Factors Impeding Wiki Use in the Enterprise: A Case Study

Lester J. Holtzblatt

The MITRE Corporation

202 Burlington Road

Bedford, MA 01730

holtzblatt@mitre.org

Laurie E. Damianos

The MITRE Corporation

202 Burlington Road

Bedford, MA 01730

laurie@mitre.org

Daniel Weiss

The MITRE Corporation

202 Burlington Road

Bedford, MA 01730

dweiss@mitre.org

Abstract

Our research explored factors that impacted the use of wikis as a tool to support the dissemination of knowledge within an enterprise. Although we primarily talked to a population of wiki contributors and readers, we discovered two major factors which contributed to **staff's** unwillingness to share information on a wiki under certain circumstances. First, we uncovered a reluctance to share *specific* information due to a perceived extra cost, the nature of the information, the **desire to share only "finished" content,** and sensitivities to the openness of the sharing environment. Second, we discovered a heavy reliance on other, non-wiki tools based on a variety of factors including work practice, lack of guidelines, and cultural sensitivities. Our findings have several implications for how an enterprise may more fully reap the benefits of wiki technology. These include implementation of incentive structures, support for dynamic access control, documenting clear guidelines and policies, and making wikis more usable.

Keywords

Wiki, social software, social computing, collaborative editing, web 2.0, social media, collaboration, collaborative environments

ACM Classification Keywords

H.1.1 [Models and Principles]: Systems and Information Theory—Value of information; H.1.2 [Models and Principles]: User/Machine Systems—Human factors, Human information processing,

Software psychology; H.3.5 [Information Storage and Retrieval]: Online Information Services—Data sharing, web-based services; H.5.3 [Information Interfaces and Presentation (e.g., HCI)]: Group and Organization Interfaces—Asynchronous interaction, Collaborative computing, Computer-supported cooperative work, evaluation/methodology, web-based interaction

General Terms
Human Factors, Management

Introduction

We describe an investigation into the use of wikis within a corporate environment. Despite the popularity of wikis (number of instantiations and volume of usage) in the enterprise, we also uncovered a widespread reluctance to share information and a heavy reliance on other, non-wiki tools based on a variety of factors (i.e., work practice, lack of guidelines, and cultural sensitivities). This research was part of a larger study to determine whether The MITRE Corporation's Information Technology group should be supporting enterprise wikis and, if so, how.

The MITRE Corporation is a not-for-profit organization with expertise in systems engineering, information technology, operational concepts, and enterprise modernization. In addition to managing several Federally Funded Research and Development Centers, MITRE supports its own independent technology research and application development for solving sponsors' near-term and future problems. MITRE has approximately seven thousand scientists, engineers and support specialists distributed across many locations and working on hundreds of different projects for various sponsors in numerous domains.

Corporate officers often refer to MITRE's value-added capacity to "bring the company to bear" on our customers' problems because staff is able to rely on the expertise and knowledge of technical and domain experts throughout the company. As a result, the corporation places a high value on sharing knowledge and expertise across individuals, projects, and business units. Virtual teams and individuals at MITRE share resources and research findings through the use of ListServs, technical exchange meetings, document repositories, and collaborative spaces.

Currently, MITRE corporately supports and mandates the use of Microsoft Sharepoint for collaboration and information sharing. Sharepoint 2007 (MOSS) includes wiki-like functionality through the use of wiki libraries and wiki pages in community sites. The Sharepoint wikis are disjoint and not linked as one large wiki; wikis within community sites are site-specific and not connected to other wikis across Sharepoint sites. None of the Sharepoint wikis is indexed by the internal search engine. Many Sharepoint sites are also unnecessarily access controlled so wiki content is not browse-able by all company employees, isolating information from people who could potentially use it.

Prior to the introduction of Sharepoint 2007 at MITRE in December 2008, wiki usage began as a grass roots effort with various organizational departments, project teams, labs, and individuals creating their own private wikis for a variety of purposes. Often, a single person was asked to set up a wiki and either continued to support it or handed off its maintenance to an internal support organization. People used a variety of freeware wiki products (e.g., MediaWiki, JSPWiki, TWiki, MoinMoin, etc.). While a number of these still exist, many wiki users have migrated to the more popular MediaWiki. There are also a few commercial products in use at MITRE today.

With the growing popularity of Wikipedia, one department within MITRE created MITREpedia in 2005 as a platform for all employees to share "information on people, projects, organizations, customers, technology, and more." Several other community-based wikis

appeared in subsequent years. These were focused around specific domains: human language (Languapedia) in 2006 and robotics (Robopedia) and biosecurity (Biopedia) in 2007.

As it became increasingly apparent that wikis were here to stay, MITRE's Corporate Information Technology group asked whether they should be supporting wikis at the corporate level and what that support might look like. Given the high value the corporation places on information sharing, the corporation was particularly interested in whether wikis could further enhance the extent and breadth of knowledge sharing within and across the corporation and with external partners. Two teams formed as part of a joint effort to investigate: one to gather statistics on the use of MITREpedia and Sharepoint wikis, and the second to conduct work practice studies to gain a better understanding of how people were using wikis.

Related Research
The world's most popular online encyclopedia, Wikipedia, as of July 2009, had over 10 million registered users with almost 148,000 active in a single month [19]. Because it was such a phenomenon, there has been much research about Wikipedia and its usage, growth, and culture [4, 10, 18, 20]. However, substantially less research has been done on the use of wikis in corporate environments.

As Stewart Mader noted in a 2008 blog post [12], there were many differences between corporate intranet wikis and wikis like Wikipedia that existed on the World Wide Web. (Mader is a wiki consultant, evangelist, public speaker, and author who teaches companies and organizations how to improve productivity and collaboration using wikis.) For example, Mader posited that enterprise wikis were not always located in one virtual space, frequently had more security and less openness than internet wikis, and were typically integrated into a larger corporate ecosystem. It is thus

important to understand how wikis are used within enterprises as distinct from internet wiki use and what factors drive or impede adoption of wiki technology in a corporate environment.

Although study of enterprise wikis has been sparse, there have been a handful of research publications regarding wikis on corporate intranets. These studies [2, 6, 8, 16, 21] reported that wiki technology was used to support a wide range of work activities within a corporation, including ad hoc and project team collaboration, project management, information dissemination within communities of practice, idea generation, project planning, e-learning, technical support, customer relationship management, and resource management. A survey of active wiki users conducted across a diverse set of firms indicated that wiki adoption within corporate environments was sustainable "based on the length of wiki existence, the number of participants, the number of lurkers, and the frequency of accesses" [16]. Arazy et al. [2] measured the extent of wiki adoption within IBM, assessing both the number of registered wiki users and the level of participation. He reported that after 16 months following the deployment of a corporate "wiki farm," 18,000 employees (out a work force of 350,000) were registered users. These adoption rates were "higher than any other web based collaboration tools" within IBM. However, in spite of the "large number of employees who used wikis, usage levels - as reported by survey respondents - were still relatively low."

Frequent users of wiki technology reported a high level of satisfaction with the technology and perceived that they derived direct benefit from using wikis. Majchrzak et al. [16], for example, reported that survey respondents claimed wiki participation provided benefits to them such as "enhanced reputation, work made easier, and helping the organization to improve its processes." In Arazy et al.'s study [2], respondents also rated highly the direct benefit of wikis in

supporting their work and enhancing their productivity. The benefit to respondents correlated with their level of proficiency; two-thirds of survey respondents rated their proficiency as high.

Majchrzak et al. [16] suggested that wiki contributors could be divided into a three groups: adders (who add pages and content), synthesizers (who integrate, reorganize, and rewrite whole paragraphs) and commenters (who comment and make small corrections). People whose editing patterns matched the adder category were more likely to be using wikis for utilitarian purposes. They were concerned with their time, making their work easier, and fulfilling their role on a project. (Implied in this is that if the wiki did not help them achieve these goals, they probably would not continue to use it.) Synthesizers, on the other hand, did not care about these things but instead valued coming up with novel solutions (i.e., using the wiki), their reputation, and how much their content was viewed by others. Primarily they were interested in the impact they made while adders were more interested in getting their job done.

Although wiki technology has begun to be adopted within the enterprise, the extent of the impact it will have on collaboration and knowledge sharing within a corporation remains unclear. Active wiki users may perceive direct benefits from using the technology, but people vary widely in their use. In addition, although wiki instances continue to be sustained, as Arazy et al. [2] noted, the level of usage within a corporate environment still appeared to be low.

Where wikis have been instantiated, their use in the enterprise has seen significant success, and, according to Gil Yehuda of Forrester [24], their value no longer needed to be justified. Given their potential, therefore, factors that impact their adoption needed to be better understood. Based on case studies of four organizations that tried to adopt wikis, Hasan and Pfaff [8] suggested

that management support may be one factor. They noted that some managers feared that wikis might alter the hierarchical structure too much. A second survey study of 7 companies also cited lack of management support due to the fear of openness in wikis [21]. However, Caya and Nielsen [5] found that many wikis were grassroots efforts that flourished without management support, gaining management backing later after they were established. For example, Intel's Intelpedia was started on a server under someone's desk but now has hundreds of users and millions of page views [5].

End users' proficiency with a wiki editor may also impact adoption [21]. In a survey of both technical and non-technical companies, users within both types of companies said that the wiki editor was insufficient. However, those employees in the technical organizations were able to overcome the insufficiencies by using wiki markup instead of the wiki editor.

Findings by Danis and Singer [6] suggested that wiki usage may also vary depending on intended use. They described the deployment of a wiki within IBM's research organization; the application was successfully adopted to support the planning and evaluation of research proposals, facilitating the ease with which researchers could share their research proposals with multiple stakeholders. However, once proposals were funded, the wiki application was not widely used to document progress during the execution of the research. Instead, researchers relied primarily on project-specific repositories for sharing information amongst project team members.

In summary, previous studies on corporate wikis focused on organizational adoption, sustainability, user profiles and motivations. Although several studies identified potential factors impacting adoption, further research on this is needed. Our own study attempts to provide a detailed understanding of user adoption and

use within the enterprise as well as the barriers to individual adoption. Our research begins to explore the factors that impact the use of wikis within a corporation as a tool to support the dissemination of knowledge across the enterprise.

Approach

To understand better what motivated people to contribute to wikis, gain insight into the perceived benefits and utility of wikis, and uncover any issues, the research team decided to conduct exploratory interviews. We adapted the Contextual Inquiry methodology [3] for gathering, interpreting, and structuring user data. 26 people were selected, based on wiki usage statistics and word-of-mouth. We conducted interviews with super-users (people who frequently created, updated, or edited wiki pages), early adopters, and wiki evangelists. We also talked to people who had created wiki pages and later abandoned them as well as to people who were not wiki users. We began by targeting a few of the top wiki users (of MITREpedia, Sharepoint wikis, and the top three domain-specific wikis: Languapedia, Robopedia, Biopedia) but, through these interviews, learned of other wikis in use at MITRE, many of which had been created for small-scale use for projects, labs, and organizational departments.

The interviews were unstructured and open-ended. We typically had a few questions to help focus the conversation around specific contributions to a wiki. In general, however, we let the interviewee talk freely about his or her own experiences; we asked questions to clarify or to probe without following a fixed script. Two interviewers were present for each interview: one to conduct the interview and one to take notes. The note taker occasionally asked for clarification or asked additional questions. Most people were very interested in talking to us and willing to share their experiences and opinions. In general, we tried to uncover how wikis

were being used, what need they fulfilled, what was lacking, and which issues existed.

Interview notes were coded to maintain anonymity and then "interpreted" by the team. The interpretation sessions were essentially a forum for recounting the interview data, making observations, asking questions, and sharing insights. These sessions helped ensure the team had a common understanding of each interview.

The interview data was printed on paper and cut into individual, tagged statements. Each of these individual interview notes, key points, insights, and questions was then arranged in an affinity model [3]. (An affinity model is a bottom-up method of organizing individual pieces of data, i.e., interview statements, into a hierarchy to reveal common issues and themes.) We built the affinity on a wall of one of our offices where we could "walk the wall" and move data around as we saw fit. The affinity grew and changed as we worked with the data. The final product was a story about quality, sensitivities and culture, general sharing and collaboration, best practices, awareness, perceived value, motivation, usability as well as likes/dislikes, and whether the company should have a single corporate wiki or multiple wikis for different purposes.

This investigation was not intended to be exhaustive or in any way statistically significant; we chose this method of interviewing to collect anecdotes and use cases that would not otherwise be identified in usage statistics. Affinity building allowed us to organize and structure the data from the bottom up and gain insights into best practices, issues, and breakdowns. While this method was neither quantitative nor showed the relative importance of specific issues or user priorities, it worked well in exposing what really mattered to the user - in the words of the user.

Results

We discovered 44 wiki instantiations at MITRE plus 282 Sharepoint wiki libraries. The largest single wiki, MITREpedia, had 1502 registered users, 1181 editors, and over 11,000 pages. MITREpedia and the majority of the other non-Sharepoint wikis were based on MediaWiki. At least six of those non-Sharepoint wikis had restricted access, and only three of the standalone wikis were indexed by the internal corporate search engine. None of the Sharepoint wikis was searchable.

A separate corporate survey provided a measure of the extent to which these wikis were referenced and updated. 21% of MITRE technical staff reported that they referenced wikis on a MITRE or customer intranet at least once a week. 36% had never used a work-related wiki. Of those that had used a wiki on the intranet, 40% had edited a wiki at least once. The others used wikis solely as a reference source.

There was a large variance in how wikis were used. While some of the wikis we found were exclusively dedicated to one purpose, others were used for multiple purposes. We found wikis that functioned as encyclopedias, discussion forums, electronic lab notebooks, developer diaries, in/out boards, project management tools, issue tracking, experimentation platforms, repositories for trip reports and meeting minutes, idea generation spaces, inventories for tools/services/technology, and more. This corroborated findings of other researchers that corporate wikis were used for a lot of different purposes whereas internet wikis tended to be used primarily for knowledge sharing [2, 6, 8, 16].

MITREpedia usage statistics provided the clearest measure of the extent to which MITRE staff used wikis for sharing knowledge across the corporation. These statistics showed that, of the 1502 registered MITREpedia wiki users, on average, there were only about 220 (approximately 3% of MITRE staff) who made changes from month to month. This was consistent with the data Arazy et al. found at IBM where they concluded that, in spite of the "large number of employees who used wikis, usage levels - as reported by survey respondents - was still relatively low" [2].

Our interview data provided insight into the factors that may impede broader usage of wikis for knowledge sharing. Although we primarily talked to a population of wiki contributors and readers, we still discovered an unwillingness to contribute to wikis under certain circumstances. We probed deeper into this reluctance and discovered that it could be ascribed to one of two major factors: a reluctance to share specific information or a reliance on other, non-wiki methods of sharing information.

Reluctance to Share

Although the corporation places a high value on sharing knowledge and expertise across individuals, projects, and business units, we observed that staff were not always willing or interested in sharing specific information widely within the company. Several social and cultural factors contributed to this lack of willingness in some circumstances: the extra cost of sharing, the nature of the information, an unwillingness to share unfinished products, and sensitivities to the openness of information.

THE EXTRA COST OF SHARING

Some people did not feel inclined to share specific information because of the extra time and effort involved. One interviewee stated that he was not paid to share. "If it's not mandatory, I won't do it." Informally emailing information to a small group of people, a task that occurs in the normal course of daily work, would require significantly less effort than structuring a wiki entry and providing supplemental context. One interviewee raised the question whether the explicit sharing of information to a larger audience,

sharing that would occur outside of an employee's normal workflow and would take an additional effort, was part of that person's job description. Stated another way, this employee suggested that sharing information on a wiki to a larger audience was an "altruistic gesture" and not one required as part of his paid work. While there was formal recognition in the company for knowledge management, there was no explicit motivation for wiki contribution; a person might be less likely to post content to a wiki if that action did not lead towards fulfilling project goals or objectives. As one interviewee said, "There is not enough time to create content [outside of what I have to do to get the job done]." Nevertheless, not everyone may consider sharing to be extra work. According to the research done by Majchrzak et al. [16], this perception was the tendency of a class of people referred to as "adders." "Synthesizers," however, might not consider time and effort to be barriers to contributing.

INFORMATION SENSITIVITY
Since the nature of some business at The MITRE Corporation involved information that was classified or sensitive, widespread sharing was not part of every employee's culture. Typically those employees shared only on a need-to-know basis, and content was restricted. In some cases, this created the need for private wikis or other secure online repositories. Even when these restrictions were removed, many employees were just not in the habit of sharing and either did not take the time or shared only to access controlled spaces. As others have observed [1, 15], wiki success is affected by the surrounding work culture and general willingness to share information.

We spoke to one participant who had intended to transfer information manually from a private to a shared wiki once the restrictions on the data had been removed. He found the entire process time consuming and never completed the transfer. It is conceivable that other resources initially shared in private spaces - for whatever reasons - were never shared with the rest of the corporation even when there was no longer a reason to protect that information.

UNWILLINGNESS TO SHARE "UNFINISHED" WORK
We saw that people sometimes were just not comfortable making their information accessible to the rest of the corporation when it was not "finished." Instead, people were used to, and more comfortable with, disseminating a document broadly only when it was a "finished product." The concept of wiki content being a continual work in progress was difficult for many people to accept. As one employee stated, "Sharing is a great idea but sometimes you are not ready to share with the rest of world. We want to feel comfortable, not the need to be secretive. I prefer to wait until I have a finished product." Because users were uncomfortable sharing documents that were still in a draft state, the documents were often kept on users' hard drives, on an access controlled site, or shared through email.

Several users asked for dynamic access control models for wikis. "It would be nice to have a space on our own wiki that no one else could see where we can work on things. When we feel comfortable, we could push this out to MITREpedia for more people to see." Another user implemented his own method of sharing out data in stages. If he was not sure he wanted to share content to MITREpedia yet, he would set up his own private wiki. Once he was ready to share, he would copy and paste his content to the more public wiki.

SENSITIVITIES TO THE OPENNESS OF INFORMATION
One participant commented, "There is a tension between using these things as an organizational tool for yourself and everyone being able to see them. I am not sure I want the chief engineers to see my latest experimental results [if they aren't up to par.]" The reluctance this participant admitted was similar to what Danis and Singer [6] observed at IBM where

researchers were unlikely to post ongoing research results to a wiki.

In another case, a technical advisor recorded meeting notes and the discussion that followed - attributing statements to meeting participants - on a wiki. He was later told by project management that they were getting "too many questions on the project" and that he should remove the content. (Interesting to note, while wiki contribution was not governed by the same top down hierarchy that governed other parts of the enterprise, corporate hierarchy still prevailed on the wiki.)

In both these instances, although users may have been willing to share information within a small team or department, they felt unwilling to place the information in a context that could be easily viewed by a wider audience.

Reliance on other channels of communication

MITRE staff relied on multiple channels to disseminate textual information, including email and ListServs, instant messaging, shared document repositories, weblogs and micro blogs, social bookmarking, intranet portals, and wikis. There were many factors that influenced people's choices of one medium over another. We discovered that these contributing factors could be described along several different dimensions: work practice, lack of guidelines and standards, and sensitivities to sharing. We discuss each of these in detail below.

WORK PRACTICE

Just because we built it did not mean people would come. This was a lesson learned through years of work practice studies at the MITRE Corporation. New tools have come and gone as technology flavors have changed over the years. Some tools were adopted while others were rarely used. Even well-designed tools that filled a much needed gap were not necessarily used if people did not want to change their work practice.

People do not want to learn another tool

A number of people we talked to mentioned not wanting to use a wiki at all. Some said the wiki was yet another tool for them to learn and they did not have the time or the desire to do so. As one person said, "I **do think there's a learning curve to using a wiki that's** an obstacle. **I've never really needed to use wikis so I haven't learned how to use them." Another person** remarked, "We have some people who would use [a wiki], and some who would kick and scream. People don't want to learn a new tool."

Wikis are not part of the current work practice

One person we interviewed noted her reason for not using a wiki was because it was not "in her face." Certain software were part of the corporate installation and therefore loaded on her desktop automatically when she logged in or loaded a web browser (e.g., instant messaging and the corporate intranet web portal, respectively). She preferred tools that were not "passive" if she was to remember to use them. With regards to this, one interviewee said, "On a research project, it took me a long time to remember to refer to the wiki for information. I would email demo instructions and put them in the code base but never [remembered to] put them on the wiki." If a tool did not already appear as part of someone's daily workflow, they may not remember to use it. "People don't even want to go and look for it - they would only go if they were told exactly where to go" and if they could get there without thinking about it. Some people were just not accustomed to using new tools. As another person commented, "People on ListServs are confident about their responses but yet no one wants to use blogs or wikis to share their opinions. How do you change this culture?" and noted that "It's hard to break old habits." (In this comment, note that while blogs and ListServs were very similar in nature, employees at MITRE seemed more willing to use ListServs than blogs.)

LACK OF GUIDELINES AND STANDARDS

Wikipedia is an encyclopedia that is open to the public to edit. Just like editors of an encyclopedia, "Wikipedians" strive for verifiable accuracy and a neutral point of view as guiding principles [22]. Many people who view and edit Wikipedia understand this. Corporate wikis, however, may not have principles as well defined as Wikipedia's which has hundreds of pages on policies, guidelines and help [4]. MITREpedia, MITRE's largest wiki, had a dozen help pages but very little in terms of guiding principles and policies. While this gave contributors flexibility and freedom, it also led to some confusion.

A number of interview participants said they did not see the utility of wikis and expressed confusion over how one would know whether a given piece of information was appropriate to be shared on a wiki. One interview participant said, "Figuring out which are the right tools is both difficult and frustrating. I have a lot of tools available at my disposal. I don't know the circumstances under which wiki strengths would map to my needs." People were not always sure that the wiki model served the purpose at hand.

At least one MITRE employee referred to enterprise wikis as "the wild, wild west." In general, there were no defined conventions, guidelines, or wiki moderators on most of the wikis within the company. There was no formal hierarchy to wiki contribution nor did the content have to go through any official approval process. People had different ideas of how a wiki should look and function as well as different ideas (or no idea) of what content belonged on a wiki (e.g., encyclopedia-style articles versus project management pages). The wildly differing opinions were often the reason for creating new wiki instances (in addition to a separate issue: the need for access control). Having multiple wikis in turn created a new argument that was hotly discussed: should MITRE have one wiki or many? If we continued to have multiple wikis, how should they be connected or linked? How could one successfully navigate across the wikis and easily find what one was looking for? How would we minimize the duplication of information across multiple wikis?

Because these wikis lacked a process for reducing duplication of information, users may have chosen not to contribute. For example an employee in one department added a wiki page on a particular research topic and subsequently found that someone from another department had added a page on a similar topic. He was afraid he had offended the other group by starting a page on a topic that might potentially be perceived as "their" area.

Once a person decided to share information and determined that a wiki might be a good venue for this, he still might not have been sure which wiki was the most appropriate. Because of the lack of clear policies and guidelines, the perception of what type of information belonged on a given wiki was as varied as people's personalities. This was most apparent in the debate at MITRE over what MITREpedia should be used for. Some people believed it should be used only for encyclopedia-type articles while others thought it should be used for any purpose provided that it increased productivity. The latter used MITREpedia to post meeting notes, to manage projects, or for personal note taking. Some people referred to their "one-stop shopping" method of data management, namely a single place to store and retrieve all information. MITREpedia was a place that could potentially fulfill this need with the added bonus of being backed-up and accessible from anywhere in the enterprise. As one interviewee said, "It makes things too complicated if you have to think about what data source you are interested in and then figure out where you should go to find it."

While reference encyclopedia-style entries were by far the largest portion of wiki pages on MITREpedia, as

mentioned before, MITREpedia was also home to project-related materials, personal information (e.g., resumes and expertise pages), community resources, and diaries or notebooks. Because of this ambiguous purpose and differing mental model as to what certain wikis were for, people indicated their reluctance to contribute information to a wiki because it might not "belong" there. One participant said, "I post in my [internal MITRE] blog some times when I have information to share, but I never felt I had enough information for an article's worth." Also of note was the interviewee's perception that a wiki page had a required minimum volume of information.

Another result of this ambiguous use was disagreement over "the right way" to use a wiki. As one employee said, "I was criticized for contaminating the **encyclopedia entries with project management... People** say that a lot of the content should not be in MITREpedia. They expect encyclopedia entries - not operational ones." People who perceived wikis, like MITREpedia, as encyclopedic felt that using it for other things created too much noise and made it harder to find the things that were important. Others continued to share non-encyclopedic information possibly because they felt the wiki was valuable as a workspace or because they felt that the information they were sharing, while not encyclopedic, was still useful to others (e.g., meeting notes from a meeting that others may not have attended).

SENSITIVITIES
A third factor contributing to people's reluctance to using wikis related to cultural sensitivities in the corporation. There was a pervasive culture at MITRE that individuals "owned" data and that they were fully responsible for that data. Because of this, people were overly sensitive to editing others' work and were protective over their own work, sharing only when they felt the work was completely finished or "good enough" for sharing.

I do not want others to edit "my" content
A cultural barrier to sharing on wikis that we found was the lack of control that people felt when putting information on a wiki. In many cases, the wiki was a tool open to anyone to edit. In the traditional document model, an author was the owner of a document and only named co-authors would consider making direct changes to that document. In the wiki model, the content may be stored where just about anyone could modify it. This made some people feel uncomfortable as they believed they were losing control over what they might have perceived to be their content. As one person we interviewed said, "My perception is that project members felt… if content is not directly on their machine, they think any anonymous person might post a picture of their cat on the project page." In reality, research showed that there was not much of a problem with vandalism in corporate media [5, 21]. Most MITRE wikis did not allow anonymity (in contrast to Wikipedia) making any inflammatory or vandalistic activity easily traceable to the offender. This discouraged people from being destructive on corporate wikis [5] thus making it unlikely that a page would be altered maliciously. A more likely scenario would be someone accidentally altering an article in a manner that the original author did not intend. Most wikis had a rich record of the history of each page and a mechanism to revert any changes so this was not a pressing concern.

One user told us that projects he worked on wanted their own, private wikis. His perception was that the project members felt "everyone in the world can read or edit my stuff. I don't want to give up control of my things to the … masses." Other project members stated that they "don't want all the pages editable, just some of them."

People are afraid of making changes
A related phenomenon we noticed was that some people would not edit information that already existed on a wiki page, a page that someone else had started. Many people were sensitive to what they perceived to

be someone else's content and were often reluctant or "skittish" to make changes. As the Society for Information Management's Advanced Practices Council (APC) study mentioned, the most difficult barrier to cross with regards to wikis is convincing people to edit others' work [9]. As one site [14] noted, rather than edit or add to the wiki, people tend to provide the person they perceive as the owner with direct feedback.

One interviewee noted, "People came to me because they were afraid of breaking things. They asked me if I would enter info for them [on our wiki pages]. I tried to encourage people to do it themselves." Likewise, one user noted that he had created numerous wiki pages, and people would come to him to discuss the content but would hesitate to make the changes themselves since they viewed the pages as his, not theirs. Another participant pondered, "What are the rules [in a wiki]? Can you just edit other people's words?"

MITRE had a culture that folks were struggling with; people were not sure what behavior was appropriate with new technology. Even when users thought they had "permission" to change a wiki page, they may have discovered that it was not considered appropriate by others. One interviewee revealed that he was asked by his project lead to update a specific wiki page. Once finished, he was told that he had "jumped the gun" and that his contribution did not fit into the structure of the article. He was asked to revert the page to its original state.

In several examples, a person started a wiki page and then emailed a group of people specifically asking them to contribute their thoughts and make corrections. Instead of adding their contributions directly to the wiki entry, people would reply to the email message with their suggested changes and leave the burden of updating the wiki to the original author. As one wiki contributor said emphatically, "I create articles, send folks links, and they *email* comments back to me! I usually email them back that they've failed the Web2.0 test, at which point they smile, and still expect I'll make the edits for them." In some cases, the people were not familiar with wiki technology and did not want to make the edits themselves. In other cases, responding via e-mail was simply quicker (see the Extra Cost of Sharing, above). A third factor was the discomfort some people felt in changing what they perceived to be someone else's content.

There were, however, circumstances in which individuals seemed more willing to modify an existing wiki page, in particular when wikis were used to host tables or lists of distinct items. Examples of this included best practices, policy recommendations, and customer engagements. The use of a wiki page for these purposes highlighted one of the distinct values of wiki technology; it allowed multiple users to contribute content independently of each other, appending their input without modifying what others had contributed, a practice not usually found in the traditional document model. However, in cases where users were creating a single article about a subject matter, many still appeared to be reluctant to edit the work of an individual or team of authors.

Discussion

Large, distributed enterprises have a vested interest in being able to leverage technology effectively to support knowledge sharing. In particular, organizations whose work force primarily consists of knowledge workers depend on disseminating the knowledge gained by individuals within the organization to others across the organization. To support such knowledge sharing, MITRE has made substantial investments in collaboration technology which MITRE staff already leverage. However, MITRE, as well as other enterprises, is eyeing new social technologies as potential levers to improve knowledge sharing even more.

Returns on investments in technology are often dependent on the level of adoption and the manner in which technology is adopted. This study revealed factors that may impede the adoption of wiki technology within an enterprise and thus limit its impact on improving the dissemination of knowledge across the corporation. In particular, we noted two major factors that need to be taken into account in influencing the adoption of enterprise wiki technology. First, an enterprise must consider what generally impedes knowledge workers' willingness to codify their knowledge and share it with others within the enterprise. We observed several of these inhibitors within our organization: the extra cost, the nature of the information, the concept of unfinished products, and sensitivities to the openness of information. Second, an enterprise must recognize that users have a wide range of options when sharing information. They use multiple tools and, even when sharing via a wiki, they may use additional methods of communication. We identified several variables that impacted which communication channel users selected: work practice, lack of guidelines, and sensitivities.

Our results have several implications for how an enterprise may more fully reap the benefits of wiki technology. These include implementation of incentive structures, support for dynamic access control, documenting clear guidelines and policies, and making wikis more usable.

Implementation of Incentive Structures

Corporations must ensure that incentive structures genuinely support information sharing across the enterprise. When employees state that they are "not paid to share information," they are explicitly noting that corporate incentives are not aligned with the corporate goals for knowledge sharing. Some researchers [11] have described the use of social incentives within Wikipedia (e.g., barnstars) that are designed to enhance a person's reputation within a community based on the type and level of their contributions to Wikipedia. The use of similar social incentives within enterprise wikis is worth exploring. In addition, less formal incentive mechanisms should also be considered. Some interviewees questioned whether anyone was reading or paying attention to what they had contributed to a wiki. People were much more likely to feel that their contributions to knowledge sharing environment mattered if they felt others were, in fact, using their content. Providing feedback mechanisms in a knowledge sharing environment that allowed contributors to know whether and how their contributions were being used might increase the likelihood that employees felt it was worthwhile to share information and keep it updated. One manager noted that senior management in his organization made a deliberate effort to acknowledge and comment on contributions in their discussion forums. Doing so, he believed, communicated to staff that their contributions mattered. Managers taking similar actions in reviewing and commenting on wiki entries would send the same message to staff. Indeed, this recognition by higher management has been suggested by others in the past [13]. Also, writing a technical paper or creating and publishing a document may receive kudos in a corporation or be noted in a performance review. As wikis gain more corporate support in enterprises, contributions to wikis need to be valued in the same way [13]. More generally, organizations need to find explicit ways to acknowledge and demonstrate that they value the level and extent of an individual's contributions to a corporate wiki.

Support for Dynamic Access Control

Wiki applications within the enterprise need to support dynamic access control. Staff would like to have control over the audience with whom they are sharing. We found that when people shared content on wikis, they tended to form a mental model of the audience with whom they were sharing. For the purposes of simplification, we break intended audiences into classes from small to large in scope: oneself, a team or small

group, a community of interest or larger network, one's entire company, and "the world." One example of sharing with oneself was using a wiki as a personal notebook where the only intent was as a place to store and easily access content. Examples of using wikis for team activities included idea development or brainstorming, sharing experiment results, updating project statuses, disseminating meeting notes, and managing tasks. Communities used wikis to advertise upcoming events, post trip or conference reports, and distribute relevant briefings and resources. Others shared items that were relevant to the entire population of MITRE such as "encyclopedic" articles on technology or research, personal resumes and bibliographies, and corporate-facing project or organizational pages.

A wide variety of factors may influence a person's target audience for sharing specific information. These include the relative sensitivity of the information, information quality, and the extent to which audiences are able to modify the content. If wiki technology within the enterprise does not allow users to define the community that will have access to information and allow them to modify these access controls easily, users may leverage alternative channels of communication that do support such access controls.

Clear Guidelines and Policies
The enterprise needs to define clear guidelines for how wikis are used [1, 15]. The guidelines may include the intended purpose of the wiki, criteria for what type of information belongs there, and what level of "polish" wiki articles would ideally have. By creating such guidelines, the confusion and uncertainty interviewees expressed about when and where to publish information would be reduced. To the extent the corporation wishes to foster the use of wikis for knowledge sharing, guidelines would provide employees clear criteria for deciding when to publish information

on a wiki and on which wiki the information should be published.

However, in creating guidelines, enterprises should be careful not to make them too rigid. As Mader [15] noted in an article on his website, "You should be thinking in terms of guiding people, instead of imposing a strict set of rules and measurements." Recent research by Butler et al. [4] suggested that Wikipedia may provide a model for how policies and guidelines that support the successful operation of wikis in an enterprise can emerge. They examined the administrative structure of Wikipedia and found that Wikipedia consisted of a complex structure of rules, processes, policies, and roles. But these were not imposed through a top-down hierarchical structure! Rather, the authors found that Wikipedia facilitated the creation of a wide variety of rich, multifaceted organizational structures. This was accomplished by providing spaces that supported the creation and evolution of policies and procedures that served a wide variety of functions. In other words, Wikipedia leveraged the flexibility of wiki technology to allow a community to evolve its own rules, processes, procedures, and guidelines. Enterprises can do similarly by offering their communities the spaces, structures and flexibility to codify and evolve the rules and guidelines that best support their particular needs and work practices.

Usability
The lack of user-friendliness in many wikis provides a barrier to their initial use and enterprise-wide adoption [21]. Since editing in a wiki is not as straightforward and familiar as, for example, editing a Word document, non-technical and first-time users may have trouble understanding how to contribute content. Wiki markup language is not self-explanatory to novice users, and WYSIWYG (what you see is what you get) editors could be enhanced. One way to increase contribution to wikis is to improve their user interface. A small research

team at MITRE is currently investigating alternative user interfaces for editing wiki pages. They plan to build several different prototypes, run usability tests, and perform comparative evaluations to help lower the barrier for novice users. Similarly, the Wikimedia Foundation received an $890,000 grant in December 2008 to work on making Wikipedia easier for first time authors [7, 17]. Their usability team is conducting behavioral studies and working on a prototype interface with a goal to **"measurably increase the usability of** Wikipedia for new contributors by improving the **underlying software... thereby reducing barriers to public participation"** [23].

Another option for lowering the contribution barrier **might be to leverage people's comfort** and constancy with their email environment. Integrating email with wiki editing would reduce the number of steps to editing a wiki and would not require that people leave their normal workflow and go to another tool. For example, an author could email a draft wiki page to a team and ask for edits and inputs. Depending on the implementation, people could either append to the wiki page or even make inline edits to the article via email.

These and other improvements may help make the wiki experience easier and less intimidating. A few changes could lower the barrier to entry and improve the editing experience for infrequent or novice users without impacting expert users.

Acknowledgements

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