Bridging the HCI-SE Gap: Historical and Epistemological Perspectives

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Abstract: Assuming that the gap between HCI and SE can be better understood through exploring their historical developments, we studied several related literature available. The insights thus gained are: thesis-antithesis-synthesis approach can be used to clarify fundamental concepts by inviting discussions between different parties; ongoing within-discipline evaluation should be based upon cross-discipline observations; balanced views about humans and technologies are essential for understanding their interactions. The fact that knowledge as dynamically-constructed personalized entity accounts for infeasibility for closing the gap between HCI and SE. The conjecture that knowledge domain can be served as a tool to sustain the control and interest of the privileged people leads us to consider that a mesh of political, social and economic issues is lurking behind the persistent separation of disciplines. Furthermore, user-inspired basic research model is regarded as ideal as it can meet dual goals of understanding and use. Finally, standards, as anchor points for collaborative activities, should be rendered more consistent and comprehensible.

Keywords: historical development, research models, knowledge, situated cognition, standards

1 Introduction

Recent interests in investigating the gap between Human Computer Interaction (HCI) and Software Engineering (SE) have invited the attention and efforts of researchers and practitioners of both disciplines to work towards resolution of different related problems (see e.g., INTERACT 2001 Workshop; ICSE'03 Workshop). Among them, problems that are commonly addressed include usability analysis and assessment techniques, scenario- and pattern-based design, curricular reforms, and user-system interaction modelling. However, limited description or discussion is dedicated to the histories of the two disciplines. Indeed, the literature in this regard is relatively meagre (e.g., Brennecke & Keil-Slawik, 1996; Glass, 1997; John & Bass, 2001; Myers, 1998). Similarly, discussion about the possible role of standards in remedying the gap between the two disciplines is scanty. In fact, several standards (IEEE-1601, ISO/IEC-9126) have been developed to define the key concept "usability", which essentially hinges the two communities of practice. However, these standards seem inconsistent. Consequently, those who attempt to link HCI with SE by anchoring them in some common standardized definitions may probably be disappointed.

Traditionally, the two disciplines were ascribed certain distinct or even antagonistic features (Table 1), while they definitely share some commonalities (Willshire, 2003). How can the distinct features be traced back to the historical developments of both disciplines?

In fact, their distinctions have faded with time when the professionals of the two disciplines initiated the dialogues, reciprocally recognized the significance of each other and even adopted the approaches developed by each other (Constantine, Biddle & Noble, 2003). Specifically, SE has put on

more humanistic flavour by taking users' needs into serious consideration (e.g., user-centred design) whereas HCI has taken up more engineering flavour by looking deeper into software development and software analysis issues. For instance, the application of design patterns (Gamma et al., 1995) that has been widespread in SE community during the last five years is currently taking ground in HCI. Another example is the optimisation of software architecture for enhancing usability of user interface (John & Bass, 2001).

Attribute	SE	HCI
Human resources	Predominantly computer scientists	Interdisciplinary professionals
Focused tasks	Coding	Evaluation
Affiliated disciplines	Mathematics, Engineering	Social Sciences
Research Paradigm	Pragmatic: Practical → Theoretical → Practical	Empirical: Theoretical → Practical → Theoretical
Major Units of analysis	Technological	Social, psychological

Table 1: Traditional distinct features of SE and HCI

When studying their histories, a basic question to be explored is: Were both disciplines conceived from the same or different inspirational sources? In fact, SE and HCI have a common ancestor – computing! SE, according to Glass (1997), was conceived in the mid 1950s, whereas its cousin HCI, according to Myers (1998), emerged in the early 1960s. However, they were rooted in different concepts and visions with SE aiming to overcome the so-called "software crisis" and HCI aspiring to bring users' needs to the forefront (i.e., a central rather than peripheral role) in the enterprise of software systems design.

Since their inceptions, the two disciplines have been nurtured by academic and industrial professionals of various backgrounds, who deployed different research methodologies, tools and techniques to examine questions of interest. Consequently, they grew into varied traditions and styles. Interestingly, in their respective histories, both disciplines encountered the same problems of experiencing "identity crisis" and gaining recognition in the overarching field "Computer Science". In particular, the status of HCI is even more ambiguous. After years of struggles, HCI has somewhat earned its autonomy as an independent institute or unit in higher education institutions. However, it can be found under Faculty of Computer Science, Faculty of Social Sciences or Faculty of Business Studies.

In fact, the relationship between SE and HCI has been evolving during the last 20 years. Both disciplines endeavour to create useful, usable, and high-quality software systems by adopting and adapting methods and theories inputted from different avenues. Nonetheless, the two disciplines have progressed too independently (John & Bass, 2001). While such independence might be inevitable or even desirable at the early stage of their formation, now most of the professionals from both disciplines see the urgency to re-examine their inherent interdependence, considering the ever-increasing complexity of software artefacts that necessitate the expertise of both disciplines. While there may be many possible ways to improve the relationship between SE and HCI, it is crucial that the professionals from both disciplines are enabled to communicate their ideas effectively and efficiently. We propose that the key is to unify their languages by developing certain standards, which should define core common terms consistently and comprehensibly.

2 Synopsis of the Review Studies

2.1 Historian-Software Engineer Seminar

The Dagstuhl seminar report (Brennecke & Keil-Slawik, 1996) documents the views of two groups of scholars - historians and software engineers, whom we normally do not associate, about the problems identified in SE. Echoing the presumption of the coordinators of the seminar, we are convinced that "In a highly dynamic scientific environment with ongoing debates about the fundamental issues, a historic investigation may help to better understand the issues …" (p.1).

Nonetheless, instead of settling down the provocative debate whether the so-called 'software crisis' has continued to exist, the seminar participants

tended to conclude that there was an 'identity crisis' in SE. Since its emergence more than 30 years ago, computer scientists are still investigating the history of other established branches of engineering to define what should be done to transform SE into a sound engineering discipline. A seminar participant even claimed that SE was then still at the pre-engineering phase (Baber, 1996). Actually, the term "Software Engineering" has the implication that software manufacture should be based on the types of theoretical foundations and practical disciplines that are established in the traditional branches of engineering. Given this assumption, SE might tend to shape itself in a way that it aligns with so-called 'hard sciences' such as most other engineering schools while distancing itself from so-called 'soft sciences' such as psychology, sociology, etc. Though no solid clear-cut conclusion could be drawn, the event registered many facets, issues and methods in SE that would be worth further exploration. It is expected that the current workshop may have similar or even more impacts than this specific seminar. Specifically, through open dialogues between SE and HCI professionals deep-seated ideas in both disciplines can be surfaced and tackled.

2.2 Evolving Views of Software Engineers

John and Bass's paper nicely summarizes the evolving role of software architecture in SE and HCI from the 1980s to the beginning of the new millennium and describes how it affected the relationship between the two intimately related disciplines. An interesting observation is how software engineers changed their views about the relation between usability and software architecture. "Software engineering in the 1990s focused on technical attributes … and process attributes ... Although usability is mentioned occasionally as a quality attribute, some authors explicitly declare that it is not related to [software] architecture …" (p. 332). Through the authors' meticulous analyses of general usability scenarios and their personal experience using them in SE processes, they have come to the recent conclusion: "… many facets of usability are indeed architecturally sensitive" (p. 335). Thanks to the collaboration undertaken between HCI and SE institutes in the same university where the authors resided, the earlier erroneous assumption could be amended. This case can clearly illustrate the importance of ongoing self-assessment within a community of practice while keeping open eyes to the development of the neighbouring disciplines.

Furthermore, the same authors criticise that, despite the call from Newell in the early 1980s that the action of HCI professionals should shift from evaluation to design, their role seems to be squarely in the arena of testing or evaluation, as shown by the publications in recent conferences. Nonetheless, we strongly support the recommendation of the authors that for HCI professionals, on top of their evaluation endeavour, *design is where the action is*, and that software engineers prioritise usability as a first-class quality attribute among the others.

2.3 HCI History on One Side

The main message Myers (1998) aimed to convey through his paper is that the advances of HCI have been contributed by both academic researchers in universities and their counterparts in corporate research labs. Anyway, looking up the item "History" in the HCI Bibliography website (http://hcibib.org/hci-sites/HISTORY.html, last modified on 03.07.2003), only 18 records are found and most of them, if not all, like Myers' paper, cover only the technical aspects of HCI. Some only report certain survey results (e.g., Nielsen, 2002). Nonetheless, Myers called for the documentation of the historical development of the other equally, if not more, important side of HCI – the social. Unfortunately, such literature seems still lacking.

As a matter of fact, studying the history of a discipline is an enormous project by itself, which should basically investigate the origin of the discipline (i.e., scientific, political, economic, and social reasons for its emergence), the facilitating and hindering factors for its development as well as sustainability (e.g., deployment of selected research methodologies, evaluation techniques, dissemination activities, professional training programs), and its respective evolving roles in university, industry, government at both the local and global levels. Presumably, with such historical data, the questions why and how two disciplines resemble and differ from each other can be systematically answered. Based on their respective past successes and failures as well as their current trends of the development, we

probably can envision a picture about the future relationship between the two disciplines - a co-existent partnership as the status quo or a merged enterprise.

3 Reflection on Nature of Knowledge and Research

3.1 Knowledge as Dynamic Entity

It is a natural tendency to explain the gap between SE and HCI with reference to software artefacts that entail contributions from both disciplines. However, perhaps the gap can be explicated from an alternative perspective – sociological views of knowledge.

Knowledge is conventionally defined as consisting of coherent islands whose boundaries and internal structure exist, putatively, independent of individuals (Lave, 1988). So conceived, "culture [and knowledge] is uniform with respect to individuals, except that they may have more or less of it" (ibid, p.43). This conventional epistemological view is problematic because knowledge, individuals and the societal context in which they are embedded are inherently inseparable (Law, 1994). Knowledge is interpreted and assimilated in an entirely individual and contextualized manner. Hence, to put it an extreme way, there would be as many interpretations of what SE or HCI should be as the number of professionals in the respective discipline. Consequently, it would be very difficult, if not impossible, to cohere a diversity of personal and idiosyncratic views.

Arguing along the same line, the concept of "knowledge domains" has several problematic implications. First, it leads to separate the study of problem solving from analysis of the situation in which it occurs. Moreover, the maintenance of strict boundaries among various academic disciplines by the professionals concerned can reflect their intended control of a body of knowledge. Hence, the seemingly unbridgeable gap between SE and HCI could be attributed to a cluster of highly intertwined political, economic and societal reasons. People of vested interests in a certain field may be reluctant to surrender their "territories". Moreover, research fund is a practical issue. Presumably, more funds will be granted to a discipline that has unique status, research goals and activities than to a discipline that shares a number of features with the others or even is subsumed by them.

3.2 Nature of Research

Can the nature of research conducted in HCI and SE be one of the possible reasons for the existing gap? It may simply be a chicken-and-egg problem! Traditionally, research was dichotomised into two categories, namely basic research with the goal of understanding and applied research with the goal of use. Furthermore, it was assumed that the knowledge acquired from the former could be transferred to the latter, somehow like a conduit transferring water from a higher to lower point. Note also basic research was regarded as more prestigious than applied research. Not until recently, criticisms have been charged against this one-dimensional view of knowledge transfer (Fischer et al., 2003). In its place, Stokes (1997) proposed two-dimensional model by conceptualising goals of understanding and goals of use as two distinct continua. Three different perspectives on the relationship between theory and practice arise from that assumption (Figure 1).

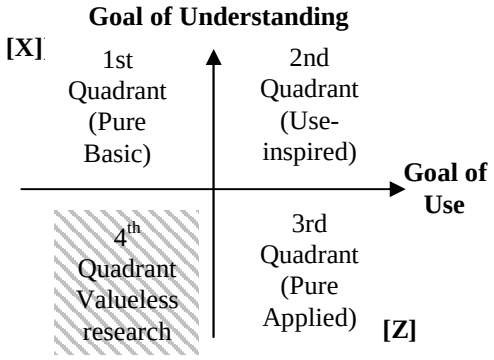

Figure 1: Research matrix
(Adapted from Stokes, 1997)

The Point [X] of the first quadrant represents pure basic research, which sets its focus exclusively on goals of understanding and has minimal concern on the application of knowledge to technological development and production. The Point [Z] of the third quadrant represents pure applied research, which only pursues goals of use and is not interested in theoretically understanding the phenomena under

investigation. The Point [Y] of the second quadrant represents *use-inspired basic* research, which combines goals of understanding and use in conducting basic research and aims to resolve important practical problems. Of these three kinds of research, use-inspired basic research has its special appeal in that it systematically links insight into learning processes and intervention for change (Fischer et al., 2003).

What kinds of research are predominant in SE and HCI? Interestingly, the three keynote papers authored by Dye, Rabardel and Cordier et al. in Proceedings of Human-Computer Interaction (HCI) 2001 could be classified as representing user-inspired basic research, basic research, and applied research, respectively. While each of the authors presents some significant achievements in HCI, Dye's paper perhaps is more appealing as it relates goals of use to goals of understanding and vice-versa. By scanning the remaining 33 papers in the same Proceedings, it is estimated that whilst most of them fall into the category "user-inspired basic" or "applied research", a few of them are in the category "basic research". When imposing the same scheme on the papers in Proceedings of International Conference for Software Engineering (ICSE) 2001, which are divided into Technical, Case Study and Educational sections, one tends to say that a large portion of all the 61 papers fall into the category "applied research", some into "user-inspired basic research", and a very small number into "basic research". Noteworthy is that the two dimensions – goals of use and goals of understanding - are continua in the way that some researches are not different in nature, but only in degree of the two attributes. Nonetheless, it is worrisome to observe that limited research efforts have been invested in exploring theoretical issues that lay the foundation of the discipline.

In analysing Stokes' framework, Fischer and his colleagues (2003) have drawn some implications that are relevant to our study of the gap between HCI and SE. As noted by these authors and corroborated by our reading of the two aforementioned Proceedings, we believe that methodological issues is a compelling concern for research communities (cf. Gray & Salzman, 1998). There are a plethora of methodologies deployed in HCI and SE, because every researcher tends to adapt selected methodologies to meet his or her specific needs. As standards on how to use different methodologies are lacking, there are no ways to evaluate their quality of use. Consequently, we propose that comparison of methodologies to highlight essential elements of the favoured paradigms used in HCI and SE should be the first step of working towards this standardization endeavour. Furthermore, we echo the proposition of Fischer et al. (2003) that it is necessary and useful to establish so-called "practical impact standards", which can provide figures of merit for the potential of some contribution to improve people's lives. To reify the dual goal of understanding and goal of use mentioned earlier, we should develop and apply standards for both scientific and practical impacts.

3.3 What are Standards for?

In the previous sub-section, we addressed the issue about the lack of standards for methodology usages and for assessing scientific and practical impacts of scholarly contributions. Nonetheless, a caveat needs to be made that developing standards is not a panacea. Nor does it guarantee that the gap between HCI and SE can be so bridged. Indeed, poor standards could be worse than no standards at all.

Take a look of the current software engineering standards, especially those related to usability, to name just a few: IEEE-1061 (Standard on Software Quality Metric Methodology), ISO/IEC-9126-1:2000 (Software Engineering –Product Quality-Quality Model), ISO 9241-11:1998 (Guidance on Usability), ISO 8402 (Quality Vocabulary), ISO 9001: 1994 (Quality Systems), ISO 9001:2000 (Quality Management Systems), etc. The concept of usability is defined differently in the original and revised versions of ISO/IEC 9126 and in ISO 9421-11. The recent attempt is to use the term "quality of use" (ISO/IEC 9126-1) to cover dual aspects of usability (Bevan 1999).

It is confusing, particularly for newcomers of the community of practice, to decide which standards to adhere, given their inconsistent terminologies, notations and languages. Eventually, they may give up following any of them. It may explain why although some software developers have some theoretical knowledge of user interface design guidelines or usability standards, they seldom use them in practice, simply because they do not know

which, when and how to apply them in their context. Despite these rather frustrating observations, we should not deny the values of standards that have actually contributed to the progress of both SE and HCI. However, what we need to do is to develop some implementation strategies through which software developers are enabled to "situate" or "localize" the principles described in standards to specific application contexts.

4 Summary & Conclusion

Based on the conviction that "the present is built upon the past", we posit that the existing gap between the two intimately related disciplines – Software Engineering and Human Computer Interaction - can be better understood through studying their historical developments, specifically their origins, their successes and failures, and their changing roles in various societal institutions. Unfortunately, the literature in this regard is scanty. Nonetheless, we were able to get some insights from the accessible references:

- The Dagstuhl seminar (Brennecke & Keil-Swalik, 1996) was successful to a certain extent to surface some issues deeply entrenched in SE by confronting software developers with the views from historians. We assume that direct dialogues between SE and HCI perhaps are not sufficient or provocative enough to uncover deeply seated problems. The presence of a third party like historians or scholars in philosophy of science may serve as observers, mediators or even provocateurs to bring the dialogues forward and enrich them. This will align with the so-called "thesis-antithesis-synthesis" approach (Hegel, 1998).
- The review on the relationship between usability and software architecture developed over the last three decades (John & Bass, 2001) showed us the significance of ongoing self-evaluation within one discipline. More important is that such evaluation activities are based on the understanding of the development of other related fields. Open-mindedness is indispensable for reflection that is in turn essential for making advancement in any discipline. Furthermore, the role of HCI professionals seems still overwhelmed by usability evaluation tasks. It is the high time for them to balance their works on both design and evaluation or even invest more efforts in the former.
- The one-sided review on the technological aspect of HCI (Myers, 1998) revealed the biases of some HCI professionals. On the contrary, HCI is distinct from SE by its human or social concerns. However, it seems that HCI has become hCI with (too) much emphasis being put on "C" rather than 'h". Nonetheless, neither hCI nor HcI is appropriate. What we should focus on is I – interaction as well as interface. Without understanding both H and C, we cannot say anything meaningful about I. It is challenging for HCI professionals and, however, it is exactly what makes HCI appealing.

Apart from the historical perspective, we believe that the gap between HCI and SE can be analysed from the epistemological perspectives. Challenged by the so-called "situated views" movement in the mid 1980s (Lave, 1988; Suchman, 1987), the traditional concepts of knowledge, knowledge domain and knowledge transfer have been challenged. Knowledge, no longer seen as a fixed commodity-like construct, is dynamically generated by learners. Consequently, each individual has idiosyncratic interpretations of the same subject matter. It may explain why the HCI-SE gap is so difficult to bridge, because it is almost impossible to coalesce a diversity of interpretations. To reach the highest possible common understanding or so-called "mutual intelligentibility" (Suchman, 1987), negotiation or open dialogues between learners or professionals is deemed indispensable.

The neo-Marxist view that knowledge domain serves as an artificial boundary to sustain the control and protect the interest of a privileged group may sound too radical. Nonetheless, it reveals the fact that sustaining knowledge domains or disciplines is not simply an academic manner, but rather it is meshed with political, economic and societal factors.

The conventional conduit metaphor for knowledge transfer from basic to applied research was proved to be inappropriate. As a matter of fact, current researches tend to achieve dual goals of understanding and use, though to a varying extent. However, one worrisome phenomenon noted is that researches in both HCI and SE tend to be too application-oriented while neglecting the theoretical aspect. In fact, the essential factor which accounts for so-called "design correctness" (i.e., all requisite functionalities present and can be operated with highest possible effectiveness, efficiency and satisfaction) is that there exists a solid foundation, be it a mathematical model of artefacts or a model of human behaviours, and that the practitioners apply this very foundation regularly and as a matter of course in their work.

Lastly, most, if not all, professionals in HCI and SE agree upon the importance of mutual communication so as to narrow, while impossible to close, the gap between the two disciplines. Standards can serve as good anchors point to focus the dialogues and collaborative activities. However, the existing standards are rather inconsistent and thus confusing. More efforts should be invested to render these tools more usable and useful. Specifically, it is worthy to develop implementation strategies for situating or localizing the standards so that they can be applied effectively in particular contexts.

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