Review on Human Computer Interaction Learning From History & Need of Rethinking

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ABSTRACT

Human-computer interaction (HCI) is the study of how people design, implement, and use interactive computer systems and how computers affect individuals, organizations, and society. This encompasses not only ease of use but also new interaction techniques for supporting user tasks, providing better access to information, and creating more powerful forms of communication.HCI is now becoming a new destination for researchers after considering its future perspective. This paper discusses what should we learn from the historical evolutions in HCI and what we need to rethink in order to make HCI a Powerful one.

Keywords: Human Computer Interaction, Research, History, Future Approaches, Rethinking.

I INTRODUCTION

HCI in the large is an interdisciplinary area. It is emerging as a specialty concern within several disciplines, each with different emphases: computer science (application design and engineering of human interfaces), psychology (the application of theories of cognitive processes and the empirical analysis of user behavior), sociology and anthropology (interactions between technology, work, and organization), and industrial design (interactive products).

The most famous definition of "Human Computer Interaction" is "Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them." The Human Computer Interaction (HCI) program will play a leading role in the creation of tomorrow's exciting new user interface software and technology, by supporting the broad spectrum of fundamental research that will ultimately transform the human-computer interaction experience so the computer is no longer a distracting focus of attention but rather an invisible tool that empowers the individual user and facilitates natural and productive human-human collaboration.

HCI has been influenced by several overlapping traditional disciplines – Computer Science, Cognitive Psychology, Behavioral Science, Anthropology and Ethnography, Communication Design, Product Design, Ergonomics, Human Factors, Writing and Rhetoric, Library Sciences and Business Process Re-engineering.

In the past 25 years, HCI has been offered as Masters level programs by departments of cognitive psychology and human factors, usually with the name of "Human-Computer Interaction" or "Usability Engineering", by departments of library sciences or information sciences with the name of "Information Architecture" and occasionally in Departments of Computer Science or Information Technology. Courses in Interaction Design, as offered by design schools have been relatively newer.

II LEARNING FROM HISTORY

Learning from history can profit from more than 100 years of HCI research. In this section, we will sketch major research lines and foci followed by conclusions for future efforts in this field.

A. Major research lines

Future solutions of HCI designs can draw on more than hundred years of HCI research . It is a topic of a broad range of disciplines, and perspectives. The diversity of perspectives is documented by diverse research paradigms, and disciplines with different names: ergonomics, human factors, usability, usability engineering, user-centered design, man-machine-studies, or human-computer interaction. The respective name depends on the time, and refers to the disciplinary community involved, as well as the focus of interest.

The first evidence of ergonomics can be found as early as in 1857, introduced by a natural scientist, Wojciech Jastrzebowski, His intention was the concern for a humane working environment, referring to the calamitous work conditions of the early industrial period. With Taylor in 1911, the first industrial studies appeared across Europe, addressing industrial health, and safety when working with different kinds of machines. Also, the research fields of work motivation, as well as personal and organizational issues were “discovered” as key factors influencing the productivity of work. In 1930 in Russia, the first human factors analysis of aircraft cockpits appeared, the forerunner of the huge field of human computer interaction and design until today. In the 1950s, human factors and ergonomics became key issues worldwide (U.K., France, Germany, Sweden, Netherlands, USA, and Japan). The introduction of quantitative modeling of human behavior, the formal description of psychophysical processes and cognitive functioning by constitutive theoretical approaches (e.g. signal detection theory, working memory, Fitts law, information theory) was another step forward, enabling the quantitative prediction of human behavior and work productivity . In 1957 the Human Factors Society, in 1961 the International Ergonomics Society were founded. Both world-wide acting institutions formed the community and are influential and active until today.

With the increasing automation in the 1960s, a further keystone was the introduction of standardizations, legalizations and international certifications of health and work safety all over the world, until today a major component of industrial productions and quality management.

Parallel to the penetration of personal computers in working and private areas, in 1982, the Association for Computing Machinery (ACM) launched the International Conference of Human Computer Interaction (CHI), until today the leading conference on human computer interaction.

Today we have considerable knowledge that allows the conceptualization and design of usable as well as useful interfaces.

B. Major research foci

The research field HCI has multidisciplinary roots from the very beginning, involving and addressing different disciplines, including industrial engineering, computer science, psychology, sociology, medicine, and linguistics. In the beginning of ergonomics, health & safety issues as well as humane working environments were key, taking well-being and physiological functioning as benchmark. In addition, organizational and personal issues in organizations were focused on. With the increasing maturity of technical systems, and standardization efforts, which assured a basic quality standard, health issues were less prominent.

Instead, the prediction of human performance became a major research topic, as well as the productivity of human work in terms of effectiveness and efficiency. In the 1980s and 1990s, two parallel phenomena can be observed: On the one hand, the overarching introduction of personal computers and a productivity-related research, on the other hand, a boom of research dealing with technology acceptance. Meaningfully, both research streams were acting separately, without much awareness for the other. While the one mainly concentrates on the usability of a technical system, the other deals with the approval, favorable reception and ongoing use of devices, exploring the relation of using motives, cognitive and affective aspects towards the respective technology.
Last, but not least, the interaction and relationship between humans and computers is one of the prominent research focuses, as well as a human-centered interface design, covering both, input and output mechanisms.

C. Essentials of history—a first conclusion

We see a lot of progress in the history of HCI, but also "blind spots". To begin with the enormous progress and innovations driven by HCI, several key moments fundamentally changed the work with computers. One is the economic benefit carried by HCI efforts. Empirical evidence shows those human-centered designs, the observance of usability issues, and the employing of HCI knowledge —processes, techniques, methods, and tools— factually increase productivity that can be measured. The benefit can be taken from higher execution speed and fewer errors, the decrease of costs, and increase users' satisfaction.
Second, as a matter of course we can rely on highly sophisticated interfaces across technical systems. Examples for groundbreaking developments are e.g. the shift from a merely ergonomic focus to cognitive designs as well as affective computing and hedonic designs, or the shift from a command-based interface to direct manipulation of graphical objects, as well as "new" forms of information management (e.g. World Wide Web). Third, many of the inventions made by university research were picked up by industrial research, before finally, products were marketable and commercialized. In Figure , this showcase is demonstrated for three HCI innovations, the Direct Manipulation of Graphical Objects, Windows and Hypertext.

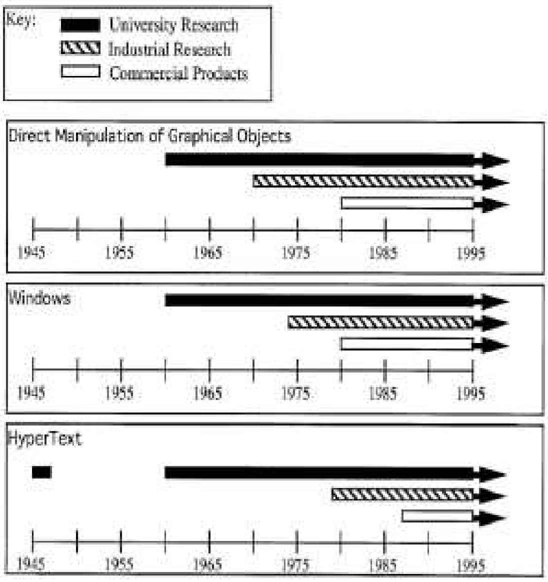

Figure 1 - Transfer of academic HCI knowledge into industrial application .

However, also blind spots and unfavorable developments occurred, which, facing the upcoming requirements for future technological developments, are highly crucial and critical. They should be carefully analyzed and translated into time-critical sensitive measures within education, research and industrial practice. Though truly multidisciplinary from the very beginning, the "discipline HCI" could only superficially profit from the surplus of different approaches. To date, HCI topics are treated within different disciplines. Theories, models, and methods are not communicated across disciplinary borders.
Instead, disciplines compete by ignoring each other. The complexity of future HCI interfaces and designs requires the full potential, i.e. the combination and cross-linking of disciplinary knowledge to an interdisciplinary school of methods in the HCI-field.
Another blind spot concerns the separation of usability and acceptance. Evidently, a product or Service can be usable, and, at the same time, it can be completely rejected. Therefore, human-centered approaches have to consider both, usability as well as acceptance. Though, human-centered approaches mean much more than merely asking users how efficient or useful an interface might be. Rather, useful and accepted interfaces must be harmonized with the properties of human information processing and should also address needs and wants of users in specific using situations. To this end, interface Development needs the users' perspective from the very beginning.

The third blind spot is the most substantial one, as single shortcomings in a chain induce a domino effect. To date, we do not have a meta-concept in combination with an overarching theoretical framework for the design of further HCI generations that goes beyond disciplinary perspectives, methods, and tools. Only a comprehensive framework that reasonably pursues societal developments and human needs would allow us to adaptively react to realities like fast changing technological environments as well as changing user profiles and motives. Such a framework would require deep insights, which of the factors to be considered in technological designs are truly "universal" (acting independently from time, Technology, and context) and which of these factors are specific (depending on time, technology, and context).

The lack of (motivation for) such integrative frameworks entails a lack of integrative educational concepts within universities. As consequence, we are missing the comprehensive HCI professionals of tomorrow, which are so badly needed, facing the multi-faceted societal challenges. Strictly speaking, the lack of appropriate academic HCI education leads to "small-minded" HCI knowledge in industrial production and a kind of "mono-culturally" educated engineers. It is undisputable though that modern and highly competitive industrial practice would significantly profit from transdisciplinary educated HCI professionals, providing new and innovative human centered products.

III REQUIREMENT FOR FUTURE HCI APPROACHES

A. Re-thinking Paradigms—function and fun

A long time HCI has been discussed from a dominantly functional perspective. According to ISO 9241, the pragmatic aspects of technology, covered by the term "usability", are measured by effectiveness (how successful is the interaction), efficiency (how fast is the interaction), and satisfaction (how satisfied are users when interacting with the interface). Though, facing the complexity of future interface designs as well as an increasing diversity of users, contexts, and technology types, the concentration on pragmatic aspects falls short. Traditional approaches and human factors practices usually do not reflect the importance of (positive) emotions. We have reached a turning point of HCI, which requires a broadening of the focus and include emotional or affective designs.

In this perspective, the quality of "good interfaces" relies on more than the orientation on performance aspects. Rather, usability should be described as a complex out of pragmatic aspects (attributes emphasizing the fulfillment of individuals' productivity), but at the same time affective and hedonic aspects (attributes emphasizing individuals' well-being, pleasure and fun when interacting with technology).

To this end, the relationship of users and technological product is of importance and the making sense of user experience. Both are highly needed facing that information and communication technology moves out of the office and into everyday- life. Modern HCI approaches should systematically address hedonic (no utilitarian) requirements in combination with goal-oriented requirements.

Yet, there are companies following this approach with great effort and success, e.g. Philips with the brand promise "sense and sensibility" or Apple with a design approach relying on aesthetics, elegance and pleasure. Increasingly, studies show that users desire more than the mere functioning of technology, but prefer interfaces with a high social or hedonic value. Hedonic functions are providing stimulation, identity, and valuable memories.

Beyond affective and hedonic computing, which is not yet included as an inherent component of design, we state another missing part: communicative usability and the question how linguistic and semiotic means may contribute to a transparent and pleasurable dialogue between humans and interfaces. Communicative usability deals with two dimensions—the communicative quality of the human-computer interface as well as the quality of user support tools (e.g. training, manual, tutorials). To date, communicative usability is not seen as an inherent part of HCI, even though we all know from daily experience that the communication with technology is one of the most sensitive parts in HCI. Users are frustrated when confronted with unreasonably structured information, an inappropriate naming with unclear or even unknown vocabulary, vague instructions, inscrutable dialogues, and missing feedback. Usually, manuals or tutorials are scribbled "last minute", by persons, which are unaware of their relevance and importance of communicative usability.

In fact, written and spoken language is one of, if not the most important communication modality, enabling users to interact with computerized artifacts. Human-centered designs should learn from what we know about human-human communication as first order approximation of information transfer, and adopt this Knowledge. Multimodal interfaces offer additional modalities as part of design means like multimodal dialogue, video stream, haptic input or gestures (e.g. in the case of augmented reality applications). A future challenge is to investigate which modality fits best to which task and goal.
Disciplines like linguistics, technical communication, or psycholinguistics offer a profound knowledge of how humans use language to describe their view on the world, to interact with each other and how humans deal with social and technological environments in order to solve problems and to learn. Theoretical paradigms, like the activity theory, investigate problem solving processes as part of a

rich system of community practices, traditions, values and behavioral patterns.

B. Re-thinking Methods—interdisciplinary and trans-disciplinarily

The communication and interaction within and across HCI-related disciplines is characterized by misunderstandings, misbelieves and misconceptions. Partly, disciplines use different terms for the same thing (e.g. ergonomics and human factors), or they use the same or similar terms for different things (e.g. *HCI* for Human Computer Interaction vs. Human Computer Interface). Another distracting phenomenon is resulting from the fact that disciplines are investigating the very same topic with different foci and different underlying theoretical and methodological framework.
Each discipline is convinced to do the right thing and to do it in the most valuable way. Different disciplinary languages, value systems, and scientific approaches build up barriers for understanding and communication on a par with each other. Another factor aggravating the missing connection is the fragmentation within disciplines (e.g. cognitive, industrial, system and/or computer ergonomics). An expert in one subfield of a discipline is unlikely to be an expert in the other. Additionally, the disciplinary fragmentation makes it difficult to overview the richness of disciplinary research objects, theories, approaches, and methods.

The challenge of future HCI approaches will be to create an effective cooperation within and across disciplines resulting in a multidisciplinary mindset and a multidisciplinary toolkit of methods. With Rogers , the current interdisciplinary practice goes not far enough. Rather, we need truly trans-disciplinary approaches. "The 'trans' refers to integrative knowledge based on the convergence of concepts and methods from different research areas, including computing, philosophy, embodied psychology, art and design, ethics and engineering"], anthropology, sociology, communication studies and linguistics.

C. Re-thinking Design—universal and differential design approaches

In fact, it is a ongoing discussion whether design approaches should direct to a "design for all" or, rather, to a differential approach. The design-for-all approach claims that HCI interfaces should be designed in order to meet requirements and needs of all users, providing universal access. This approach relies on empirical evidence, that a design for all approach is indeed feasible. In contrast, the differential design approach claims that HCI designs should focus on the "diversity" of users, using contexts, technology types and domains.

On a first sight, the two positions seem to be contradictory. However, actually they are not, if the two positions are applied in succession, it becomes evident that both perspectives are not exclusive, but may be combined. The "design for all" approach is focusing on human universals, thus the functioning of basic senses, cognitions, psychomotor functions as well as basic emotions. The differential design is focusing on the specifics, determined by the social, cultural context as well as individual needs. Both approaches are highly reasonable and must be considered at the same time. HCI interfaces meeting demands of universal design are harmonized with information processing and assure a basic fit of technical interfaces to the persons which use these interfaces. This should be provided as a minimum quality standard is benefitting all users.

As using contexts are determined by many other factors in addition—fun, aesthetics, experience, gender, cultural diversity, trustworthiness, security, safety, intimacy, individual abilities—differential design approaches assure users' satisfaction, acceptance and the contextual, adaptive and individual fit between humans and interfaces.

D. Re-thinking Users—user diversity

As opposed to the past, when mostly sophisticated and technology prone professionals were the typical end-users of technical products, now broader user groups have access to technology. Still, the development of technology seems to be limited to dominantly young, technology experienced, Western, middle- and upper class males. Although the vital importance of ensuring that the technology produced is both usable and appropriate for a diverse user group, recognition of the importance of diversity is only slowly influencing mainstream usability studies.
Design approaches thus have to undergo a radical change taking current societal trends into account, which have considerable impact for the inclusion of a diverse user group.

Aging: A first trend refers to the profound demographic change with an increasingly aging population across many nations. According to census data in 2050 more than 30% of the population will be 65 years and older. Increasingly more and older adults will be confronted with a broad range of technology, and urged to understand, learn and use it. Older users face difficulties in learning and using new computer applications. Contrary to current stereotypes, according to which older users are unable or unwilling to learn new technologies, they are indeed interested to become acquainted with new technology. However, older users do have higher demands on usable interface designs. Up to now, HCI designs are often realized without considering the abilities and needs of this user group.

Experience with technology: The second trend is the ongoing diffusion of technical devices in all parts of daily life. Applications like electronic services are deeply integrated into daily life. Although these technologies are supposed to be accessible to everyone, a gap between those, who are “computer literate” and those, who are not (predominantly older users) is emerging. It should be kept in mind that older users differ considerably with regard to their needs, abilities and competencies. In order to address elderly users as a growing market segment, age-sensitive interface designs are needed. Age-sensitive HCI solutions allow user of different ability levels to interact with new technical applications.

Mental model of technology: As a third trend, the technology itself has changed considerably over time: At the same time, technology innovation cycles become increasingly faster. The trend described is aggravating the situation especially for older adults, as the understanding of how technology works is to a large extent formed by upbringing and socio-cultural factors. Older adults were educated in times when technical devices were far less ubiquitous and complex. A mental model of how technology works, built in a former time, should interfere with, or at least should not be sufficient for, proper interaction with devices currently available While 25 years ago, stationary computers were the state-of- the art-technology, the Internet characterized the 1990s, introducing the basic networking of computers worldwide. Today, mobile wireless communication technologies are predominant. The concept of mobile devices and networking completely changed the hitherto existing technical concept. Mobile devices are often miniaturized with a small display, but a huge functionality, providing on-the-go lookup and entry of information, quick communication and instant messaging. Mobile technologies are expected to specifically support older adults in their daily needs, applicable for different tasks and goals (e.g. medical monitoring, navigation, memory aids, and personal data management). Also, mobile devices are increasingly used in ambient intelligent environments, in which devices are communicating with remote computers, sometimes integrated in clothing, furniture or walls.

Cognitive complexity: The combination of small screens and mobile using contexts creates a still higher usability demand compared to large display technologies. The limited screen space is extremely problematic for providing optimized information access. However the question how to deal with different interfaces concerns not only the information presentation and the alteration of technology generations, but also the amount of technology a user has to deal with. Interfaces are designed with the idea that users will focus their full attention to them. With ubiquitous computing, the number of devices for each user is multiplying.

Altering from one interface design to another duplicates the required mental effort and the cognitive load when using these technologies. It is a central claim that mobile displays are designed to be in line with older users’ specificity and diversity. Design approaches should therefore take the user-perspective seriously. The duty of further research efforts is to fill the knowledge gap, and to systematically integrate user diversity—age, gender, social and cultural factors—into usability approaches.

E. Re-thinking Context—context diversity

Interface design is strongly context-related. Human beings do not use a single technology in isolation; they use technical artifacts as part of a complex situation. The components are interrelated—contextual factors are influencing how humans are acting with technology; the use of technology modifies the embedding context.

The term ‘context’ covers a broad range of factors. They form a rich contextual framework including the professional or personal workplace as part of an embedding organizational framework, domain, culture, and society (figure 2). A good interface design requires a broad understanding of contextual aspects as well as their interplay.

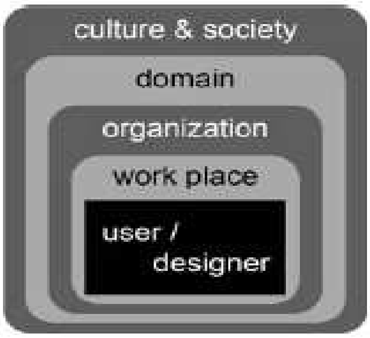

Figure 2 - Inclusion model of contextual framework

A lot of studies discuss the impact of workplace conditions or the impact of institutional frameworks on technology and vice versa. Only few approaches consider that workplaces and organizations are part of a broader social, cultural, and societal environment. For example, the way humans use technological artifacts is affected by the domain, in which a technology is used (e.g., industry, military, or public domain). The term 'domain' denominates societal areas of acting and domain-specific norms, values, and conventions guiding human expectations and behavior. The overarching framework is built by societal and cultural framing factors. We should be aware that the claim for "universal access" and the overcoming of the "digital divide" always implies a certain political system (e.g. democracy), a certain socio-economic level (as welfare) as well as a certain legal frameworks. HCI products must be seen in their relationship to political, economic, and legal constraints.

A clear shortcoming of current HCI research regards the discussion of the interaction of technology, society and culture. Up to now there is a notable lack of knowledge on how society and culture affect the design of technology, and HCI as part of it. "Although culture has recently been recognized as one factor in interface design, CS and engineering are generally thought to be culturally neutral". Otherwise "technological systems are socially Produced, and social production is culturally informed" . Therefore, the design of Technologies should fit to a certain culture and Society.

F. Re-thinking Tasks—task and goal

In traditional human-centered HCI approaches the category 'task' and related methods like task analysis are highly relevant components. In order to design a user interface—meeting the user's needs—the designer must understand for which tasks one will use the system for and how they will be performed. Terms like 'functional', 'usable', 'learnable' and 'efficient' are directly related to the task category.

In our opinion the concentration of tasks is not going far enough; it should be more fine-grained. Often there is no one-to-one relation between goals and tasks. The perspective focuses too much on the isolated use of a certain technology. As we mentioned above the use of a technology is part of a complex situation and overarching interests. Tasks are the result of former decisions, directed by super ordinates individual as well as institutional goals which can be competing. For example, somebody is consulting an expert portal to be sure (super ordinate goal) that they are doing the right things. With this intention they are searching for information (task). They are not only interested in easy to use search facilities but also in other aspects linked to their overarching goal like trustworthiness of the information they will get.

G. Re-thinking Technology—technological Diversity

There is some evidence that the definition of a good user interface is closely related to the technology type in question and its problem-solving potential. Up to now HCI and usability research has shown little attention for the interrelation of technology type and user interface design. In contrary, a short view on the very fast growing number of computerized artifacts and their increasing diversity makes it quite clear that this must have profound effects on the design of human computer interfaces. Innovations like hypertext, Internet and graphical user interface, allowed the creation of new applications, platforms and services that now dominate our private and professional life.

CONCLUSION

Concluding, future HCI demands should pick up the shortcomings existing so far.

HCI education: We need an integrative HCI education, in academia as well as in advanced trainings. The complexity of HCI challenges requires inter-, trans- and multidisciplinary approaches, realized in new educational programs (HCI Master of Science). A HCI master education should not only train a comprehensive understanding of different disciplinary frameworks and paradigms, it should also direct to a trans-disciplinary School of Methods.

HCI research: Interdisciplinary and trans-disciplinary research involves a comprehensive toolkit of models and methods. We need research frameworks integrating different types of methods, tools, and data types. Another indispensable requirement is the willingness to discuss traditional, within disciplines well-established mindsets and the openness to broaden these approaches by other approaches, perspectives and methods.

Industrial practice: New approaches integrate users as a valuable source for new ideas and innovations (end-user driven innovation cycle) and integrate their ideas and perspectives in the technical development. User communities are a significant source for innovation and provide market insight before launching an innovative product . User-driven innovation requires cross-functional approaches. The integration of user perspectives enables the profiting from user insights and customer experience. It helps to find new ideas for products in an early stage of the innovation cycle, to create new product concepts and to optimize product generations.

Quality management: The ongoing fundamental technological shift, the changing societal, economic and legal circumstances as well as the changing demands and desires of users require new ways of quality management (e.g. Total Quality Approach). One possibility for a new quality management approach is to create an integrative HCI "seal", similar to the TCO seal, introduced in 1978 for visual displays in Sweden. A seal, promising "HCI proven interfaces" though is only feasible by an integration of different perspectives and a sustainable inter-disciplinarity within and across academia and industrial practice.

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