College of Information Science and Technology

How do Design and Evaluation Interrelate in HCI Research?

Christine E. Wania, Michael E. Atwood, Katherine W. McCain
College of Information Science and Technology
Drexel University
3141 Chestnut Street, Philadelphia, PA 19104
cew29@drexel.edu, michael.atwood@ischool.drexel.edu, kate.mccain@ischool.drexel.edu

ABSTRACT
Human-Computer Interaction (HCI) is defined by the Association for Computing Machinery (ACM) Special Interest Group on Computer-Human Interaction (SIGCHI) as "a discipline concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of the major phenomenon surrounding them" [18]. In HCI there are authors that focus more on designing for usability and there are authors that focus more on evaluating usability. The relationship between these communities is not really clear. We use author cocitation analysis, multivariate techniques, and visualization tools to explore the relationships between these communities. The results of the analysis revealed seven clusters that could be identified as Design Theory and Complexity, Design Rationale, Cognitive Theories and Models, Cognitive Engineering, Computer-Supported Cooperative Work (CSCW), Participatory Design, and User-Centered Design.

Author Keywords
Theories of design, design taxonomy, bibliometrics

ACM Classification Keywords
H.1.2 User/Machine Systems, H.5.2 User Interfaces

INTRODUCTION
Human-Computer Interaction (HCI) is defined as "a discipline concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of the major phenomenon surrounding them" [18]. *Design* and *evaluation* are two very important words in this definition. While many (e.g., [11, 17, 23] have argued that *design* and *evaluation* are closely related, they are typically separated in practice. The *evaluation* community (often labeled the *usability* community) focuses primarily on the evaluation of designed artifacts while the *design* community focuses primarily on the design of artifacts that will be evaluated later. Clearly, one cannot be done without the other. Design and evaluation both share the common goal of usability but each takes a different path in trying to achieve it. In this paper, we question this approach.

Our goal in this paper is to discover how *design* and *evaluation* are related and to use this as a basis for building an overarching theory of HCI. Rather than report our own thoughts on this, we want to find the understanding that the global HCI community uses. To this end, we analyze the citations in the HCI literature over a fourteen-year period in a database of over ten million documents and employ bibliographic cocitation analysis to uncover the understanding implicitly used by these authors.

We begin by discussing design and evaluation and the methods used in these areas of HCI research. We then briefly explain the multivariate techniques used in author cocitation analysis. We conclude with an analysis of the results and we begin to explore the interrelationships between design and evaluation in HCI research.

HUMAN-COMPUTER INTERACTION (HCI)
Human-Computer Interaction (HCI) is a multidisciplinary field, which combines the theories and practices from a number of fields including computer science, cognitive and behavioral psychology, anthropology, sociology, ergonomics, and more. According to John Carroll in his book *Human-Computer Interaction in the new millennium*, HCI "is about understanding and creating software and other technology that people will want to use, will be able to use, and will find effective when used" [8]. Carroll points to four threads of technical development from the 1960s and 1970s that provided the foundation for HCI. The four threads are described as follows: prototyping and iterative development from the field of software engineering; software psychology and human factors of computing systems; user interface software from computer graphics; and models, theories and frameworks from cognitive

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science. In [8] Carroll explains that HCI initially had two foci, methods and software, with a major theme of integrating methods and software into user-centered system development. The methods focus was on techniques to achieve better usability. This became known as usability engineering. The software focus was concerned with inventing and refining graphical user interface (GUI) concepts and techniques. This became known as user interface software and tools.

As seen in the definition of HCI above and in the literature, *design* and *evaluation* are dividing factors in HCI research. There is no agreed upon definition of either design or evaluation. Atwood, McCain and Williams [2] summarize various views and taxonomies of design. Just as there is no agreed upon definition of design there is also no agreed upon definition of usability (evaluation) or how it should be measured but, there are a various definitions [13, 36] and descriptions of how it may be measured [4, 37] in the literature. Through the use of design and evaluation methods and techniques we are able to conduct research in these two areas of design and evaluation.

The focus of this article is on the design and evaluation techniques used to achieve better usability. A variety of techniques are discussed in HCI literature but the relationships between these methods are not well understood. We cannot say, for example, how an evaluation method, such as a *cognitive walkthrough*, would inform a designer engaged in *user-centered design.* Similarly, we cannot say what evaluation method might be most useful for someone engaged in *participatory design.* In the next section we present a brief review of usability design and evaluation techniques. Then, we use bibliographic author cocitation analysis to see how the broad HCI community understands these topics to be related.

USABILITY DESIGN AND EVALUATION METHODS

There are many design and evaluation methods or techniques, each with its limitations, advantages, and disadvantages. Which method(s) should be used depends on a number of different factors. There may not be one best method or technique for any given situation. Many times a combination of methods may be most beneficial. Every situation must be assessed individually in order to determine which methods to apply.

Design Methods

Design methods have evolved over the past few decades. First generation, or product oriented, design methods focused on systems theory and software engineering [10]. Second generation, or process oriented, design methods developed in the 1970's, focused on user participation, communication and democracy in the design process [10]. Third generation, or use oriented design methods, focus on the actual use situation and assess the quality in use of the designed system [10].

Third generation software design methods attempt to be participatory and evolutionary. These methods are concerned with understanding the "designing way of thinking" in which the understanding of problems emerge as the problems are investigated. Third generation approaches focus on using design artifacts for exploring design decisions. According to Ostwald [39], third generation approaches acknowledge the dangers of prototyping described in Atwood et al. [1] and attempt to embed prototyping in design processes in which prototypes are intended to change as understanding evolves.

There are a variety of design methods or techniques available that serve different purposes in designing for usability. The choice of a method can depend on a variety of factors including the purpose of the design and the available resources. In the following sections we discuss a number of design methods including participatory design, user-centered design, and interaction design.

Participatory Design

Beginning in the 1970's Participatory Design (PD) was being used in Europe [15]. PD focuses on workplace democracy and human development. It was not until the late 1980's that PD was used in North America [7]. PD or cooperative design as described by Kyng [25] is a way for users and designers to apply their knowledge and experience in designing computer systems. The Scandinavian approach to cooperative design, stresses the importance of active, creative, participation of potential end-users in the design process [26]. There are many views of participatory design, but underlying each approach is a focus on users actively participating and cooperating with designers in the design process.

User-Centered Design

User-Centered Design (UCD) methods have varied through the years. UCD places the user at the center of the design process. As stated by Donald Norman in *The Design of Everyday Things* [38] user-centered design is "a philosophy based on the needs and interests of the user, with an emphasis on making products usable and understandable" (p. 188). Preece, Rogers, and Sharp [40] explain user-centered design as an approach in which users and their goals, not just technology, are the driving force behind the development of a product.

PD and UCD are two similar approaches to design that are often confused. In North America PD is sometimes understood as an approach to UCD [40]. Carroll [8] points out that in many UCD approaches users are involved but not as full participants. He notes that UCD can be non-participatory [8] while one of the defining factors of PD is fuller user participation [15]. In North America usability engineering and human-centered design are sometimes also understood as approaches to UCD. There are a number of techniques [29, 33, 53] with varying degrees of user

participation that are sometimes characterized as UCD methods.

Interaction Design

Interaction design is a method for designing interactive products to support people in their everyday and working lives [40]. Preece, Rogers and Sharp summarize the four basic activities in interaction design as: identifying needs and establishing requirements, developing alternative designs, building interactive versions of the design, and evaluating designs. The authors emphasize that these activities are intended to be repeated and inform one another. The three key characteristics of interaction design are: a focus on users, iteration, and specific usability and user experience goals should be identified, documented, and agreed upon at the beginning of a project. Preece, Rogers and Sharp [40] consider contextual and participatory design user-centered approaches to interaction design.

Each design method reviewed in the previous section stresses iteration which implies evaluation and redesign but, exactly how evaluation fits in each method is not clear. In the next section we briefly discuss evaluation methods.

Evaluation Methods

There are a variety of evaluation methods or techniques available that serve different purposes in evaluating usability. According to Nielsen [35] these evaluations can be done four basic ways: automatically, empirically, formally, and informally. Automatic usability inspection is done by programs that compute usability measures based on user interface specifications (e.g., [21]); these will not be discussed here since the literature is relatively sparse. Empirical usability can be done by having users assess the usability of an interface. Formal or model-based usability evaluations involve using exact models and formulas to calculate usability measures. Informal or inspection-based usability evaluations involve assessing usability based on rules of thumb and evaluators experience and skill.

The choice of a method can depend on a variety of factors including the purpose of the evaluation and the available resources. These evaluation methods may be used along with other methods depending on the needs of the situation. A number of informal, formal, and empirical evaluation methods will be discussed in the following sections.

Informal or Inspection-based Evaluation

Nielsen uses *usability inspection* as the generic name for a set of methods that are based on having evaluators inspect the interface [35]. Usability Inspection Methods (UIMs) are non-empirical methods for evaluating user interfaces. Virzi [47] points to conserving resources and identifying potential usability problems as the essence of UIMs. There are a number of UIMs including: heuristic evaluation, cognitive walkthrough, pluralistic walkthroughs, formal usability inspection, feature inspection, consistency inspection, standard inspection, usability expert reviews, and group design reviews. Two of the more commonly used methods are *heuristic evaluation* [34] and *cognitive walkthrough* [27].

Formal or Model Based Evaluation

Model-based evaluation [22, 24] involves using a model of how a human would (might) use a proposed system to obtain predicted usability measures by calculation or simulation. GOMS is a well-known model-based evaluation method (see [22] for a comparison of GOMS techniques). GOMS is an acronym for Goals, Operators, Methods, and Selection Rules. Goals are what the user wants to accomplish, operators are the basic actions, methods are the sequences of operators that will accomplish the goal, and selection rules determine which method to apply to accomplish a goal.

Empirical or User-based Evaluation

User-centered evaluation methods include verbal reports, surveys and questionnaires, walkthroughs, usability testing and think aloud methods [9]. More than one of these evaluation methods is often used in the same evaluation. A commonly used empirical method is usability testing.

According to Barnum [3], usability testing is the process of learning from users about a product's usability by observing them using the product. Usability testing determines whether users can find and use the features in the amount of time and effort they are willing to expend searching.

While many argue [14] that usability testing is the *gold standard* of evaluation methods, this view is not universal. Rubin [42] points out that usability testing does not ensure usability since testing is often in an artificial situation. Others [e.g., 17, 46] argue that evaluation should be situated in the context of use.

The design and evaluation techniques discussed above provide researchers with a variety of ways to conduct research in areas related to the design and evaluation of interactive systems. In HCI research, *design* and *evaluation* are typically treated as separate activities. In addition, students are typically taught these skills separately and industry typically hires people to be either *designers* or *evaluators.* However, we believe that the global HCI community sees these topics as related. What we do not yet know, is how they are related. We turn to this topic in the next section.

DATA ANALYSIS

Many problems that information systems address are complex, ill-structured [43], or wicked [41]. It is very difficult, if not impossible to define all requirements before a system is actually used, to predict exactly how an information system will be used, and to predict how an environment will change after the implementation of an interactive system. It is impossible to predict the unintended consequences of a design [45]. For all of these reasons and

many more it is necessary to incrementally grow, not build, software systems [5].

Many authors in the field of HCI have begun to focus on design and evaluation as an evolutionary process situated in the context of use [11, 12, 16, 17, 23, 46]. Henderson and Kyng describe design "as a process that is tightly coupled to use and that continues during the use of the system" [17]. John Karat states "while it is still important to ask how to do an evaluation of a designed system it seems more important to ask about the broader role of evaluation in the design of a system" [23].

There are authors who draw attention to the fact that design and evaluation go hand in hand. But even some of those who do draw connections between design and evaluation seem to spend most of the time talking about them separately and then spend a short time talking about both design and evaluation together. In much of the literature there are separate chapters dedicated to design and evaluation. Preece et al [40] point out that in the real world design and evaluation are closely integrated and that you do not do one without the other. However, they spend most of the book talking about design and evaluation separately.

There is a recurring theme that design and evaluation go hand-in-hand. However, there is also a recurring theme that these are taught as separate skills, often written about as separate activities, and seen as different skill sets by hiring managers. In much of the literature writers tend to focus mostly on design or mostly on evaluation. A focus on both together, as papers cited above do, is rare. We have come to realize that design and evaluation cannot be separated, but we still talk about them as two different things. What would enable us to talk about design and evaluation together as one process?

In an attempt to seek an answer to this question we conducted an author cocitation analysis to reveal how authors who focus on design and evaluation cite one another.

Bibliometrics

According to White and McCain [51] bibliometrics is the quantitative study of literatures as they are reflected in bibliographies. In scholarly publications the cited references are assumed to have some type of relationship with the citing article. Multivariate techniques such as cluster analysis, multidimensional scaling, and factor analysis can be used to identify citations patterns in bodies of literature and to visualize the underlying intellectual or subject structure of a discipline or subject [51].

Author Cocitation Analysis

Author Cocitation Analysis (ACA) focuses on cited authors bodies of work (*oeuvres*) [31, 48, 49, 51]. The frequent cocitation of two authors' names may be evidence of the similarity of their work, or of citing authors' recognition of opposing views, or of social relationships, among other things. Author cocitation analysis is concerned with the frequency with which pairs of authors' names co-occur in reference lists and with the similarity of their patterns of cocitation. In this way, ACA allows the unseen structures and relationships in the literature as seen by citing authors to emerge. Here, ACA allows us to visualize the connections between well-cited authors within the field of HCI. In the following sections the methods used in the ACA will be discussed briefly. McCain [31] provides an in-depth discussion of the ACA methodology.

Author Set

The initial author list was compiled based on examination of the HCI literature, considered broadly, and on discussion with domain experts. The initial author list included 104 authors. This list was reduced to 64 by eliminating authors with low citation and cocitation counts and by dropping a set of authors representing software engineering. This set was spatially extremely isolated from the remainder of the map creating substantial distortion in the map [32]. The 64 remaining authors shown in table 1 were used in subsequent analyses.

Ackerman M.	Ackoff R.L.	Alexander C.
Anderson J.R.	Argyris C.	Bannon L.
Bødker S.	Card S.K.	Carroll J.M.
Churchman C.W.	Conklin E.J.	Dourish P.
Ehn P.	Fischer G.	Gould J.D.
Gray W.	Greenbaum J.	Greenberg S.
Gruber T.R.	Grudin J.	Hartson H.R.
Hix D.	Hollnagel E.	Hutchins E.
Jones J.C.	Karat C.M.	Karat J.
Kieras D.E.	Klein M.	Kraut R.E.
Kyng M.	Lee J.	Lewis C.
March J.G.	Marchionini G.	Mitroff I.I.
Monk A.F.	Moran T.P.	Muller M.
Myers B.A.	Nardi B.	Newell A.
Nielsen J.	Norman D.A.	Olson G.M.
Olson J.	Polson P.G.	Popper K.R.
Preece J.	Rasmussen J.	Reason J.T.
Rittel H.	Rosson M.B.	Schön D.
Schuler D.	Shneiderman B.	Simon H.A.
Suchman L.	Sutcliffe A.	Vicente K.J.
Wickens C.D.	Williamson O.E.	Winograd T.
Woods D.D.		

Table 1. Authors included in the study

Cocitation Analysis

The raw cocitation counts for the 64 authors were obtained by searching across all three Institute for Scientific Information (ISI) citation databases SciSearch, Social SciSearch and Arts and Humanities Search, in Dialog for the years 1990-2004. A typical search statement would be: SELECT CA=NORMAN D AND CA=GRUDIN J; RD [remove duplicates]. This statement retrieves all unique records of journal articles citing at least one work by Norman and one work by Grudin. One limitation of ACA is that coauthors cannot be searched as cited authors, therefore only documents in which the searched author is the first author are retrieved as cited references [31].

The raw cocitation count for each unique pair of authors is stored in a square matrix; off-diagonal cells of the matrix contain the raw cocitation counts while the diagonal cells contain the mean of the off-diagonal cells for each author [51]. For the cluster and MDS analyses, the raw cocitation counts are converted into a matrix of Pearson correlations representing the similarity of cocitation patterns of each pair of authors.

Several multivariate techniques are used to examine the author cocitation patterns. In the following sections cluster analysis and multidimensional scaling (MDS) are discussed.

DISCUSSION

The results of the hierarchical cluster analysis as a dendrogram are seen in Figure 1. All hierarchical agglomerative cluster analyses begin with a set of individual objects and, step by step, join objects and clusters until a single cluster is achieved. The dendrogram shows the cluster structure, beginning with 64 individual authors on the left and ending with a single cluster on the right. Two authors are joined, an author is added to a cluster, or two clusters are merged, based on the distance criterion. The horizontal distance traveled between mergings is evidence of the integration or isolation of the authors or clusters. Authors clustered together generally have an identifiable link based on the subject matter of their writings, their geographic or institutional affiliation, school of thought, or other intellectual connection. Inspection suggests that a seven-cluster solution is a good representation of the cocited author structure of this data set (see McCain [31] for discussion).

A two-dimensional multidimensional scaling (MDS) map is shown in Figure 2. The seven clusters identified in the cluster analysis are added to enhance the map. MDS attempts to represent the whole data matrix as a two dimensional (or more) map. In MDS R Square and stress are indicators of the overall "goodness of fit." The R Square is the proportion of variance explained. The stress is the distortion or noise in the analysis. Stress less than 0.2 is usually acceptable [31]. When the authors are mapped in a two dimensional map, as seen here, the R square = .89485 and stress = .15254 (Young's S-stress formula 1 is used).

Here, authors, represented as points on the MDS map, are positioned based on the correlation matrix of profile similarities. Authors with similar cocitation patterns are placed near each other in the map. Those with many links to others tend to be placed near the center of the map while highly dissimilar authors are placed at a distance and those with few local links are at the periphery. Authors closely positioned but placed in different clusters have important secondary links and may be considered boundary spanners.

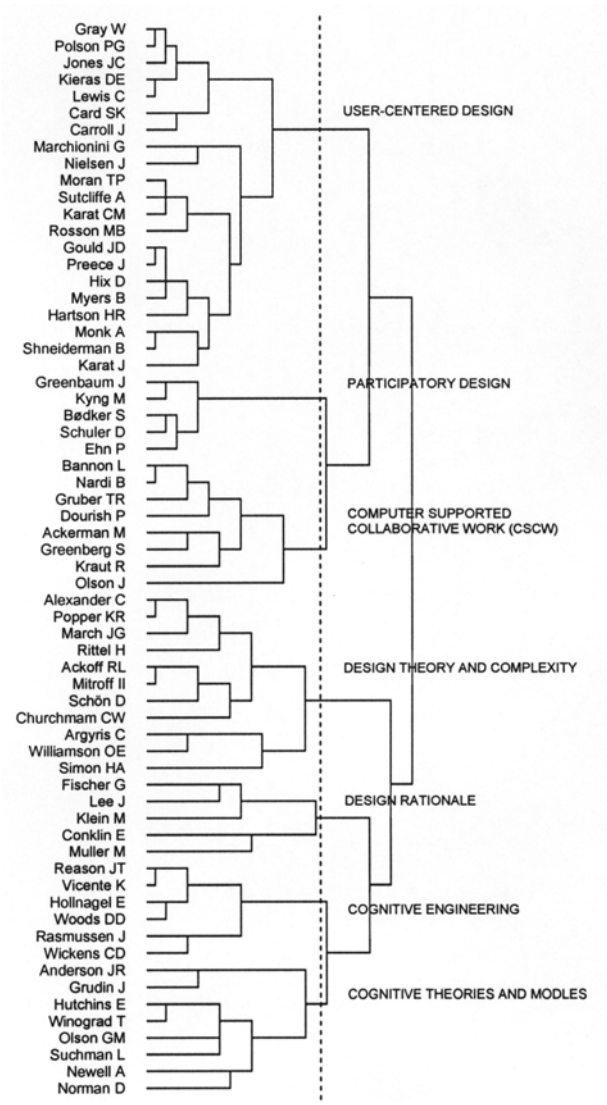

Figure 1. Cluster Analysis

We began this analysis by noting that design and evaluation are typically taught and practiced separately. In forming the author set for this analysis, we then took highly-cited authors from each of these broad areas. When two distinct areas are combined in a single author cocitation analysis, an expected result would be two primary clusters of authors with, perhaps, a few boundary spanners [19]. If this were the case, we would see a large cluster related to design, with sub-clusters showing specialization, a similar large

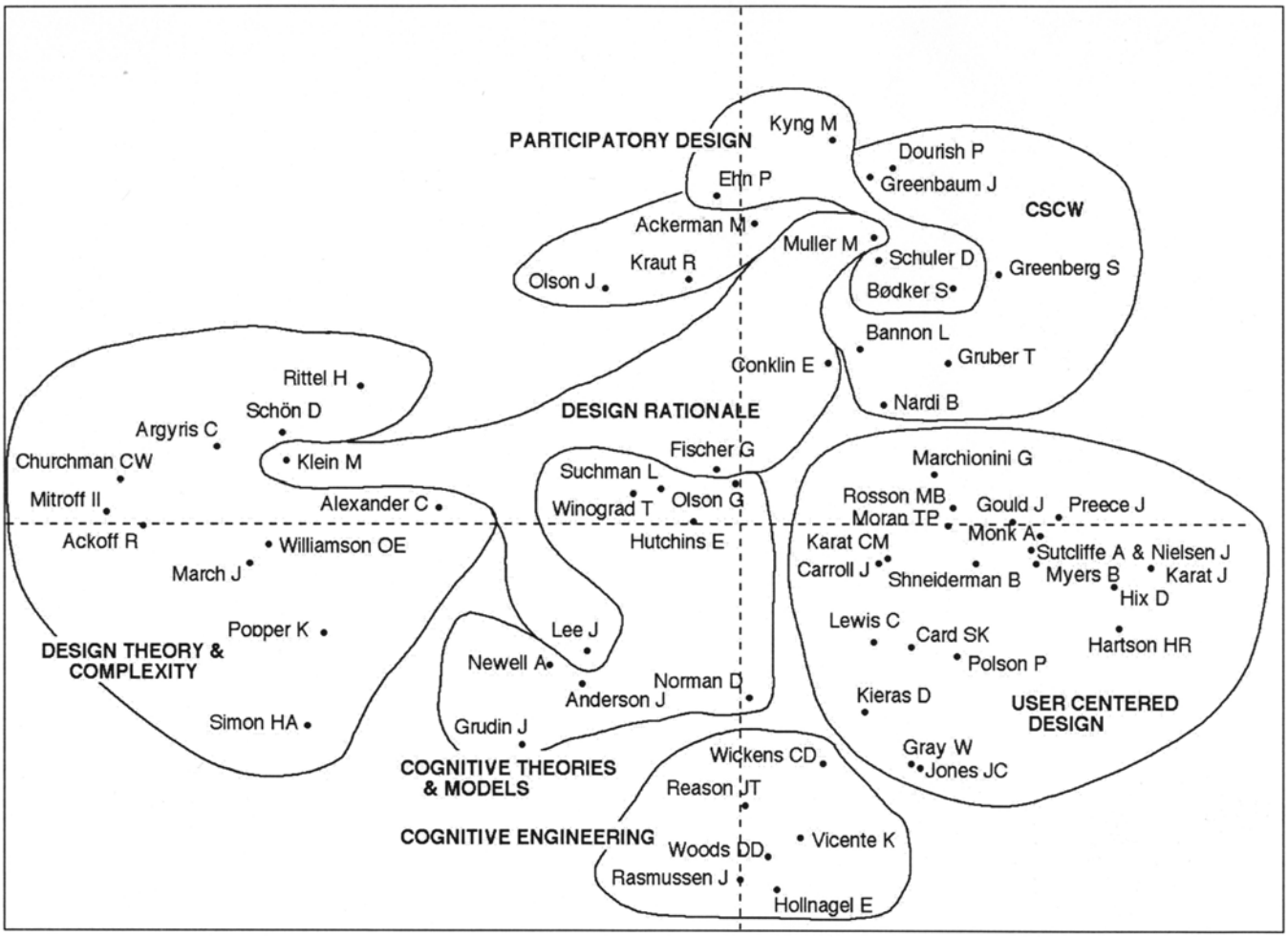

Figure 2. Author Cocitation Map

cluster for evaluation, and a few authors who combine the two topics centered between these two large clusters. This is not what we see here.

It is difficult to classify authors as focusing on only design or only evaluation, but an examination of the map reveals that authors that focus more on the evaluation of systems are spread throughout a number of clusters rather than just situated in their own cluster. This suggests that certain design and evaluation methods are discussed together in literature. How these design and evaluation methods are linked together and what differentiates one set of methods form another is apparent in the cluster analysis.

Overall, the HCI community sees seven clusters of authors with seven corresponding viewpoints within the topic of usability. These seven clusters are Participatory Design (PD), Computer-Supported Collaborative (or Cooperative) Work (CSCW), User-Centered Design, Cognitive Engineering, Cognitive Theories and Models, Design Theory and Complexity, and Design Rationale.

There are a few authors located close to the center of the map that share similarities with many other authors in this analysis. Those who appear closest to the center of the map include E. Hutchins, G.M. Olson, L. Suchman, T. Winograd, and G. Fischer. These authors focus on cognitive theories and models. This may suggest that cognitive theories help hold these communities together. We will return to this topic in the conclusions section.

The axes in an ACA map point to underlying themes or continua in modes of scholarly inquiry. Here, we can see two major perspectives in HCI research. The placement of authors and author clusters on the X-axis appears to span a range from theory to application. Authors at the left-hand extreme of the axis are primarily concerned with building theory while the authors at the far right side are concerned with building usable systems. Ideas from authors in Cognitive Theories and Models and Design Rationale integrate these two extremes. Moving from the top to the bottom of the map, the Y axis appears to point to two aspects of user participation (the "Human" in HCI). The authors near the top of the map seem to focus more on

collaboration and users in the aggregate (group work) while the authors on the bottom portion of the map focus more on cognition and the individual user.

The Participatory Design cluster focuses on enhancing the workplace and enabling workplace democracy. The authors in this cluster focus on users and designers actively participating and cooperating in the design process.

The CSCW cluster focuses on building systems that enable and enhance collaboration and cooperation among groups in the workplace.

The User-Centered Design cluster focuses on building systems with a focus on users. They focus on methods for creating usable systems and evaluating systems.

The Cognitive Engineering cluster focuses on the cognitive properties of people and how these properties influence people's interactions with elements in an environment.

The Cognitive Theories and Models cluster focuses on understanding the users, how they accomplish tasks, and why they think something is usable.

The Design Rationale cluster spans across much of the map, almost connecting one side to the other. The authors in the Design Rationale cluster all seem to be boundary spanners. Each author in this cluster is located very close to another cluster. Klein is located very close to the Design Theory and Complexity cluster. Lee appears very close to the Cognitive Theories and Models cluster. Fischer is also located very close to the Cognitive Theories and Models cluster but he is located close to a different part of the cluster on the map. Conklin appears close to the CSCW cluster and Muller is located close to the PD cluster. This suggests that design rationale may mean different things to the different clusters on the map.

Design rationale tries to address some of the major problems faced in design including communication and problem solving. Design rationale reaches toward evaluation in the sense that it attempts to document why a system is designed the way it is so that in the future others may examine these documents and foresee the consequences of any proposed changes [28]. In this way design rationale attempts to aid in the redesign process.

CONCLUSIONS

As stated in the introduction our goal is to discover how *design* and *evaluation* are related and to use this as a basis for building an overarching theory of HCI. We are not there. But, we have made significant progress. We know that when members of the HCI community write about HCI, they, collectively, see seven major topics. We know that these topics do not split between *design* and *evaluation*, but rather split according to philosophies of how systems should be designed and evaluated. This analysis also raises some questions, which we consider below.

Who is at the center of the HCI community? Figure 2 shows two orthogonal dimensions and these were discussed above. One, vertically, shows high involvement with end users (at the top) and low involvement (at the bottom). The second dimension, running horizontally, shows a strong focus on theory development (on the left) and a strong focus on system building (on the right). Where these two dimensions intersect is the center of the HCI community, as seen by people who write research papers within this community. An author here would share similarities with many other authors in this analysis. This author would be the *center* of the design community.

While this analysis is clear about *who* is at the center, we must speculate about *why* this particular set of authors is at the center. The authors in question (see Figure 2) are Gerhard Fischer, Terry Winograd, Lucy Suchman, Ed Hutchins, and Gary Olson. All but Fischer are in the cluster labeled "cognitive theories and methods." But, the closeness of these authors on this map indicates that the ties among these authors are stronger than those with others in their respective clusters.

Asking *why* they are at the center is equivalent to asking what they have in common. And, what they have in common is viewed as the central theme in HCI during the period covered by this analysis.

We believe that the central theme that ties these five authors together is a focus on *the context of use* of systems. Suchman's *situated action* [44] and Hutchin's *cognition in the wild* [20] have a clear focus on *context.* Fischer's *seeding-evolution-reseeding* [11] model of system development bases design decisions on studies of systems in their *context* of use. Since this analysis is based on author cocitaton rather than article cocitation, we cannot point to specific articles for a given author, However, we would speculate that Olson's work on *collaboratories* show a strong focus on *context*, as does Winograd's edited text *Bringing design to software* [52].

How should we teach HCI? Although design and evaluation are typically treated as separate activities in literature, academia, and industry, the author cocitation analysis discussed above reveals different philosophies of design within HCI rather than a distinct design community and a distinct evaluation community.

This suggests that rather than teaching separate courses for the design of interactive systems and the evaluation of interactive systems we should be teaching multiple courses each with a focus on a particular design philosophy. For example, one course would focus on participatory design and another on user-centered design and both would cover the design and evaluation methods within these philosophies.

Why do we not have distinct clusters of design and evaluation methods? There are distinct clusters here, but there are not clusters consisting only of design methods and

others consisting only of evaluation methods. Rather, each of the seven clusters contains examples of both design and evaluation methods. What, then, is the glue that holds each cluster together? One way to paraphrase this question would be ask whether a given HCI problem is equally approachable by any methods in any of the clusters or whether each cluster focuses on a unique type of problem. To some extent, there is some mapping of problems to approaches, but it seems that the ties are weak. For example, the *CSCW* cluster obviously focuses on problems in which multiple people use technology to collaborate. But, such problems could also be approached by other methods, such as those in the *cognitive engineering* cluster.

What will be the next *hot* topic in HCI? We believe that the answer to this question parallels that of the initial question in this section. The next *hot* research area will be the one in the center of the HCI map. That the authors near the center come from two distinct clusters makes it clear that there is no single cluster at the center. However, the fact that the five authors near the center are grouped so tightly, relative to their groupings with others in their respective clusters indicates that the science base of HCI is moving toward the formation of a tightly grouped cluster in this area of the map. We predict, therefore, that the next *hot* topic in HCI will be a focus on understanding design and evaluation in the *context of use*.

For years we have focused on design and evaluation methods that are used outside the real context of use. We may begin to see more and more methods and techniques that focus on taking into account the context of use or methods that are intended to be used in the real context of use.

FUTURE WORK

We intend to further analyze these findings by using Pathfinder Network (PFNet) analysis to provide another viewpoint of the author cocitation data. A PFNet would complement the analysis presented here by focusing on the single highest cocitation counts between authors [50]. PFNets can identify dominating authors and point to specialties within a discipline [50]. We also intend to further explore the interrelationships shown in the author cocitation analysis map. For example, authors with many links to others are near the center of the map shown in Figure 2. In some sense, these authors are at the center of the global HCI community. What is about the authors that appear here that puts them in this position?

Finally, we ask for your help. While we tried to use in this analysis the most appropriate set of authors, we may have inadvertently left someone out. If so, please let us know. We also intend to use any feedback we receive to expand the list of authors and conduct further analyses on similar data sets.

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