AN ASSESSMENT OF HCI: ISSUES AND IMPLICATIONS

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Background

The focus of Human Computer Interaction (HCI) is to generate an understanding of how people can best interact with computers, and then to design and build technologies and tools that facilitate that interaction. As a field, HCI draws on many disciplines and perspectives. The primary contributors have historically been psychology, computer science and human factors -- more recent entries include (among others) anthropology, communication, education, graphic and industrial design, linguistics, sociology, and systems science. The work being done in the HCI field is shifting rapidly in response to the influx of these new perspectives. A quick survey of the literature from the past ten years reveals some further trends, and even some unexpected paradoxes [1]. Much of the work reported focuses either on theory [8], or on practice [3], although in many cases, work moves from theory to implementation and evaluation [4]. Papers are usually either technology-based [7] or user-based [11], but there is also work that approaches HCI problems from both of these ends of the interaction spectrum [12].

Some of the most interesting questions raised by these casual observations are: What kinds of work have characterized the HCI field, over time? What approaches have been used? As a multidisciplinary field that purports to shape the relationships among people and very complex tools, what kinds of working patterns have we developed? Are we approaching our work from different -- and perhaps mutually exclusive -- perspectives, or is our work converging? And where, as a field, might we go from here?

A survey characterizing the HCI field

In order to attempt to answer these questions, we decided to carry out a somewhat less casual and more systematic survey of the kinds of work that have occurred within the HCI field. To reduce the scope of a seemingly huge problem, we made the decision to limit our survey to the papers published in the ACM SIGCHI Proceedings since the first conference -- the one held in Gaithersburg, Maryland in 1982. Although ACM SIGCHI is not the only forum for presenting work in the HCI field, it is, perhaps, the most recognized.

1. The presence of a series of paradoxes can lead to the radical reconceptualization of a field [13]. If, as this paper will suggest, we are at the edge of such a turning point, then we must identify the sources of the paradoxes and build a coherent set of responses. Both individual and organizational self-reflection are vital to capitalizing on, and precipitating, change [2]. As a field, we must encourage reflection, evaluation and criticism, and we must take unprecedented intellectual and emotional risks--as part of our daily work.

Much more goes on at the CHI conferences than can possibly be captured in the proceedings. In 1985, panels were added, and subsequent years saw the addition of exhibits, posters, demonstrations, lab reviews, etc. It is also important to note that the composition of the conferences, and the contents of the proceedings have been influenced by the various conference committees and boards, and by the calls for papers sent out in advance. Despite these reservations, we still thought that a survey of the CHI conference papers would be useful as a means of characterizing the larger HCI field.

Our first task was to develop a survey instrument for categorizing all of the papers (about 360) presented in the seven issues of the CHI Proceedings spanning the years from 1982 to 1989. We developed an initial categorization scheme based on a preliminary survey of the contents of the proceedings. Roughly, this scheme allowed us to evaluate papers according to three criteria: models of users, interface evaluation techniques and interaction styles. Then, we went through several iterations of testing the scheme on the first five articles of each of the Proceedings, and revising it according to the results [1]. Essentially, we used our data to help us develop our instrument.

Our final categorization instrument combined revised criteria from the most successful trial schemes, and was primarily based on the most common content-areas or subject matters of the papers. This decision was motivated by two assumptions: 1) that changes in the areas of work done over time would be the most helpful in mapping the territory of the larger HCI field; and 2) that categorizing papers by content area would allow them to be objectively placed into groups (and subsequently counted) with little subjective or qualitative evaluation [2].

Our final instrument contained the following categories:

Metacomments -- HCI as a whole; the history, current situation and future of the field; overviews of sub-topics (for example CSCW); discussions of larger field-wide issues (for example, patents); often "directions;"

Design process -- how HCI design is done; developing design methods; developing design tools; organizing design teams; often "the design of HCI design, engineering or inquiry;"

Science -- advances in basic HCI theory; generating a foundation of common knowledge; observation, hypothesis generation and possibly experimental validation; development of principles; often "cognitive science;"

Cognitive engineering -- the engineering application of cognitive science; generating heuristics and techniques, based on science, to inform artifact building; direct application of heuristics and techniques to engineering activities; development of models for processes that reflect back to interface design; often "non-tangible engineering;"

Artifact building -- engineering; the construction of artifacts (mice, keyboards, screens, menus, windows, etc.) based on technology or opportunity; the construction of interaction schemes (audio, voice, gestural, etc.); often "practical problem solving;"

Evaluation -- the evaluation (by UI researchers, builders or users) of existing theories, artifacts, processes or tools; new methods or tools for UI evaluation; often "usability" or "testing;"

Visualization -- the appearance of the interface; the relationship of interface content (architecture or functionality) to form; screen, icon or menu design; color; often "graphic design;" and

Documentation -- user documentation; project or program documentation for UI builders; online and hardcopy help; advising, training and tutorial systems; often "help systems."

Once we defined our final categorization instrument, we began evaluating papers. First, we went through the Proceedings and discarded plenary sessions, panels, lab reviews etc. Then, we numbered the remaining papers within each year (01/82, 02/82, and so on). Next, we read each paper, determined the most appropriate content-area category for it (based on keywords, approaches, results and general content) and assigned it to the most appropriate category.

We both categorized all of the papers in the '82 Proceedings as a final test of whether or not the categorization instrument was sound and to give a very informal indication of reliability. As an additional, informal indication of reliability, we also both categorized the titles of the paper sessions for

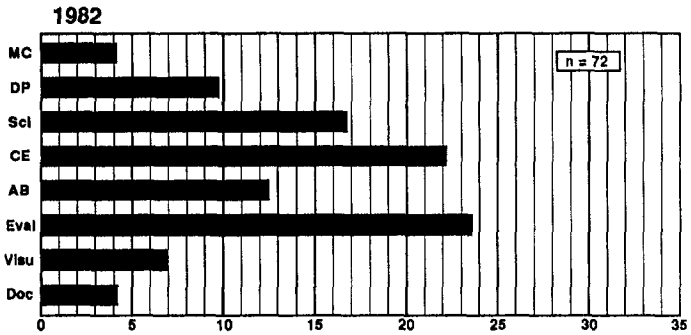
2. We recognize that not everyone will agree with the categories we selected for our final instrument (or with our assignments of individual articles to categories), but that is almost unavoidable. This problem would have been much worse if we had attempted to evaluate the quality of the papers as well. We hope that what we have done is informative, and add that we would be curious to see different approaches to the same idea.

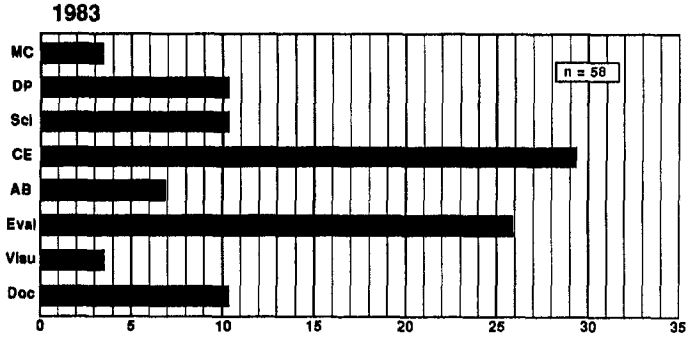
each of the issues of the Proceedings. After finding that there were only a few differences in our categorizations of the '82 papers and the session titles, we split the remaining papers between us. At the end of the evaluation, we prepared raw data sheets containing all of the information. These were used to verify that we had categorized all of the articles.

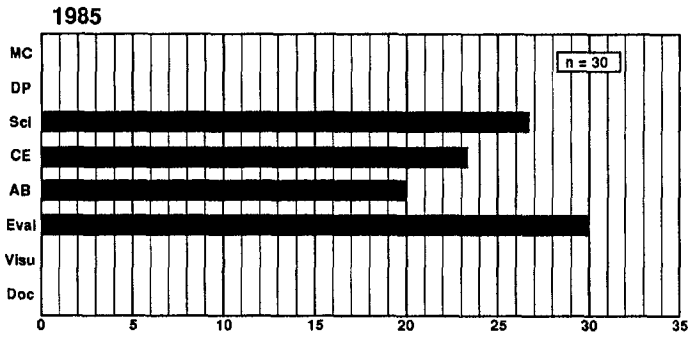
Results of the survey

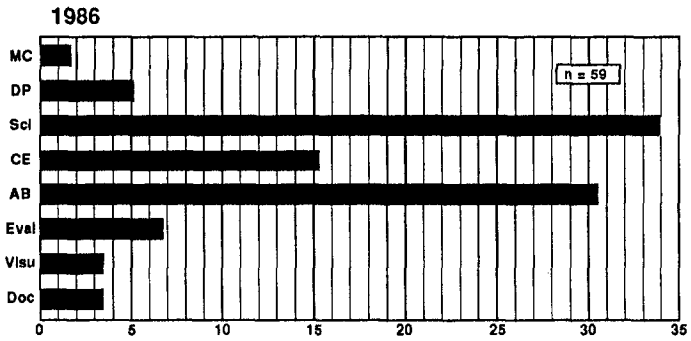
Papers by year

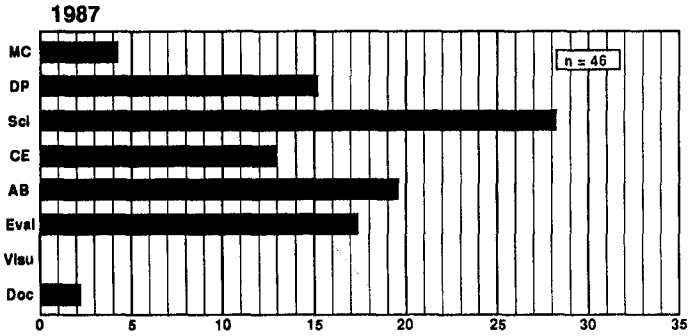
Within a given year, we calculated the percentages of papers in each category. (e.g. In 1982, 4.2% of the papers were Metacomments.) We also give the total number of papers per year. (e.g. For 1982, n=72.)

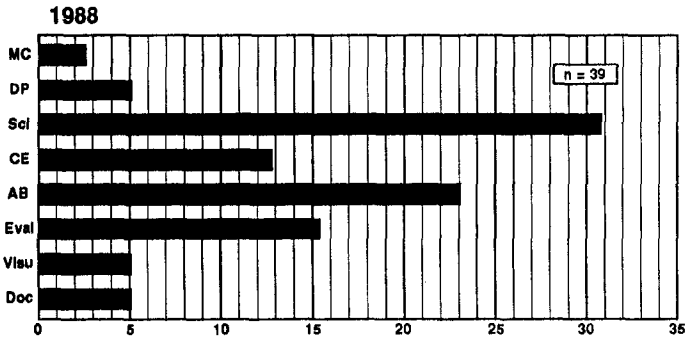


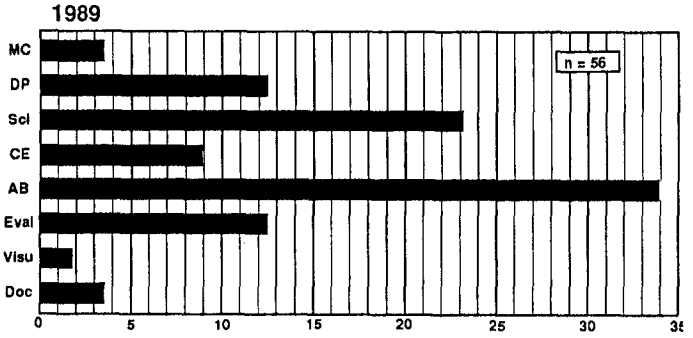








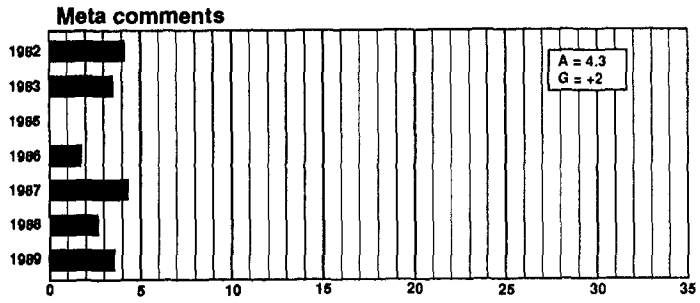


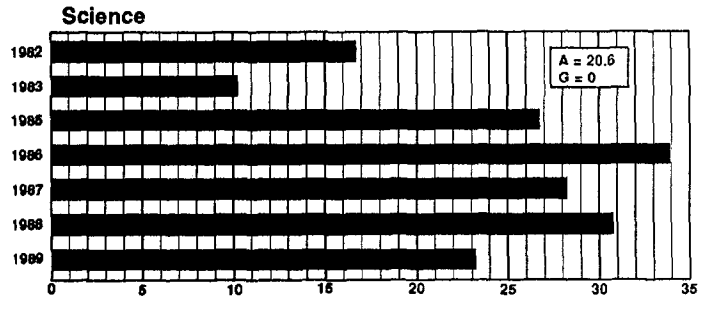


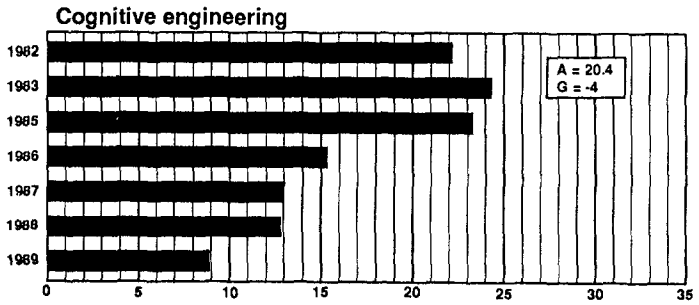
Papers by category

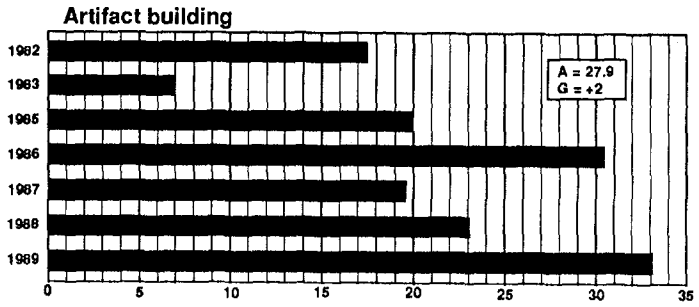
Within a given category, we listed the percentage of that category within each year. (e.g. Metacomments was the subject of 4.2% of the papers in 1982, 3.4% of the papers in 1983, etc.) This compensated for the differences in numbers of papers among years.

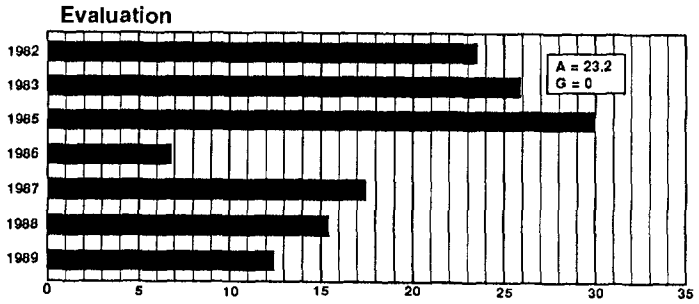
We also used the within-category tabulation for two additional sources of information. For an indication of "activity" within each category, we took the difference between the lowest and highest percentage points. (e.g. for Metacomments, A = 4.3.) A high A would indicate that a category has experienced change or activity over time -- perhaps moving from 2% in one year to 30% in another. For an indication of "growth rate" within each category, we looked at the positive and negative changes in percentage points over the years. For each year in which the percentage point was higher than that of the previous year we assigned a category one growth point. We subtracted one growth point for each year in which the percentage point was lower than the previous year's. Since there are seven Proceedings, the range for this measure is - 6 to +6. (e.g. Metacomments, G=+2.) A high +G would show that a category was growing, a high -G would show the reverse.

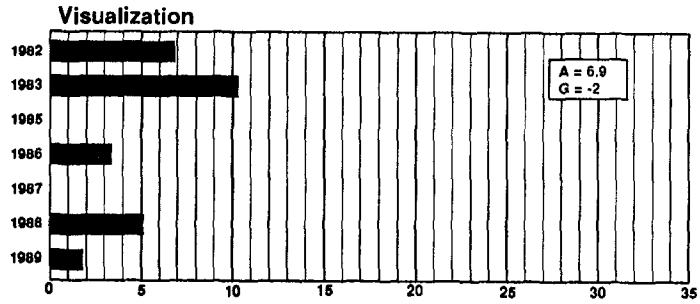


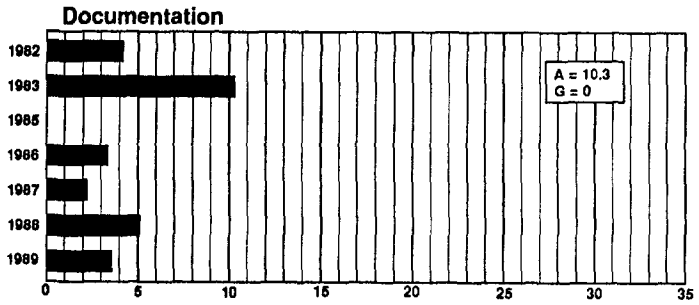












Issues and trends

By year

The composition of each of the Proceedings over the years has remained fairly constant. Within each year, most of the papers fall into the categories of science, cognitive engineering, artifact building and evaluation. This is not surprising, since one of the goals of the CHI conference is to share advances in research and practice that will help people understand user behavior and need, and build effective user technology. Science informs both cognitive engineering and artifact building, and evaluation tests (and frequently builds on) the products of engineering and artifact building. The four categories are closely related -- it is logical that all four should be strongly represented within each year.

1982 shows fairly good representation in all of the categories and also has the highest n at 72. 1983 shows a focus on cognitive engineering and evaluation. 1985 has no representation in four of the eight categories (metacomments, design process, visualization and documentation). It also has the fewest papers (n = 30). 1986 highlights science and artifact building. 1987 maintains the momentum in science and loses visualization all together. (This is surprising since 1987 was also a computer graphics conference, but we noted that much of that work was actually artifact building or science.) 1987 also shows an increase in design process papers. 1988 continues to focus on science, while losing some cognitive engineering and adding some artifact building. In 1989 we see that this trend continues, with artifact building clearly gaining ground, and cognitive engineering clearly decreasing. 1989 also shows an increase in design process papers.

By category

Metacomments

The metacomments category, with the exception of the year 1985, appears to show little change. The activity is low and the growth is a moderate increase of +2. One interpretation is that metacommentary was popular at the inception of CHI, less popular during the middle years, and, as one might expect, more popular now that the field is older and more mature. The tail end of this trend possibly presages a move towards more metacommentary and the eventual development of an overall strategy (or strategies) for CHI and for the HCI field [3].

3. The data here might be somewhat misleading, since we disregarded the plenary papers, panels and lab reviews. When those components of the Proceedings are taken into account, metacomments shows an even larger increase in recent years, especially in 1989. This confirms the maturing-field hypothesis and the shows the presence of organizational self-reflection.

Design process

The design process category, again with the exception of 1985, shows a moderate increase, with moderate activity, and growth of +2. As one would expect, the appearance of papers on the "design of UI design" is another strong symptom of a maturing field. In 1989 there was an entire session devoted to design tools, we take this as an indication that the increasing trend uncovered here is likely to continue. One interpretation? The increase in focus on design methods and tools could reflect an increase in explicit efforts to integrate the various perspectives at work in UI design. We hope to be seeing more interdisciplinary approaches to UI design, more integration, more collaboration among designers and end users and, perhaps, the development of innovative processes and tools that bridge the gap between designers, engineers and users. Another impetus behind an increased focus on design processes could be the economics of design. As systems and interfaces become larger and more complex, they become more costly to build. This trend might spark an increase in research leading to the development of more efficient and effective design processes.

Science

With the exception of 1983, science shows up as a strong, steady category. The growth of 0 indicates little change over the years, the activity is high, and the percentages are consistently high across the board. It seems that science is a strong underlying foundation of CHI -- as it should be. We have noted that the science category has two strong sub-categories: ground breaking work and new progress based on previous work. An informal guess is that CHI contains more of the former than the latter, but we did not sort for this distinction. It would be positive to see scientific work of both types accepted equally within the field. The goal of practicing science should not just be "new and different" discoveries, but also better descriptions, explanations, and understandings of existing observations.

Cognitive engineering

Surprisingly, this category shows a strong decreasing tendency. With a growth of -4, high activity and an obvious decrease over the years, we see that the application of cognitive science to engineering is becoming rarer. Our interpretation of this discontinuity appears later in the paper.

Artifact building

Artifact building is another volatile category, one which seems to be sharply increasing over time. The growth of +2 indicates moderate increase, the activity

is high and the graph shows increasingly more representation, especially in 1986 and 1989. Again, we comment later, in conjunction with our views on the decrease in cognitive engineering.

Evaluation
The overall trend here seems to be that evaluation was moderately well represented in the early years, especially in 1986, but has been decreasing since. The growth of 0 indicates no change, but the graph shows a decreasing trend and the activity is high. We noted that evaluation sometimes overlaps with other categories, and we tried to handle this by insisting that evaluation papers be primarily about evaluation. If a paper was about both artifact building and evaluation, and if when artifact building seemed to be the primary purpose of the paper, then we assigned the paper to artifact building. As more and more papers both report on an advance, and then evaluate it, the pure evaluation category becomes less important, and we almost need new categories like "artifact building plus evaluation" or "cognitive engineering plus evaluation." Generally, we interpret this development as a positive one. The combination of two or more major categories is a clear signal that multidisciplinary approaches are being developed in response to the needs of a multi-faceted field.

Visualization
Visualization was a sideline that we tracked out of an interest in the appearance of interfaces [4]. In many cases we noted that visualization was subsumed into instances of artifact building, but occasionally it surfaced as a focal point. We had expected that visualization, on its own, might increase over time, perhaps thinking that advances in visualization would enhance existing work in functionality. What we found instead was that visualization has been inconsistent over the years, and that overall, with a growth of -2, and an activity of 6.9, it has been decreasing moderately. We view this as a negative finding, and use the opening to call for more work in the area. (This call has been made before, in the CHI '83 Proceedings. We have yet to see a significant response.)

4. The esthetic appeal of products -- and interfaces are products -- has a real effect on the way people perceive, value and use them. Traditional graphic and product designers have known this for a very long time, and have worked accordingly. Yet, we are just starting to see the impact of this kind of thinking on HCI design. For interfaces to be intrinsically motivating, fun and comfortable, HCI designers are going to have to consider some of the softer aspects of "design." Emotional appeal and subjective appreciation can be approached from a design perspective -- the Japanese have a strong tradition of "kansei" or "sentiment engineering" which has allowed them to create artifacts from a clearly different emotional perspective.

Documentation
Documentation, which also includes training and advising, has been a fairly consistent sideline. With the exception of 1983, which was very high, and 1985, which had no documentation papers at all, the category has enjoyed a small, but steady presence in the field. The growth of 0 indicates that this trend is likely to continue. We had expected to see a slight increase over time here. Innovations in documentation could benefit from, and be co-developed with, new developments in theories of learning and skilling; theories that are calling for new forms of documentation altogether. Perhaps, this will still happen.

Changes in cognitive engineering and artifact building

Our survey has uncovered one interesting change over time -- the decrease of cognitive engineering and the increase of artifact building. If one assumes that -- in good HCI design -- cognitive engineering should mediate between science and artifact building, then a decrease in cognitive engineering and an increase in artifact building might point to a possible breakdown in the flow of information within the HCI field. Is there, perhaps, something wrong with the integration of basic HCI science with design and engineering that makes theory -- or the implications and applications of theory -- less useful in practice than they should be?

1. Are the perspectives of science, design and engineering converging, or are these pursuits simply taking place at the same time, in the same place?

HCI is an applied field, unique perhaps, in that has the potential to integrate the applications of many basic sciences into one practical speciality. HCI should -- at least -- integrate science, engineering, design and art. The core of most HCI problems ought to be to simultaneously generate understandings of what is occurring (science) [5], and solve particular problems (engineering) [6], while producing products that will enable people to accomplish their own tasks in specific situations of use (design) [7]. An additional twist is that the products and the understandings must be constructed and represented in two different worlds: the physical world of computer engineering and the more abstract one of cognitive engineering. The mention of physical representation brings another concern to the foreground: that of the relationship between form and content (essentially, applied art).[8].

2. Is the kind of cognitive science being done actually producing the robust theories of cognition needed to inform the practice of HCI, or is it somehow generating a body of knowledge that falls short of this mark?

Traditionally, cognitive science has been a key component of HCI, including topics like: reasoning, perception, memory, etc. More recently, situated cognition has started to contribute to HCI from another perspective. While it is still too early to tell if theories of situated cognition will form a strong foundation for HCI, their presence is important simply as an indication that alternative underlying theories -- and perhaps entire scientific foundations -- might contribute to HCI in unexpected, but positive, ways.

3. Is this change a normal occurrence in the lifecycle of a field, and will it lead to other lifecycle stages that can be anticipated and possibly provoked?

Perhaps the discontinuity pointed out by our survey is an indication of natural change. In recent years, there have been other events confirming the fact that the HCI field is changing. The number of smaller, specialized conferences growing out of CHI has increased, for example -- the Hypertext conference and the Document Processing conference. It would be interesting to see how the contents of the Proceedings of these conferences compare to those of the early and more recent CHI conferences.

5. Science is a method for generating a body of knowledge, which then becomes the foundation of the field in question. Science results in new knowledge and in new processes of inquiry. Science employs a variety of approaches (experimental, deductive, inductive etc.) and has as its goal both innovation and continual progress. Science operates in a general or universal context, rather than in the context of specific problems.

6. Engineering is the application of scientific understandings or tools, often in a creative way, to solving specific problems. Engineering results in the generation of specific technical solutions which function in the contexts of specific technical problem spaces. Engineering is primarily concerned with the opportunities surrounding tools (cognitive and concrete).

7. Design is done for, and by, users. Designers take into account the limitations and possibilities provided by human needs, real and simulated situations of use, and technologies and then iteratively generate, evaluate and refine solutions until an effective response is produced. Design is proactive -- good design should begin with and build on the capacity of people to adapt products to their own uses.

8. "Art is a form of speech. Speech must be based on human needs, not abstract theories of grammar. Or anything but the spoken word. The real word." [6].

Conclusion

The first part of this paper pointed out that the key areas in HCI, as represented by the papers in the ACM SIGCHI proceedings, have historically been science, cognitive engineering, artifact building and evaluation. A survey of the papers in these areas, over time, uncovered at least one interesting paradox: in a field that is by nature both theoretical and applied, there seems to be a decrease in the area of work that applies the results of theory to practice. The paper then posed and attempted to answer a series of questions about this discontinuity. We would like to end with a suggestion about integrating the key areas within HCI through the development of task-based interfaces.

We suspect that there might be a missing link in our understanding of the structure of the relationships among people and the systems they use. This link might be the *tasks people must accomplish.* The idea of task-based or work-based UI is not particularly new [5], but few designers have approached it from a perspective that integrates science with artifact building through cognitive engineering; a perspective would result in better understandings of tasks, tools for using the understandings in the design process, and interfaces and systems that would respond to, and support, the work people do. We have only recently started to look at how people view and represent tasks, and at how those views and representations can be incorporated directly into the design of interface conventions and system functionalities [10]. Another point where tasks, systems and users intersect that seems promising is the construction of design tools that will allow interfaces to be continually co-produced by both designers and users in response to changing situations [14]. Quite possibly, it is where the person and the system together confront tasks that we will begin to see the full potential inherent in truly integrating the key disciplines and areas that contribute to HCI.

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