasize the following requirements: 1) innovations protecting people from the tidal wave of information (including "do not call" telephone lists, e-mail filters, and cellphone-free zones); 2) regulations that shield people from being available at all times (e.g., limiting or barring e-mail after work hours to achieve a desired work/life balance); and 3) opportunities and incentives for humans to change their behavior (e.g., engaging consumers in occasional "information celibacy" by abstaining from the constant flow of information).

Beyond the exclusive reliance on big data. Some of the assumptions behind our ability to gather huge amounts of data are: 1) everything that can be measured should be measured, and data is a transparent and reliable lens through which to make informed decisions; 2) we should analyze the behavior of learners (e.g., with learning analytics); and 3) we should illuminate patterns of behavior and functions that we are unable to observe and analyze. The *positive* impacts of big data on different QoL dimensions are: 1) overcoming beliefs, opinions, and mistaken assumptions by documenting a descriptive account of how things are (thereby exposing when our intuitive view of reality is wrong); 2) reducing information overload via personalization and making information relevant to the task at hand (see Sidebar 1); 3) collecting information and giving feedback on activities in the physical world (e.g., activity trackers providing data for a "quantified self"); 4) enabling new business models (as the sharing

SIDEBAR 2. DESIGN TRADE-OFF: PRESCRIPTIVENESS VS. PERMISSIVENESS

Sociotechnical environments for computation, learning, and decision making can be characterized by opposing choices on a continuum: being prescriptive or being permissive. In prescriptive environments, designers define context and rules by creating finished systems at design time (by defining rules, checklists, and workflow processes), and teachers define curricula and provide guidance by acting as "sages on the stage." In permissive environments, users have autonomy and can do whatever they want to in a self-determined way. As a specific example, Table 2 contrasts "curriculum-driven learning" (primarily prescriptive) with "interest-driven, self-directed learning" (primarily permissive) learning environments.

The opposite choices described in the two columns of the table are design trade-offs. The challenge to contribute positively to QoL lies (as in the other examples given) in identifying the most promising mix. Numerous attempts to explore and support the middle ground by exploiting the strengths and minimizing the shortcomings of the prescriptiveness versus permissiveness spectrum include: guided discovery learning in education (representing a mix between curriculum-driven and self-directed learning; see Table 2), meta-design, and libertarian paternalism (briefly described in the section "A Research Agenda for the Future").

	Curriculum-Driven Learning	Interest-Driven, Self-Directed Learning
characteristics	problem is given by the teacher or the system; learning is driven from the supply side	problem is based on the learner's needs and interests; learning is driven from the demand side
strengths	organized body of knowledge; pedagogically and cognitively structured presentations	real interests, personally meaningful tasks, high motivation
weaknesses	limited relevancy to the interests of the learner or the task at hand	coverage of important concepts may be missing; unstructured episodes; lack of coherence
primary role of the teacher	sage on the stage—presents what he/she knows and is prepared for	guide on the side—answers questions posed by learners
planning versus situated responses	anticipation and planning of the learning goals and content	learning needs arise from the situational context
distribution over lifetime	*decreasing* in importance from school to university to lifelong learning	*increasing* in importance from school to university to lifelong learning
assessment	"standard" assessment instruments are applicable	"innovative" assessment instruments are needed
unique research challenges	presentation of an organized body of knowledge; responsiveness to individual differences	task identification; context awareness

Table 2. Distinctions between curriculum-driven learning and interest-driven, self-directed learning.

economy mentioned above); and 5) helping us be environmentally responsible (e.g., with smart grids and smart meters).

A trade-off analysis of big data uncovers some of the *negative* consequences for QoL dimensions: 1) the tendency to value what we measure (based on data that is easy to obtain) rather than focusing on measuring what we value, 2) the quantification of fundamentally holistic human experiences combined in many cases to the reduction of a single number, 3) privacy violations, 4) the elimination of the positive aspects of forgetting, and 5) the narrowing of our exposure to different themes and value systems determined by filter bubbles [16], leading to an increased polarization of (particularly online) discussions.

Meta-design and libertarian paternalism: Distributing control. *Meta-design* (focused on "design for designers" [17]) is a theoretical framework to conceptualize and to cope in unique ways with design problems. In a world that is not predictable, improvisation, reflection, evolution, and innovation are more than luxuries: They are necessities. The challenge of design, particularly in the context of wicked problems, is not a matter of getting rid of the emergent, but rather of including it and making it an opportunity for more creative and more adequate solutions to problems [2]. Many approaches force all the design intelligence to the earliest part of the design process, when everyone knows the least about what is really needed. Meta-design extends the traditional notion of system design beyond the original development of a system by supporting users as *co-designers*.

It is grounded in the basic assumption that future uses and problems cannot be completely anticipated at design time, when a system is developed. Users, at use time, will discover mismatches between their needs and the support that an existing system can provide for them. These mismatches will lead to breakdowns that serve as potential sources for new insights, new knowledge, and new understanding. Meta-designers use their own creativity to produce sociotechnical environments in which other people can be creative, defining the technical and social conditions for broad participation in design activities. It is important to point out that the

goal of making systems modifiable by users does not imply transferring the responsibility of good system design to the user. In general, end users will not build tools of quality equal to that of a professional designer; they are not concerned with the tool, per se, but rather with doing their work. However, if the tool does not satisfy the needs or tastes of the users (which they know best themselves), then users should be empowered to adapt the system without being dependent on developers.

An interesting design trade-off discussed broadly in behavioral economics and public policy is to find a balance between the binary choices (see Sidebar 2) of paternalism (being prescriptive) and libertarianism (being permissive). The book *Nudge* [1] introduces and advocates libertarian paternalism and associated concepts such as choice architects and well-chosen defaults. The implications and the consequences of employing nudges are illustrated in the book with a variety of examples contributing to QoL in domains such as health, wealth, and happiness. Nudges distribute control among choice architects (e.g., policymakers in governments, meta-designers, teachers) and customers (e.g., citizens, users, learners). Nudges are less coercive than commands, scripts, workflow processes, requirements, or prohibitions. The appeal of libertarian paternalism is rooted in the respect it has for individual autonomy represented by the libertarian component.

The QoL design trade-offs in relationship to libertarian paternalism center on the issue of whether (and in what ways) individuals want government, teachers, or parents to protect them from their own mistakes or poor decisions. The critics arguing against nudges believe that individuals may be imperfect decision makers, but they still possess more information about their lives than others and should therefore have more control over their lives than others. By being nudged they are deprived of responsibility for their actions and decisions. Supporters of nudges argue that whatever designers and decision makers do, they will inevitably be setting contexts and default positions anyway and that the libertarian part allows individuals to be free to do what they like. The nudge framework shares many objectives that meta-design pursues in the context of human-centered design.

CONCLUSION

If information and computing technologies are developed to improve the QoL of all humans, then it is necessary to analyze what those needs are and how technology is required to meet them. Beyond basic needs (food, water, and shelter), needs for necessity, importance, and urgency are not something imposed by nature upon humanity, but rather are conceptual categories created by cultural choice. Humans are creatures of both needs and desires. Therefore, a QoL framework should be grounded in not only understanding new media and technologies in terms of productivity, efficiency, reliability, and from economic perspectives, but also in exploring innovative sociotechnical environments that contribute to human creativity, gratification, and enjoyment.

Design trade-offs are important because *the future of the digital age is not out there to be discovered; it must be designed*. Technology developments are not inevitable, and the HCD community should demonstrate that design alternatives are possible. As researchers, we need to explore and understand the implications of design trade-offs, and engage multiple voices in constructive controversies. As designers, teachers, educators, and members of scientific communities, we need to encourage and support learners of all ages in exploring QoL requirements, and provide opportunities for nurturing mindsets for thinking, reflecting, and acting in an informed way by considering design trade-offs in all areas of human life.

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