Designing Tools to Support Advanced Users in New Forms of Social Media Interaction

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ABSTRACT

Interface design practices in social media systems change rapidly, routinely presenting new tools and functionalities. In order to attract a broad base of users and acceptance of system enhancements, interface designs are typically highly conventional, building on best practices in HCI. In such systems, the needs of advanced users are often secondary. To probe how the design of tools should be adjusted to the needs of advanced users, we created CrediVis, a tool for visualizing multi-dimensional user data in Wikipedia. Through a two-round study of advanced users, we find that such users value specialized and complex tools designed to fit their needs. We further observed that although they value such advanced tools they prefer conventional rather than novel interface design. Our study suggests that tool design for advanced users must be closely aligned with needs that can be co-discovered with advanced users.

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: User-centered design, H.5.3 [**Group and Organization Interfaces**]: Collaborative computing.

General Terms

Design, Human Factors, Verification.

Keywords

Wikipedia; WikiProject; visualization; tool design.

1. INTRODUCTION

Finding collaborators in an online community is a constant problem. Even when people are regulars in an online community, knowing who is knowledgeable about which topics and who has a compatible personal disposition is always a struggle. The challenge of finding effective collaborators grows as the size of the community grows and is even harder for newcomers. Wikipedia, a large scale online community, offers no explicit support for finding collaborators. Most Wikipedians rely on their interactions with other users or spend time hunting through user edit histories and user pages to understand and identify potential collaborators.

A structure within Wikipedia that helps advanced editors find others with similar topical interests is the WikiProject. WikiProjects are groups of editors who affiliate with one another to jointly work toward some shared goal, such as the improvement of encyclopedia content related to a broad topic of mutual interest (e.g., chemistry, Manga) or to improve the overall characteristics of Wikipedia (e.g., citation cleanup, stub sorting). Even within WikiProjects, however, one can encounter a large and diverse group of people with whom they have little experience. Thus, despite having some ostensibly shared interests, an editor may not have a means of identifying others who might be good candidates to approach for a potential collaboration.

A challenge for users of large, online, distributed communities like Wikipedia is that participants often need to work with people with whom they have no prior experience. That is, they must make decisions about whom they want to trust to work with them on a collaborative effort without having a history of interactions on which to build their confidence. Trust is crucial to collaboration since trust can affect its outcome [5, 12]. In this paper, we design and evaluate a visualization tool to help Wikipedia editors better understand some of the editing activity of other editors in the specific context of a WikiProject.

This type of design work represents a largely neglected area in HCI research: How best to design for advanced users and their needs in a system that has a broad user base. The user-centered design approaches that are widely known in our field are primarily based on assumptions of a generic user. Such generic users typically represent a class of person who should be able to intuitively use system tools to quickly become competent users of the technology. This sort of levelling of the user in our design work has largely proven successful in creating systems and technologies for the general public (e.g., social media systems used by broad bands of society, including young children and the elderly). We are motivated differently in this investigation. We are interested in how we can best support design for advanced users. What are the best ways to create more complex and sophisticated tools than those that would be used by common users? More specifically, in large-scale social media systems like Wikipedia,

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what design approaches could be pursued to address that needs of advanced users?

A tool specifically designed to support Wikipedians as they search for a collaborator would be more specialized than most users of Wikipedia would require. Such a tool would address the needs of a niche in the user community occupied only by advanced users. The vast majority of Wikipedia users—those who use the system as an encyclopedic information resource—have no need for such a tool. Beginning editors, those who edit a page to add a detail to an article or to correct a typo, likewise have no need for such a tool. For these two types of users, the design of the system is largely right already. That is, the system is designed in a relatively intuitive way that serves the needs of information consumers and beginning editors. Advanced users, however, have different needs. Our interest is in how we can best discover those needs, how we can design novel tools via interactions with advanced users, and how we can understand the value of such designed tools in practice.

In the following sections we briefly review prior work that has addressed a challenge for advanced users, understanding and interpreting user activities in large scale online communities. We then describe our design process for creating a tool to support advanced users in Wikipedia, including how we established baseline community needs for such a tool, how we designed a tested a working prototype of a visualization tool, and how we worked with members of the community in two rounds of interactions to understand how the design of the tool would work in practice and how it would be valued by those for whom it was designed. We then conclude with recommendations for how to design new tools that correspond to the needs of an advanced user community.

2. DESIGN TO SUPPORT TRUST AND COLLABORATION IN DISTRIBUTED COMMUNITIES

As a social media system, Wikipedia is a remarkable success. It is a success both in terms of providing valued information to millions of people worldwide, but also in terms of facilitating the social process of aggregating and presenting this information. The work of creating Wikipedia is open to all individuals with access to the Internet. As such an open, social system, Wikipedia has a broad and highly diverse body of users. Design for such a broad and diverse user base is clearly challenging.

Among these users are several thousand users who regularly engage in varied forms of work [10] to make and maintain the encyclopedia. Many of these editors engage in complex work in the system, which routinely brings them into social interactions with others. These interactions can be contentious [2], but more often the parties involved seek opportunities to work collaboratively. The needs of these advanced users—that is individuals who are proficient with system tools and who also need to achieve complex work tasks cooperatively—presents a challenge for those who would design appropriate tools.

Researchers study trust at the group or team level because trust can affect group performance. Previous research shows that high levels of trust impart positive attitudes within organizations, such as increased commitment to the group and high team satisfaction [5], and higher levels of autonomy within teams [12]. Traditionally, trust has been considered in the context of long-term relationships and establishment of trust has relied largely on the history of a group over long-periods of interaction between members.

However, this view is problematic when studying distributed collaborative communities such as Wikipedia that rely on temporal collaboration involving anonymous collaborators [21]. In such non-traditional collaborative contexts, swift trust has been proposed as a form of trust occurring in temporary organizational structures, which can include rapidly formed groups or teams [19]. In swift trust theory, a group or team assumes trust initially and later verifies and adjusts trust beliefs accordingly. Researchers have used swift trust theory as a lens for understanding short-period trust in online communication and collaboration. One of the earliest studies examining how to create and maintain trust in distributed teams was conducted by Jarvenpaa [10], which demonstrated the effectiveness of swift trust while also noting its fragile and temporal nature. Zolin et al. [28] conducted a longitudinal study to understand cross-functional, geographically distributed teams. Their study revealed that people build trust based on initial impressions of trustworthiness that stabilize over time. Hung et al. [9] suggested an integrated model of trust that encompasses both traditional forms of trust relationships and swift trust, observing that both can easily be found in virtual teams. Li et al. [14] studied the relationship between team individuals' status or performance and trust. These studies illustrate the need to visualize individual work characteristics within a specific work context. Our tool adopts that perspective by visualizing Wikipedia editors' work within the context of a given WikiProject. Swift trust can be influenced by some qualitative aspects as well. Lankton [13] studied how interpersonal and corresponding technologies distinctively affect trust on Facebook. Schumann et al. [24] concluded that presenting potential collaborators' relevant information elements, such as domain expertise and personal hobbies, could enhance trust. While we appreciate the potential value of a rich qualitative view of individuals when making a trust decision, our tool implements an incremental step in this direction. Our tool focuses on exposing a select version of expertise specifically in the context of a WikiProject.

Taken together, this prior work suggests a tight relationship between trust and the experiential quality of distributed collaboration. As such contexts proliferate, we will benefit from new research into how swift trust among participants in large online systems could facilitate collaborative relationships.

3. DESIGN TO SUPPORT COLLABORATOR RECOMMENDATIONS

Meaningful contributions in Wikipedia happen through collaboration. Understanding how to facilitate and enhance both the quality and quantity of collaboration is vital to Wikipedia's future success. However, many Wikipedia studies have focused on increasing individual motivation or individual total contributions almost to the exclusion of what we know about the attraction people have to working with others.

The challenges of making social recommendations, recommendations of people instead of artifacts, were outlined in prior work by Terveen & McDonald [27]. The majority of work related to social recommendation systems has been focused on getting people who need specialized information connected to people who have expertise. Several studies have considered the motivations and techniques for recommending people in an organizational setting [6, 18, 22, 23, 26]. Some work has considered scientific productivity as a form of profile to

recommend collaboration within the scientific community [1]. Cohen and Ebel, for example, suggest a keyword-based recommendation system for scientific social networks [4].

Another approach to collaboration is presenting the status of potential collaborators. McDonald suggests the need for ways to recommend experts in groupware systems and also identifies contextual considerations when designing a recommendation system, such as perceived trade-offs and user control of social matching [17]. Still other researchers have investigated collaborator recommendations via activity-awarding in distributed systems. Heck, for example, pursues this approach to recommending potential collaborators in knowledge-intensive organization, such as academia [8]. Lim et al. built a system for activity awareness and suggested that activity awareness could help users glean more about what their collaborators are doing [15]. In many cases, these researchers investigated means to support interdisciplinary research or academic collaboration. However, mechanisms for recommending collaborators in massive online communities like Wikipedia are not sufficiently studied.

4. DESIGN PROCESS FOR DEVELOPING CREDIVIS

In order to create an appropriate design for the advanced users of Wikipedia who seek to find collaborators, we engaged in a process that had us interacting with the community at several junctures. As described below, this process involved listening to the community before any design work was started, creating a sophisticated tool that addressed special needs, putting the tool in front of community members and having them use it in actual work tasks, and using community feedback to refine the tool and then re-study its use with actual community members. In essence, we attempted to involve members of the community in an approximate co-design process in an effort to design a tool that would be valued by advanced users.

4.1 Preliminary Research to Establish Needs

The design of our tool was motivated by the community. In order to understand the wants and needs of experienced Wikipedians, we conducted two rounds of focus group studies with active editors who maintained their own user pages in Wikipedia. In these discovery-oriented studies, experienced Wikipedians were asked to identify what they most desired to know about other Wikipedians when making decisions about how to interact and collaborate with them online. Our findings led to a series of editor-related metrics that reflected what experienced Wikipedians wanted to know about each other's editing actions when deciding how to interact online.

The list of things Wikipedians desired to know about each other's previous editing actions was extensive, including 28 unique items. We analyzed this list, identifying a set of four highly rated information elements confirmed by a majority of the study participants. We subsequently initiated a design process in which we created a visualization tool that could present this four-part, multidimensional data in a single visualization. The visualization tool was also designed to be suitable to a context of work valued by the experienced Wikipedians, contributing to work organized in the context of a WikiProject.

4.2 User Studies to Develop Design and Measure Value

We evaluated the tool through a set of structured interviews with experienced Wikipedia editors. These interviews were framed around a set of scenario-driven activities that prompted editors to first demonstrate their normal techniques for finding collaborators and then to use our tool to find potential collaborators. We analyzed the transcripts of the interviews and interactions with the visualization from screen capture recordings to reflect on the design of our tool and its value for advanced users of Wikipedia.

4.2.1 Design of the user study

In our study, experienced Wikipedia editors used our visualization tool to explore potential collaborators in the context of WikiProjects. We conducted the study in two rounds. In round 1, 16 experienced Wikipedians worked the CrediVis tool had designed, performing scenario-driven tasks with it. In round 2, 5 additional experienced Wikipedians used a redesigned version of the CrediVis tool to perform the same set of scenario-driven tasks.

We recruited our participants from a broad population of editors affiliated with existing WikiProjects. Individuals interested in participating in the study were required to speak English. All potential participants were screened to ensure that they were active editors, and that they were engaged in the kind of project-based, collaborative work that our visualization was designed to support. All participants were between 18 to 70 years old, and included a mix of female and male participants. Although all participants were English speakers (and active editors of the English version Wikipedia) they resided in locations around the globe: Asia, Europe, North America, and Oceania.

4.2.2 Facilitating/Preparing the Study

For our institutional review board (IRB)-approved study, we recruited participants through both Wikipedia and Facebook. All study sessions were conducted via synchronous remote connections in which participants interacted with the research team via screen and audio channel sharing with Google Hangout. We used screen capture software to record their interactions with the tool and their accompanying audio. Participants also provided feedback via web-based forms, which included questions about their experiences and observations related to their use of the tool as well as questions to measure satisfaction and confidence in the tool's support of their work. Study sessions lasted about one hour, during which participants worked through three scenarios.

4.2.3 Scenarios

Our user study engaged Wikipedians in a series of scenario-based activities to help us understand their existing practices related to finding a collaborator and how our visualization tool might support or expand their practices. In our first scenario (Scenario 1), we asked participants to read a description of CrediVis and explore the tool. The main goal of Scenario 1 was to elicit initial thoughts on CrediVis. Our second scenario (Scenario 2) was divided into two different tasks. The first task (Scenario 2A), we asked participants to demonstrate their typical procedure for finding potential collaborators in Wikipedia to understand how these Wikipedians currently find collaborators. For the second task (Scenario 2B), we asked participants to use our visualization tool, CrediVis, to identify potential collaborators. This task was designed to conduct further comparative analysis between their method(s) with and without CrediVis and to help familiarize

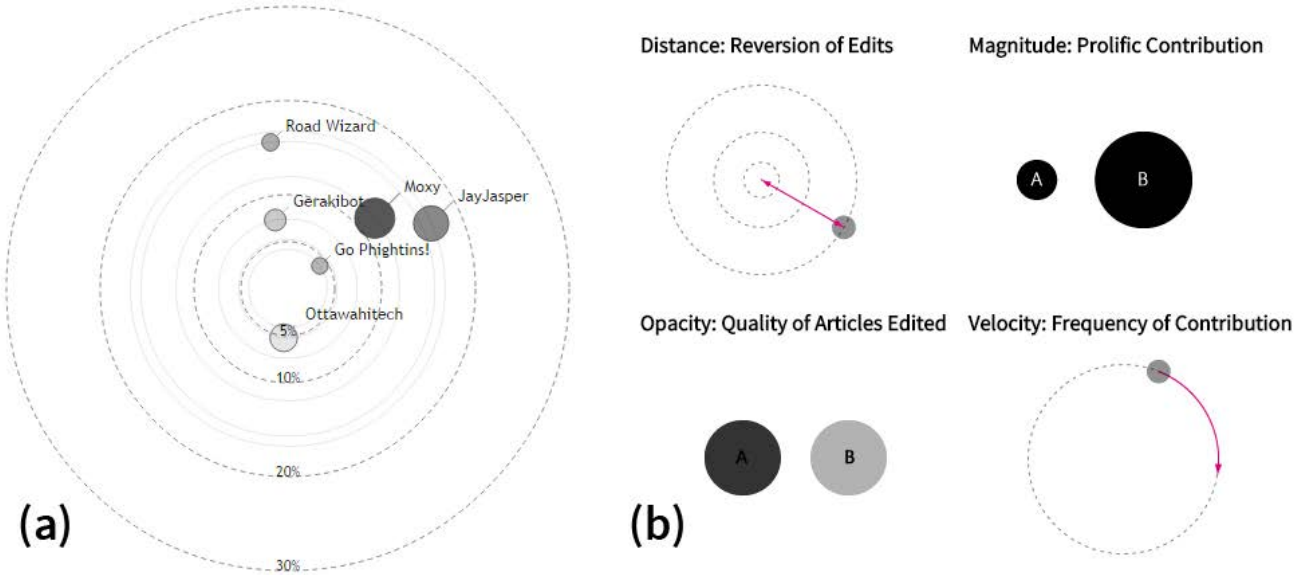

Figure 1. Initial design of CrediVis System, including (a) animated orbital visualization of potential collaborators, (b) summary of the four metrics represented in the CrediVis visualization

participants with the features and functions of the tool. For the final scenario (Scenario 3), we asked participants to engage in a task that required finding several collaborators who have specific domain knowledge pertaining to different WikiProjects. Using the tool, participants identified multiple potential collaborators to fulfill the goals presented in the scenario.

By observing participants' behaviors through these three scenarios and by soliciting their thoughts and reflections during and after the scenario-driven activities, we were able to identify features of current practices and possible new means of identifying potential collaborators for project-based work in Wikipedia. Our participants, thus, were treated as close allies and invaluable informants in the development of our tool design.

5. UNCONVENTIONAL TOOL DESIGN APPROACH TO ADDRESS A UNIQUE USE CASE

The tool we designed, CrediVis, is a mechanism for advanced users to visualize 4 different editing behavior characteristics of other Wikipedians. The tool functions as a visualization displayed in the context of a Wikipedia page in the WikiProject namespace. WikiProjects are self-organized work groups within Wikipedia that share a common interest in performing some type of joint task, such as improving articles related to a topic like chemistry or improving formatting consistency across all articles in the encyclopedia. Our tool was designed to allow visitors to any given WikiProject a mechanism for learning about the prior work of the most active editors affiliated with the project. The tool was thus focused on contexts within Wikipedia that require extensive collaborative interactions between multiple, advanced Wikipedians to complete a series of related tasks.

5.1 Overview of Design

CrediVis originally adopted a radial, orbital metaphor where multiple objects representing WikiProject editors orbited around a central point that represented a specific WikiProject domain. Our design was inspired by Johnson and Lackoff, who advanced the idea of an image-schematic model within the HCI community. We also took design inspiration from prior research by Blackwell, who explored the visual metaphor of a solar system-like orbital that users could drag to support engagement and creativity during tasks [3].

We mapped four visual channels: 1) total # of edit - magnitude of the circle, 2) quality of articles edited - density of the circle, 3) reverted ratio - distance from the center, 4) number of edits within 3 months - radial velocity. Figure 1 provides a visual summary of this design.

For CrediVis, we deployed an animation effect to give agency to the recent contributions of the editor (the number of edits within 3 months). Radial velocity is not a traditional way to express metrics in the information visualization community since users cannot perceive absolute values via animated velocity. However, animation has a strong attention-drawing effect and expressing recent activity through animated velocity matches image and schema. We hypothesized that velocity would be perceived as intuitive by participants despite the lack of precision.

5.2 User Study 1

The first user study involved 16 participants from across the world who were advanced or expert users. The study was conducted over the course of six months, starting in November 2013.

5.3 Results

5.3.1 Tool design flawed

The novel design of the tool created confusion for participants. Participant comments revolved around a set of common issues: excessive visual complexity, unmet information needs, unsupported information seeking practices, and conflicting mental model of participants with behavior of the tool.

Excessive visual complexity. The complexity associated with displaying multidimensional data using different and succinct visual channels proved to be a barrier for participants using the tool. Participants had to keep track of four different metrics each

with a unique visual channel when using the tool to evaluate potential collaborators. Some participants found it difficult to memorize what each of the visual cues stood for without having to repeatedly read the tool's description.

Additionally, the radial visualization proved to be a barrier in the tool's interpretability. Overlapping orbits created visual clutter and obscured other important visual channels. For instance, some participants noted that they were not able to select many of the orbital nodes due to the overlapping and overcrowded orbits. Participant (P)1.8 and others noted that overlapping, overcrowded orbits affected the readability of visual elements and created further excise: there were "too many circles near the center of the graph."

The radial velocity used to represent the recent activity of an editor, while designed with the intention of being attention-grabbing to reflect the importance of an editor's recent activity, was unintuitive, drew too much attention, and obscured potentially useful information. P1.4 observed, "Angular velocity is hard to determine if the circles move around in different places." We recognize that angular motion is not appropriate for this very important visual channel.

Unmet information needs and unsupported information seeking practices. In seeking and selecting potential collaborators, participants actively sought additional user information that our tool did not provide. Almost all participants attempted to click on visualization nodes believing they would be linked to the user pages of recommended potential collaborators. The information sought by participants included barnstars, behavioral records, good/featured article badges, and profile completeness. These informing elements were mentioned by participants as very important and often more important than other metrics for evaluating whether or not a Wikipedia editor would be an effective collaborator. Our tool did not address these information needs and did not support these common information-seeking practices among Wikipedia users.

This lack of additional information presented a barrier for participants when they were asked to identify potential collaborators using the CrediVis metrics alone. Participants like P1.12 were unsure whether metrics on the visualization tool would be beneficial or suitable for selecting collaborators and made clear the importance and value of other Wikipedia artifacts: "I am not sure that the variables in the tool are the best for determining who is a good collaboration partner. I would always want to evaluate someone's user page before reaching out to them."

We also observed the use of off-wiki spaces such as Facebook, Twitter, and Skype for collaborator-seeking. For instance, P1.2 said, "I have known some members for several years, and have become friendly to the extent that I would consider them friends. Again, the instant communication is helpful off-wiki." To collaborate on Wikipedia, P1.1 describes a method for collaborator-seeking: "The only other method I can think of is asking friends (who aren't wikipedia editors) over Skype/Facebook to read through what I've written and copyedit it."

Conflicting mental models of participants with functionality of the tool. Most participants believed that the visualization tool recommended potential collaborators based on an editor's specific contributions contextualized to each WikiProject. However, the tool in its current form displays aggregate metrics that are not contextualized to each WikiProject but instead global throughout an editor's activity across Wikipedia. A handful of participants recognized this discrepancy and noted that without contextualized metrics, the tool was not as useful as they had hoped.

Other participants noted they were more influenced by their prior histories of interactions with other Wikipedians as opposed to metrics. P1.7 explained, "If I was operating in a topic area well-known to me, I would be more influenced by my past interactions with those editors in selecting collaborators, i.e. it would override any metrics."

Participants also pointed the tool does not supported choosing a collaborator who may have specific niche interests in project subtopics or a collaborator who performs specialized project tasks—facets of WikiProjects that the tool did not capture. P1.8 noted "CrediVis appears to only give analysis of potential contributors at the WikiProject level, which may be too broad for my needs."

5.3.2 Tool functionality supported

Our initial user study also yielded some positive perceptions of the tool's utility in finding potential collaborators. By providing editors with an overview of potential collaborators, the visualization tool added utility and reduced time for accessing information required for identifying collaborators. P1.1 said, "It [CrediVis] provides a quick glance at an editor's history to gauge their suitability ... this tool gives a fairly good overview of each editor."

After using CrediVis to identify potential collaborators, participants described the added benefits of using the tool, such as reviewing an editor's user page and edit history. P1.14 when asked to compare his/her standard practices to collaborator finding using the tool said, "It would have been harder because I would guess based on [the] user page and talk page of user. The visual of the number of edits and impact is great to separate the wheat from the chaff." P1.3 also said, "The tool has a useful impact in the way that it allows me to easily have the information on my fingertips than do a search for it ... overall it makes matters a lot simpler."

Participants noted another benefit of the tool was the time saved in identifying potential collaborators. P1.1 who explained the value of time saving said, "I was able to fairly quickly find possible editors ... Without the tool I would have likely spent much longer looking for editors, having had to go round each wikiproject searching for editors." P1.7 said, "I find the metrics, being constrained to a topic area, to be a useful way to profile editors otherwise unknown to me."

When participants were asked whether they preferred their traditional methods for finding potential collaborators to using the visualization tool, participants had mixed responses. P1.14 expressed a preference for the tool, "I prefer CrediVis because I do not have to hunt and peck at finding a fellow editor that is trustworthy or is good. It makes it very simple."

At the same time, though, some participants did not find added utility in using the tool over their standard practices. P1.16 said, "I personally prefer looking via my social networks. I have a long history of working with people and I generally prefer to work with people I already know and trust."

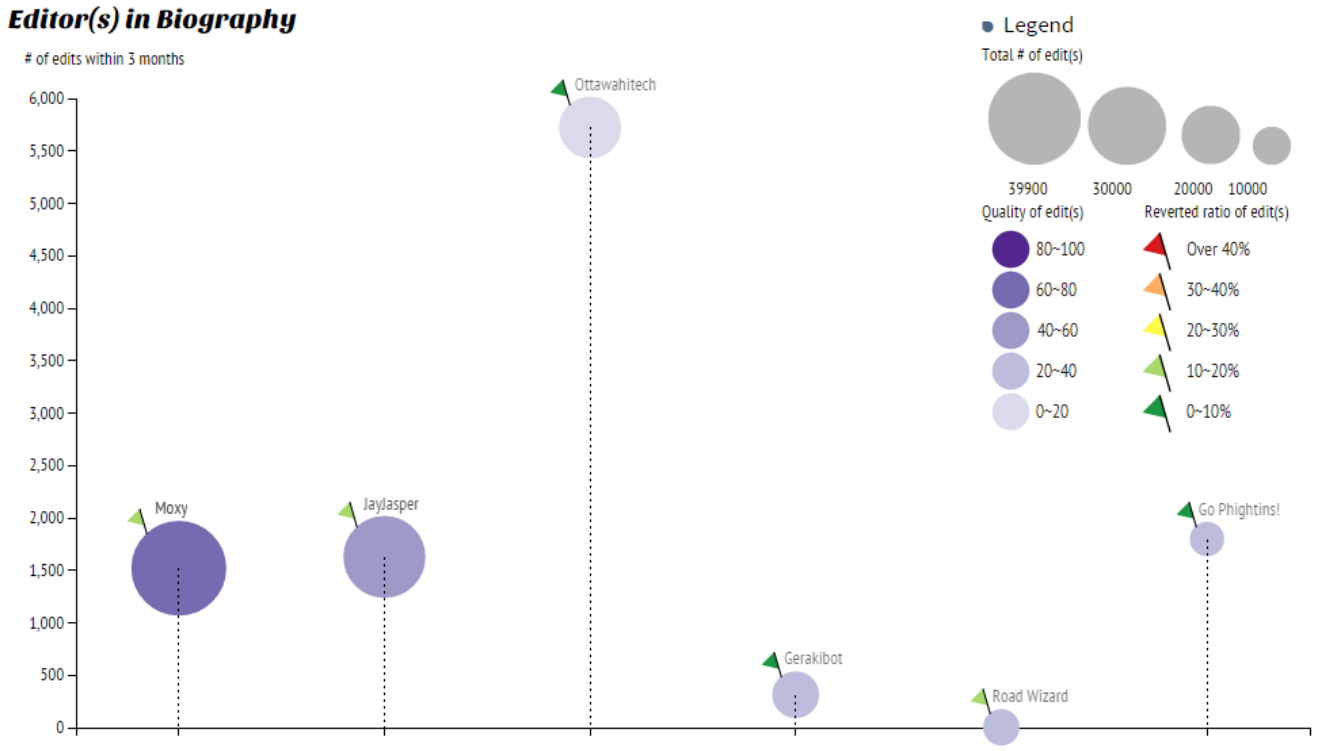

Figure 2. Redesigned CrediVis visualization. In the example, the CrediVis interface is applied in the context of WikiProject Biography.

5.4 Analysis and New Design Direction

From the first user study, we gained valuable information for the design. We discovered certain elements of the first design were not interpretable. We also discovered which design choices worked and could be retained in the future redesign of the tool. Further, we identified the most important information users sought that we would feature in the redesign.

5.4.1 Editors want to see clear visual cues

For future iterations of the tool, a metric legend with proper labels and definitions would be best suited for assisting users' understanding of the tool's features and functions without creating additional obstructing or distracting excise. For example, one out of six participants said that he/she needs a legend to remember what visual cues/metrics represent. P1.6 said, "I'd like to be able to, quickly and easily on the specific project related screen (e.g., finance) "refresh my recollection" of what I had read a few minutes earlier. E.g., a SHORT legend." Another participant preferred a tabular format to the radial visualization. P1.7 said, "I do not find the rotating circles to be a helpful visualization. A tabular format using colour or some other form of visualisation would make comparisons between editors easier."

5.4.2 Editors seek descriptive information of potential collaborators

While the CrediVis metrics may be useful, for participants they do not always give enough context for evaluating whether an editor will be a good potential collaborator. The study with our initial version of CrediVis suggest that future iterations of the tool integrate existing Wikipedia elements such as WikiProject pages and editors' history pages—sources of relevant information valuable in the search for desirable collaborators.

5.4.3 Editors want to have additional functionalities

Participants sought a different visual channel to visualize editor activity and wanted additional manipulative control over moving orbits that would reduce cognitive excise. P1.5 said, "A tabular format using colour or some other form of visualisation would make comparisons between editors easier."

Participants also wanted to control the exclusion criteria for the data displayed on the visualization. For example, participants wanted to filter out editors who did not meet a minimum edit count. Many participants also noted that the visualization tool displayed bots and non-registered editors denoted by an IP address, neither of which were capable of engaging in a meaningful collaboration.

6. NEW TOOL DESIGN USING CONVENTIONAL DESIGN APPROACHES TO SUPPORT

6.1 Overview of the new tool design

In the second round of the design, we shifted to a more conventional design. We used an x-y plane, a well-known technique for presenting visual information. For CrediVis, we used the x-axis to display each editor because this removed visual clutter associated with overlapping orbits (which was one of the main problems in the previous visualization). Then, we mapped the information into the following visual channels: 1) total # of edits - magnitude of the circle, 2) quality of articles edited - density of the circle, 3) reverted ratio - colored flag, and 4)

	Design 1 Study	Design 2 Study
Barriers	Difficult to understand and interpret radial visualization Tool does not reflect mental model of what makes a good collaborator Visual clutter and information overload associated with radial visualization Tool does not provide link to Wikipedia userpages and meet all information needs	Lack of in-depth description of how to use CrediVis Visual glitches and malfunctioning controls
Preferences	Recent edits is the most helpful metric Metrics provided are quick and easy to access/convenient Good for newcomers	Visualization could be resized for 13-inch screen Detailed description could be represented with visuals

Table 1. Barriers and preferences when using CrediVis based on participant responses compared across studies 1 and 2

number of edits within three months - y-axis. Figure 2 provides a visual summary of the new design.

We used Mackinlay's mapping strategy to prioritize the information that we present in the redesigned tool [15] to prioritize the visual information. Following this strategy, we used position to encode the most important information; we used area to encode the second important information, and we used color saturation to encode the information of third importance. In this new design, reverted ratio is also visualized, but now in the form of a flag in the visualization that has a differentiated color scale (red to green). We used this approach because an additional or auxiliary color-coded element can present the quantitative information without encoding a specific interpretive value (e.g., good or bad value).

The y-axis position of the nodes denotes the number of recent edits within three months, replacing the previously distracting cue of moving orbits.

The flag visual cue representing reverted ratio was created as an exploration of the fourth dimension to replace the problematic overlapping orbits. Because reverted ratio was considered the least useful of all the metrics, the relative small size and less obstructive design of the flags correlate to this new design decision. The flag minimizes that design element. Quality of articles edited and magnitude of contributions (total edits) maintain the same visual cues with slight modifications.

We incorporated a sort functionality to allow users to sort potential collaborators by any of the four metrics. We also decided to link user names in the visualization to the relevant Wikipedia user page—a function that participants from the first user study noted was needed to align with their standard information seeking practices.

6.2 User study 2

Upon completing the redesign of the tool, we began planning for the second user study. User study 2 was conducted in August 2014 and involved 5 participants, all of whom were experienced Wikipedia users and met the same editor characteristic profile as the participants in the previous study.

6.3 Results

6.3.1 Tool design changes successful

Decreased barriers. Participants reported few issues with using tool as illustrated in Table 1. There were a few small issues encountered with the new tool design, but overall it was more effective in supporting the collaborator-finding process. In contrast to first study responses, comments reflected minor design issues. When observing study participants performing our three scenarios, we noted both barriers and issues associated with how the designs supported their use of the tool. We counted as a barrier any design characteristic that made it difficult or impossible for participants to use the tool as intended. We counted as an issue any design characteristic that caused the participants to comment on a limitation of the design that they had to work around or that they suggested could be improved to make the tool more useful. As shown in Table 1, both barriers and issues are further subdivided into subcategories.

When using design 2, participants encountered far fewer barriers than they did with design 1 as shown in Table 1. We found the barriers of design 2 were associated with misinterpretation of visual cues and metrics and minor design quirks such as a lack of support for certain native screen resolutions. This observation supports the value of the design changes made between the two versions. It was also the case that fewer issues were identified with design 2.

6.3.2 Tool functionality better supported

Increased accuracy. When comparing the performance of our study participants in answering analytical questions using CrediVis, we observed notable improvements in their accuracy from design 1 to design 2. Two of our scenarios, Scenario 2B and Scenario 3, included four questions that asked participants to identify specific, correct Wikipedia users using the tool. Scenario 3 required a more sophisticated analytical process than the other.

Table 2 shows the average correct scores across the two user studies. Participants using the second design averaged higher scores than participants using the first design, illustrating that the new design led to higher performance and increased accuracy in identifying information.

Increased satisfaction. We asked participants whether CrediVis would help them find potential collaborators when editing Wikipedia. We found that all the participants mentioned that our

Scenarios	Design 1 Study	Design 2 Study
Scenario 2B	3.5 / 4 (87.5%)	3.8 / 4 (95.0%)
Scenario 3	2.69 / 4 (67.25%)	3.6 / 4 (90.0%)

Table 2. Average score of scenario-based questions compared across study 1 and study 2

tool would help them identify potential collaborators. With the first version of CrediVis, only 7 out of 16 participants considered this tool to be useful, 4 participants did not think so. 5 participants responded that the tools would still need to be modified, although there were some items that would lead users to use it nevertheless. Table 3 illustrates the breakdown in responses between the first and second designs. As shown here, all participants using the second design reported they would use CrediVis again as a tool for collaborator-seeking.

7. DESIGN IMPLICATIONS

From the results of both user studies and community feedback on the design of CrediVis, we realize that designing tools to facilitate collaboration-seeking for advanced users of social collaborative systems like Wikipedia must follow these principles: 1) provide a combination of activity/contribution statistics and descriptive information, 2) integrate with existing system features and functions, 3) support the formation of social networks and augment existing ones, and 4) design tools with conventional approaches.

Based on our work, we suggest that a future tool provide editors with a combination of editing statistics and descriptive information. In addition to illustrating editing statistics based on four key metrics, the tool could represent editors' prior experiences with new, richer metrics such as barnstar counts. Or, such information as if other editors have collaborated before or the number of articles a potential collaborator has worked on successfully with other editors before.

This leads us to recommend that the tool integrate with existing Wikipedia features and functions such as links to the talk pages of users or WikiProjects which would give added information and context to editors using the tool. Both of our user studies revealed that advanced Wikipedia editors tend to seek additional information from the talk page of users of WikiProjects and had favored, niche collaborative work contexts such as project subtopics and non-editing tasks.

We recommend that the tool also support or augment future or existing networks of collaborators. As observed, participants' prior personal connections were the most significant factor for them in identifying a list of collaborators, not aggregated metrics. Participants also utilized off-wiki spaces for collaborator-seeking. A tool in support of collaboration should enable users to maintain and develop robust social networks in support of collaboration.

In recognizing the short comings of the first design, we suggest that conventional design approaches be observed when designing tools for advanced users of social collaborative systems. In designing our first version of CrediVis, we adopted a radial visualization with an animation effect, which was an unconventional approach. However, this generated a number of issues in identifying collaborators. For instance, overlapping and overcrowded orbits reduced the readability of visual elements and

	Design 1 Study	Design 2 Study
Would use	7 / 16 (43.75%)	5 / 5 (100%)
Would not use	4 / 16 (25.0%)	0
Mixed	5 / 16 (31.25%)	0

Table 3. Responses whether participants would use CrediVis across study 1 and study 2

generated extra work. Our first user study revealed that a radial visualization was unintuitive in interpreting the information CrediVis offered. Instead, our second version of CrediVis, representing potential editors on the x-y plane (a conventional approach), showed better performance. As illustrated in Table 1, we found fewer barriers in user study 2 than user study 1. Additionally, participants performed better when responding to scenario-based questions using the second design as shown in Table 2 and had higher satisfaction as shown in Table 3.

8. CONCLUSION

In this paper, we described a two-round study of advanced users to design a multidimensional visualization tool for advanced users where such a tool did not exist. Through this investigation, we found that advanced Wikipedia editors value specialized and complex tools designed to fit their needs. Our study, however, has application beyond a tool created for advanced Wikipedians.

The primary contribution of this work is to advancing an understanding of designing for advanced users through a process of designing with the community. Designing with a community of advanced users is a cumbersome process, requiring the research-designers to engage with people out in the world. In addition, as our development process for CrediVis revealed, it was necessary to engage with the community at several junctures. We could not simply design and then seek summary evaluation from the community. We had to invest in the community before any design work was initiated and we had to listen to the community in more than one round of observations to realize a design that would be valued by them and would be functional. Such design pursuits are a worthwhile endeavor for the HCI community as systems become increasingly socially distributed and include increasingly diverse user bases.

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10. REFERENCES

[1] Afzal, M. T., Latif, A., Saeed, A. U., Sturm, P., Aslam, S., Andrews, K., and Maurer, H. 2009. Discovery and visualization of expertise in a scientific community. In *Proceedings of the 7th International Conference on Frontiers of Information Technology* (Abbottabad, Pakistan, December 16 – 18, 2009). FIT '09. ACM Press, 43. DOI= http://dx.doi.org/10.1145/1838002.1838051.

[2] Kittur, A., Suh, B., Pendleton, B.A., and Chi, E. 2007. He says, she says: conflict and coordination in Wikipedia. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (San Jose, CA, USA, April 28 – May

03, 2007). CHI '07. ACM, New York, NY, USA, 453-462. DOI= http://dx.doi.org/10.1145/1240624.1240698.

[3] Blackwell, A.F. 2006. The reification of metaphor as a design tool. *ACM Transactions on Computer-Human Interaction*. 13(4), 490-530. DOI= http://dx.doi.org/10.1145/1188816.1188820.

[4] Cohen, S. and Ebel, L. 2013. Recommending collaborators using keywords. In *Proceedings of the 22nd International Conference on World Wide Web Companion* (Rio de Janeiro, Brazil, July 13 – 17, 2013). WWW '13 Companion. ACM Press, 959-962.

[5] Costa, A. C. 2003. Work team trust and effectiveness. *Personnel review*, 32(5), 605-622. DOI= http://dx.doi.org/10.1108/00483480310488360.

[6] DiMicco, J., Millen, D. R., Geyer, W., Dugan, C., Brownholtz, B., and Muller, M. 2008. Motivations for social networking at work. In *Proceedings of the 2008 ACM Conference on Computer Supported Cooperative Work* (San Diego, CA, USA, November 08 – 12, 2008). CSCW '08. ACM Press, 711-720. DOI= http://dx.doi.org/10.1145/1460563.1460674.

[7] Forte, A., Kittur, N., Larco, V., Zhu, H., Bruckman, A., and Kraut, R. E. 2012. Coordination and beyond: social functions of groups in open content production. In *Proceedings of the 2012 ACM Conference on Computer Supported Cooperative Work* (Seattle, WA, USA, February 11 – 15, 2012). CSCW '12. ACM Press, 417-426. DOI= http://dx.doi.org/10.1145/2145204.2145270.

[8] Heck, T. 2013. Combining social information for academic networking. In *Proceedings of the 2013 ACM Conference on Computer Supported Cooperative Work* (San Antonio, TX, USA, February 23 – 27, 2013). CSCW '13. ACM Press, 1387-1398. DOI= http://dx.doi.org/10.1145/2441776.2441932.

[9] Hung, Y. T., Dennis, A. R., and Robert, L. 2004. Trust in virtual teams: Towards an integrative model of trust formation. In *Proceedings of the 37th Annual Hawaii International Conference on System Sciences* (Big Island, HI, USA, January 05 – 08, 2004). HICSS '04. ACM Press, 10042.1. DOI= http://dx.doi.org/10.1109/HICSS.2004.1265156

[10] Jarvenpaa, S. L. and Leidner, D. E. 1998. Communication and trust in global virtual teams. *Journal of Computer-Mediated Communication* (1998), 3(4). DOI= http://dx.doi.org/10.1287/orsc.10.6.791.

[11] Kriplean, T., Beschastnikh, I., and McDonald, D.W. 2008. Articulations of wikiwork: uncovering valued work in wikipedia through barnstars. In *Proceedings of the 2008 ACM Conference on Computer Supported Cooperative Work* (San Diego, CA, USA, November 08 – 12, 2008). CSCW '08. ACM, New York, NY, USA, 47-56. DOI= http://dx.doi.org/10.1145/1460563.1460573.

[12] Langfred, C. 2004. Too much of a good thing? Negative effects of high trust and individual autonomy in self-managing teams. *Academy of Management Journal*, 47(3), 385. DOI= http://dx.doi.org/10.2307/20159588.

[13] Lankton, N. K. and McKnight, D. H. 2011. What does it mean to trust facebook?: Examining technology and interpersonal trust beliefs. *ACM SIGMIS Database* (2011), 42(2), 32-54. DOI= http://dx.doi.org/10.1145/1989098.1989101.

[14] Li, Y., Li, H., Mèdche, A., and Rau, P. L. P. 2012. Are you a trustworthy partner in a cross-cultural virtual environment?: behavioral cultural intelligence and receptivity-based trust in virtual collaboration. In *Proceedings of the 8th International Conference on Intelligent Computing Theories and Applications* (Huangshan, China, July 25 – 29, 2012). ICIC '12. ACM Press, 87-96. DOI= http://dx.doi.org/10.1145/2160881.2160895

[15] Lim, B. Y., Brdiczka, O., and Bellotti, V. 2010. Show me a good time: using content to provide activity awareness to collaborators with activity spotter. In *Proceedings of the 16th ACM International Conference on Supporting Group Work* (Sanibel Island, FL, USA, November 07 – 10, 2010). GROUP '10. ACM Press, 263-272. DOI= http://dx.doi.org/10.1145/1880071.1880115.

[16] Mackinlay, J. 1986. Automating the design of graphical presentations of relational information. *ACM Transactions on Graphics*. 5(2), 110-141. DOI= http://dx.doi.org/10.1145/22949.22950.

[17] McDonald, D. W. 2003. Recommending collaboration with social networks: a comparative evaluation. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Fort Lauderdale, FL, USA, April 05 – 10, 2003). CHI '03. ACM Press, 593-600. DOI= DOI=http://dx.doi.org/10.1145/642611.642714.

[18] McDonald, D. W. and M. S. Ackerman. 2000. Expertise Recommender: A Flexible Recommendation System and Architecture. In *Proceedings of the 2000 ACM Conference on Computer Supported Cooperative Work* (Philadelphia, PA, USA, December 02 – 06, 2000). CSCW '00. ACM Press, 231-240. DOI= http://dx.doi.org/10.1145/358916.358994.

[19] Meyerson, D., Weick, K. E., and Kramer, R. M. 1996. Swift trust and temporary groups. In Thousand Oaks, CA: Sage (1996). DOI= http://dx.doi.org/10.4135/9781452243610.

[20] Morgan J. T., Gilbert, M, McDonald, D. W., and Zachry, M. 2014. Editing beyond articles: diversity & dynamics of teamwork in open collaborations. In *Proceedings of the 2014 ACM Conference on Computer Supported Cooperative Work* (Baltimore, MD, USA, February 15 – 19, 2014). CSCW '14. ACM Press, 550-563. DOI= http://dx.doi.org/10.1145/2531602.2531654.

[21] Morris, S. A., Marshall, T. E., and Rainer Jr, R. K. 2002. Impact of user satisfaction and trust on virtual team members. *Information Resources Management Journal (IRMJ)*, 15(2), 22-30. DOI= http://dx.doi.org/10.4018/irmj.2002040103.

[22] Pipek, V., Wulf, V., Johri, A. 2012. Bridging Artifacts and Actors: Expertise Sharing in Organizational Ecosystems. In *Proceedings of the 2012 ACM Conference on Computer Supported Cooperative Work* (Seattle, WA, USA, February 11 – 15, 2012). CSCW '12. ACM Press, 261-282. DOI= http://dx.doi.org/10.1007/s10606-011-9138-y.

[23] Reichling, T., Veith, M., and Volker Wulf, V. 2009. Expert Recommender: Designing for a Network Organization.

Learning in Communities 2009: 139-171. DOI= http://dx.doi.org/10.1007/s10606-007-9055-2.

[24] Schumann, J., Shih, P. C., Redmiles, D. F., and Horton, G. 2012. Supporting initial trust in distributed idea generation and idea evaluation. In *Proceedings of the 17th ACM International Conference on Supporting Group Work* (Sanibel, FL, USA, October 27 – 31, 2012). GROUP '12. ACM Press, 199-208. DOI= http://dx.doi.org/10.1145/2389176.2389207.

[25] Searle, E., Derthick, K., Ferro, T., Morgan, J. T., and Zachry, M. 2009. Using user-centered design to discover motivation and priorities in an established online community. In *Proceedings of the 27th ACM International Conference on Design of Communication* (Bloomington, IN, USA, October 05 – 07, 2009). SIGDOC '09. ACM Press, 313-314. DOI= http://dx.doi.org/10.1145/1621995.1622062.

[26] Shami, N. S., Kate Ehrlich, K., Gay, G., and Hancock, J. T. 2009. Making sense of strangers' expertise from signals in digital artifacts. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Boston, MA, USA, April 04 – 09, 2009). CHI '09. ACM Press, 69-78. DOI= http://dx.doi.org/10.1145/1518701.1518713.

[27] Terveen, L. G. and D. W. McDonald. 2005 Social Matching: A Framework and Research Agenda. *ACM Transactions on Computer-Human Interaction*. 12(3), 401-434. DOI= http://dx.doi.org/10.1145/1096737.1096740.

[28] Zolin, R., Hinds, P. J., Fruchter, R., and Levitt, R. E. 2004. Interpersonal trust in cross-functional, geographically distributed work: A longitudinal study. *Information and Organization*, 14(1), 1-26. DOI=http://dx.doi.org/10.1016/j.infoandorg.2003.09.002.