MIS Quarterly

RESEARCH NOTE

THE IMPACT OF SHAPING ON KNOWLEDGE REUSE FOR ORGANIZATIONAL IMPROVEMENT WITH WIKIS[1]

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In this study, we explore the Wiki affordance of enabling shaping behavior within organizational intranets supported by Wikis. Shaping is the continuous revision of one's own and others' contributions to a Wiki. Shaping promotes knowledge reuse through improved knowledge integration. Recognizing and clarifying the role of shaping allows us to theorize new ways in which knowledge resources affect knowledge reuse. We examine the role of three knowledge resources of a Wiki contributor: knowledge depth, knowledge breadth, and assessment of the level of development of the Wiki community's transactive memory system. We offer preliminary evidence based on a sample of experienced organizational Wiki users that the three different knowledge resources have differential effects on shaping, that these effects differ from the effects on the more common user behavior of simply adding domain knowledge to a Wiki, and that shaping and adding each independently affect contributors' perceptions that their knowledge in the Wiki has been reused for organizational improvement. By empirically distinguishing between the different knowledge antecedents and consequences of shaping and adding, we derive implications for theory and research on knowledge integration and reuse.

Keywords: Wiki, Intranet, knowledge management, KMS, knowledge reuse, shaping, knowledge depth, knowledge breadth, transactive memory

Introduction

Wikis, defined as a "collaboratively created and iteratively improved set of web pages" (Wagner 2004, p. 265), have recently attracted researchers' attention as knowledge management tools (e.g., Cress and Kimmerle 2008; Yates et al. 2010). The theoretical value of research on Wikis in explaining knowledge management and reuse, however, has not yet been well understood (Majchrzak 2009). We seek to address this apparent research gap in knowledge management by focusing on the unique affordance of Wikis to foster online knowledge integration for knowledge reuse.

Intranet-enabled knowledge reuse is the process by which an individual is able to locate shared knowledge on the Intranet and use it to receive value (Alavi and Leidner 2001). Our

[1]Detmar Straub was the accepting senior editor for this paper.

The appendices for this paper are located in the "Online Supplements" section of the *MIS Quarterly*'s website (http://www.misq.org).

focus is on organizational or corporate work-related Intranets supported by Wikis where contributors can observe reuse that leads to improvements in organizational work processes. Intranet-enabled knowledge reuse is a phenomenon of critical importance to IS researchers interested in knowledge transfer and the design and use of knowledge management systems (KMS) (Alavi and Leidner 2001; Bock et al. 2005; Kankanhalli et al. 2005). However, according to Gartner Research, low reuse from KMS deployed in corporations continues to be a problem (Rozwell 2009), despite corporations' substantial interest in technology-fostered knowledge reuse in general, and most recently in Wiki-enabled knowledge reuse (Mann et al. 2010). Therefore, it is incumbent upon IS scholars to develop theories that can predict technology-fostered knowledge reuse, particularly in ways uniquely enabled by Wiki technology.

Critical for knowledge reuse is the ability to integrate others' knowledge (Grant 1996b). Previous theoretical reflection about knowledge reuse has assumed that integration was not broadly distributed among knowledge contributors (Alavi and Leidner 2001; Grant 1996a), yet recent research has identified the affordance of "shaping" in the context of Wikis (Reinhold 2006; Yates et al. 2010), which enables a new form of knowledge integration that broadly distributes the opportunity for all participants to engage in integration behavior. We argue that this affordance requires theories of knowledge reuse to be modified to incorporate shaping as a contribution behavior that may affect knowledge reuse. Moreover, this affordance of shaping may be affected by antecedent factors differently than the more commonly researched behavior of simply adding domain knowledge to the Intranet. We provide preliminary evidence supporting the need for theory modifications.

A Key Assumption of Current Research on Organizational Knowledge Reuse ■

Knowledge integration refers to the recombination of knowledge by merging, categorizing, reclassifying, and synthesizing existing knowledge (Alavi and Leidner 2001; Grant 1996a). Knowledge management research has generally argued that knowledge integration is an important intermediate process between knowledge capture and personal knowledge reuse (Garud and Kumaraswamy 2005; Postrel 2002), as well as between knowledge capture and reuse for process improvements in the organization (Hollingshead et al. 2002).

The knowledge-based view of the firm (e.g., Grant 1996a, 1996b; Moran and Ghoshal 1999) provides a theoretical perspective for the importance of this integration and how it might happen, although not at the level of the individual knowledge contributor. The knowledge-based view contends that complex recombination-based integration of knowledge occurs either implicitly, by privileged individuals such as managers, or explicitly, through centralized and formal organizational structures. Researchers examining knowledge reuse of KMS and organizational intranets (e.g., Fulk et al. 2004) have adopted this position by arguing that integration either occurs through directives and organizational routines (Mitchell 2006), knowledge stewards and librarians (Kankanhalli et al. 2005), or FAQs created by discussion forum administrators (Butler et al. 2007). However, this argument has received limited theoretical development concerning factors that could affect explicit, online knowledge integration carried out by a broad contributor group.

Wikis Afford Open Online Integration ■

A Wiki-based organizational intranet[2] or KMS may focus on any of a range of work-related topics that need to evolve to meet higher organizational standards for content. Work-related Wikis tend to focus on knowledge about an evolving work project (strategic analysis, requirements capture and negotiation, work progress, and identification and analysis of unresolved issues), or the capture of information that might typically be decentralized in an organization (e.g., competitor information or unique expertise). Individuals in the organization contribute their knowledge to the work-related Wiki as they participate in the project or gain knowledge relevant to the Wiki topic. Others in the organization viewing the work-related Wiki can then reuse the accumulated knowledge to improve their own work performance.

Wikis differ from earlier knowledge management technologies in that they enable the *collaborative* publication of content to a common website (unlike many content management systems), they are organized by topic and subtopic (unlike discussion forums that are organized by chronology), and each topic is a different Wiki website (name space) with each subtopic kept on a different page on the Wiki website. Rather than chronologically, individuals add their contributions on subtopics within the logic of the evolving online document by finding the right page, discussion, or location in the online document to share their knowledge. To ensure that the knowledge in the online document is logically integrated,

[2]We focus on Wiki-based organizational (or corporate) intranets. As discussed in Appendix A, such intranets differ from those intranets that are not supported by Wiki platforms, as well as from public Wikis.

contributors can change the content in the online document, whether the content was contributed by them or by others (Cress and Kimmerle 2008; Kane and Fichman 2009; Wagner and Bolloju 2005). The changes can be rolled-back if needed. A history of the changes is available. In a Wiki-based intranet in an organization, the author of each change is typically explicitly identified ("last edited by") such that individuals can have a clear idea of who made prior modifications and the context in which the changes occurred. Appendix A elaborates on these differences between Wikis and other KMS.

Contributing knowledge to a Wiki, then, may involve not only contributing the content of one's domain expertise but also integrating knowledge already contributed to the Wiki to make it more logically organized. This activity is referred to as "shaping" the Wiki, reflecting the iterative, cumulative, and organic nature of the activity (Korfiatis and Naeve 2005; Reinhold 2006; Yates et al. 2010). Shaping behavior involves publicly modifying others' contributions as well as one's own, and entails reorganizing content, removing redundancies or inconsistencies, and making the content more meaningful, usable, and maintainable (Wagner and Bolloju 2005). Shaping, then, is a synthesis and organizing activity. Wiki shaping does not require explicit organizational routines or management directives (e.g., Kogut and Zander 1992; Moran and Ghoshal 1999) nor is it limited to only privileged individuals; instead, it allows anyone to engage as self-directed agents integrating contributions enabled by their own knowledge, their willingness to act, and the technology affordance of shaping.

For example, a manager identifies the need for a new set of process guidelines. The manager creates a new Wiki topic, and alerts employees about the Wiki's objective. Within a few days, dozens of employees contribute their ideas to the Wiki about the scope and content of the guidelines, with some contributors integrating ideas that seem similar, others indicating where more detail is needed to understand the ideas better, and another contributor shaping the Wiki contributions into a preliminary outline structure. Over the next few weeks, additional employees make clarifications and finalize the process guidelines for use by the organization. Later, other contributors broaden the guidelines for application reuse to a broader set of related processes. Finally, the guidelines are posted to the company's extranet to inform the company's customers, suppliers, and general industry practice.

This example illustrates how Wiki technology affords individuals the opportunity to modify their own and others' topic-specific knowledge contributions (Reinhold 2006; Wagner and Bolloju 2005). The individuals in the example above were not simply posting their domain knowledge but also organizing others' knowledge, clarifying where new knowledge was needed, and building on others' contributions to co-create new knowledge.

This example also illustrates how contributors to an organization's Wiki-based intranet can see their knowledge being reused. Employees using the Wiki can infer knowledge reuse when the pages on which they have contributed have been accessed and referenced by others, such as for the broader guidelines as in the example above. Employees can observe additions or modifications of their contributed knowledge made by other employees using the Wiki, enabling them to draw conclusions about how their contributed knowledge is reused within the Wiki. References made to their contributed knowledge on the Wiki's discussion pages, in links to other websites, and in face-to-face meetings further indicate how the knowledge they contributed to the Wiki is reused for organizational process improvement. Therefore, in a Wiki-based knowledge-sharing context, knowledge reuse can often be visibly observed.

This potential for any Wiki contributor to engage in shaping the Wiki, and any contributor to view the reuse of their contributions, suggests a model of knowledge reuse that examines how the contributions of many individuals in an organization with different knowledge resources can be reused. The knowledge management literature has given little research attention to the importance of online shaping behavior as a determinant of knowledge reuse. The lack of easily shapeable KMS prior to the use of Wikis may have led to the assumption that integration happens outside the KMS or in ways the individual contributor cannot control (e.g., Kankanhalli et al. 2005; Markus 2001), resulting in less research attention. Since KMS are becoming increasingly supported by Wiki technology (Kane and Fichman 2009) and hence allow for shaping, we suggest that the role of online shaping behavior deserves research attention. Based on theorizing about the importance of integration to knowledge reuse in organizations, and the visibility of knowledge reuse to Wiki contributors, we hypothesize:

H1. Content adding and shaping behaviors positively affect contributor perceptions about reuse of knowledge for organizational improvement.

Exploring Knowledge Resources for Adding and Shaping

If shaping behaviors are substantively different from behaviors in which users simply add their specialized domain knowledge, and if both shaping and adding behaviors independently affect knowledge reuse, then previous theories on knowledge resource use when contributing to organizational intranets and KMS need to be reconsidered in light of these different forms of contributions. Theories of how knowledge resources affect contributions to such online repositories as discussion forums, Intranets, and KMS focus on how individuals contribute by adding their specialized knowledge (e.g. Kankanhalli et al. 2005; Roberts et al. 2006; Wasko and Faraj 2005). Studies that recognize the role of shaping (e.g., Reinhold 2006; Yates et al. 2010) have not as yet explicitly considered that different forms of knowledge resources may differentially affect the different forms of contributions.

Three knowledge resources have been acknowledged in the literature for their influence on knowledge integration and knowledge adding. Grant (1996a), in examining knowledge integration at the organizational level, suggests two knowledge resources: breadth and depth of one's knowledge. Research by Fulk et al. (2004) and Hollingshead et al. (2002) on intranets suggest a third resource, referred to as transactive memory systems, or knowledge about knowledge as displayed in the intranet. Recognizing the distinction between shaping and adding contributions, we argue for the possibility that these three knowledge resources may have different effects on the different contribution behaviors. Below, we explain our hypotheses about each of these three resources.

Knowledge Depth

An individual contributor's knowledge depth is defined as the possession of substantial skills and abilities related to a specialized domain of knowledge (Wasko and Faraj 2005); depth indicates how much of an individual's knowledge is focused and pertinent to the task at hand. The knowledge-based view of the firm argues that knowledge depth provides an important resource for organizational competitiveness when deep knowledge is integrated and reused to create new opportunities for the organization (Grant 1996a), yet past empirical research on the effect of knowledge depth on adding contribution behaviors has been equivocal. Some studies found that knowledge depth is a crucial antecedent to individuals' adding behavior (Constant et al. 1996; Kankanhalli et al. 2005), while others did not find a relationship between knowledge depth and adding behaviors (Roberts et al. 2006; Wasko and Faraj 2005). The equivocal nature of the effect of knowledge depth may be due, in part, to knowledge depth being conceptualized based on a narrow view of adding behavior as the primary form of contribution to knowledge reuse. That is, when contributing to the intranet involves only adding domain knowledge to existing knowledge (see Kankanhalli et al. 2005), then knowledge depth may be important. Adding one's knowledge to an existing list of domain facts does not generally require an understanding of other domains, only an understanding of the particular domain to which contributions are being added (Boland and Tenkasi 1995). Consequently, adding behavior is probably less affected by the individual's knowledge breadth. Therefore, we state a relationship specifically between knowledge depth (but not breadth) and adding (but not shaping) behavior:

H2. Contributor knowledge depth positively affects contributor adding behavior.

Knowledge Breadth

For shaping behavior, a more critical knowledge resource than depth may be the individual's breadth of knowledge (Boland and Tenkasi 1995; Garud and Kumaraswamy 2005). Breadth of knowledge indicates an individual's cognitive ability to assess the relevance, parallels, overlap, and congruence of knowledge across domains; contributors who are able to recognize, access, and understand different domains are more likely to make useful integrative contributions (Reagans and McEvily 2003). Individuals with knowledge breadth are able to engage in "perspective-taking" (Boland and Tenkasi 1995), in which they receive and/or share their knowledge across domains in order to identify areas of differences and similarities. Thus, organizational Wiki users are likely to exhibit their knowledge breadth by receiving and/or sharing their knowledge across domains, either by exposing themselves to more viewpoints as they read multiple corporate Wikis, or contributing to multiple Wikis in other disciplines. The value of knowledge breadth to help frame conversations for improved knowledge reuse has been demonstrated in non-Wiki contexts (Allen 1977). In Wiki contexts, an individual's knowledge breadth may foster perspective-taking by providing the ability to assess the relevance, parallels, overlap, and congruence of knowledge across the different domains, thereby facilitating shaping contributions. At the same time, knowledge depth may be less important. Hinds and Pfeffer (2003), for example, argue that an individual's knowledge depth may become a barrier when synthesis of others' knowledge is needed, since individuals with deep expertise often have great difficulty in taking non-experts' perspectives. Therefore, we hypothesize a relationship specifically between knowledge breadth (but not depth) and shaping (but not adding) behavior:

H3. Contributor knowledge breadth positively affects contributor shaping behavior.

Transactive Memory System as a Knowledge Resource

A third resource employed by individuals when using online knowledge repositories is the knowledge that the Wiki provides about how the Wiki community effectively shares (i.e., transacts) its knowledge, referred to as transactive memory systems (TMS) (Lewis and Herndon 2011; Moreland and Argote 2003; Wegner 1987). A well-developed TMS in a community is determined by three conditions: (1) community members' differentiated knowledge, (2) members' knowledge credibility, and (3) members' ability to coordinate their knowledge with others (Lewis and Herndon 2011).

Research on TMS has demonstrated that the level of development of TMS affects individual-level behavior in small teams (e.g., Lewis 2003) as well as in larger groups (Ren et al. 2006). This research has shown that a highly developed TMS allows individuals to redirect incoming information to the appropriate credible experts in the group or community, allowing each individual to process less total information (Hollingshead 1998). With well-coordinated processes for sharing information that come with a highly developed TMS, individuals can make assumptions about others' behaviors and thus better target their own efforts in contributing to the community (Moreland and Argote 2003).

Although the notion of a TMS was originally developed for teams, the comprehensive documentation of contributions, changes, and revisions in some organizational intranets has led several scholars to suggest that intranets provide a means for individual contributors to assess each of the three conditions determining the level of development of a community's TMS (Griffith and Neale 2001; Hollingshead et al. 2002; Jarvenpaa and Majchrzak 2008; Moreland and Argote 2003). A contributor to an organizational Wiki can assess the first TMS condition, the community's differentiated knowledge, by noting the degree to which different participants contribute to the different subtopic pages of the Wiki. A contributor can assess the second TMS condition, credibility of the knowledge posted in the Wiki, by noting the degree to which the Wiki discussion page revolves around discussions that question the credibility of contributions, the degree to which the contributor personally judges the information posted in the online document as credible, or the frequency with which the Wiki is edited to fix errors in the document. Finally, a contributor can assess the third TMS condition, the community's coordination ability, by examining how well-organized the Wiki appears to be, including how easy it is to locate information and the lack of redundancy.

Thus, when the employee uses an organizational Wiki to share or receive knowledge, we suggest that the employee will be able to observe the distribution of contributions to different sub-pages, the nature of the discussion, and the degree to which the Wiki is well-organized. These observations will then allow the employee to draw inferences about the Wiki community's TMS by determining if different types of subknowledge seem to be appropriately differentiated, if the posted knowledge seems credible, and if the community keeps its knowledge organized.

The findings in previous research on the positive effects of TMS on individuals' behaviors in groups and communities suggest that individual contributors' inferences about the level of TMS development for the Wiki community may affect how they target their contributions. Specifically, individual contributors' assessments of the Wiki community's TMS should positively moderate the relationships between the contributors' knowledge resources (of depth and breadth) and contribution behaviors (of shaping and adding).

For knowledge depth, the contributors' assessment that their Wiki communities have well-developed TMS may be used by them to target their knowledge depth toward adding their expertise to their Wiki's content (Preece and Shneiderman 2009). With a Wiki community demonstrating a well-developed TMS, a contributor with deep knowledge may be more likely to identify which aspects of the content are missing and thus can provide the community with needed expertise. In a community with a poorly developed TMS, on the other hand, content in the Wiki may lack sufficient credibility, differentiated knowledge, and coordinated action so much that an individual with deep expertise may not be motivated to help, or not know where to begin to help.

For knowledge breadth, a contributor's assessment that the Wiki community has a well-developed TMS may be used by the contributors to target their knowledge breadth at shaping the Wiki's content to further enhance the possibility of reuse. With a Wiki community demonstrating a well-developed TMS, an individual with broader knowledge is more likely to identify ways to improve how the content is organized to foster search, retrieval, and co-creation. However, in a community with a poorly developed TMS (i.e., the three conditions determining a TMS are minimally present if at all), the content posted on the Wiki may not be sufficiently credible or differentiated for the individual with breadth to know how to help.

Thus, we hypothesize:

H4. *Contributor assessment of the Wiki community's TMS development level positively moderates the relationship between the contributor knowledge resources and the contributor shaping and adding contributions.*

Research Design

We conducted a field study with experienced users of work-related corporate Wikis, using an online questionnaire to collect our data. In all, 168 individuals completed the online questionnaire. We solicited participation by posting, with the administrators' approval, a URL to our anonymous questionnaire on 10 publicly accessible websites.[3] The notice was posted for two weeks and a prize drawing was offered in exchange for completing the questionnaire. The 10 specific communities were chosen because they are frequented by experienced corporate Wiki users who exchange information, patches, and plug-ins specifically about corporate Wikis (e.g., TWiki.org). Soliciting respondents anonymously through interest groups instead of organizational channels reduces social desirability bias by disassociating responses from organizational commitment factors (Rogelberg et al. 2000). Since many of the sites did not require registration to access, it was impossible to know the number of unique visitors to our URL, or the click-through rate. Consequently, we could not calculate nonresponse rates, which is a typical problem with anonymous online surveys (Sivo et al. 2006). We attempted to reduce nonresponse bias by offering an incentive, the opportunity to respond anonymously and online (therefore at low personal cost), and by stating that the purpose of our survey was to identify the lessons corporate Wiki users have learned about how to enhance corporate use of Wikis, a purpose not likely to foreshadow our hypotheses. Finally, we compared data from responses received in the first few days to the last few days and found no systematic differences, which suggests nonresponse bias may not be an issue (Armstrong and Overton 1977; Visser et al. 2000).

To reduce generalized response bias to the individual questions, we used a cognitive anchoring technique (Reis and Gable 2000) in designing the survey: we asked respondents to pick a single corporate Wiki they used most in their daily work, complete a paragraph describing it, and then answer all remaining questions with respect to that single Wiki. Across the 168 respondents, Wikis focusing on a variety of different work activities were selected, including software development, documentation, general knowledge management, project management, sales, corporate policies, human resources, and scheduling. Respondents came from organizations ranging in size from having less than 100 employees (22 percent) to having more than 10,000 employees (19 percent). On average, the 168 respondents were experienced Wiki participants (15 months contributing to a work-related Wiki, and 26 months contributing to Wikis in general).

We asked the respondents to estimate how many individuals contributed on a regular basis to the Wiki they selected by examining the list of contributors shown in the user name space or site statistics for the Wiki. The number of contributors ranged from 2 to 700 (median = 12), indicating a wide range of Wiki community sizes included in the sample. Because of this wide variation, we tested a 10 percent trimmed model at both ends and found no difference with or without the extreme high/low outliers; nevertheless, we included the number of contributors as a control in our analysis.

Measures

The research instrument items are shown in Appendix B. We measured the individual's *Perceived Reuse of Personally Contributed Knowledge to the Wiki for Organization Improvement (Reuse)* with three items asking respondents to indicate the extent to which they had observed in the Wiki that their knowledge had improved the organization's work processes. Three similar process improvements—collaboration, work, and knowledge reuse—were adapted from Bock et al.'s (2005) scale on the extent to which one's knowledge sharing helps the organization. We measured the individual's *Extent of Shaping Contributions (Shaping)* as how often respondents rewrote whole paragraphs, reorganized pages, and integrated content on their selected Wikis, following Yates et al. (2010). Also following Yates et al., we measured the individual's *Extent of Adding Contributions (Adding)* as how often respondents either added new pages to the Wiki or added new content to existing Wiki pages. We measured the individual's *Assessment of the Wiki Community's Level of Transactive Memory System Development (TMS)* using the Lewis (2003) scale, dropping the reverse-coded items. The individual's *Knowledge Depth (Depth)* was adapted from the Kalman et al. (2002) scale of the perception of one's level of expertise as viewed by oneself, others in the Wiki, and others in the organization. The individual's *Knowledge Breadth (Breadth)* was measured as two alternative ways in which the respondent could stay current with other domains and disciplines: either reading or contributing to Wikis in other domains.

Constructs were modeled as formative or reflective based on decision rules from Petter et al. (2007). Generally, items should be formative not reflective when indicators are defining characteristics of a construct rather than manifestations of the construct, when they are not interchangeable, and

[3] We compared responses based on solicitation sites (communities) and found no systematic differences and thus no indication of community-level biases or clustering effects.

Table 1. Summary of Key Constructs

Construct	Definition	Formative vs. Reflective Justification (Based on Petter et al. 2007)
Reuse	Extent to which an individual perceives that his/her contributed knowledge has been used by others for organizational improvements.	Formative. The three indicators are conceptually similar but represent different types of improvements that could occur independently of each other.
Adding	How often an individual adds new pages or new content to his/her work-related Wiki.	Formative. The two items are conceptually similar but represent two different ways of adding that could occur independently.
Shaping	How often an individual rewrites, reorganizes and integrates content on his/her work-related Wiki.	Formative. The three items are conceptually similar but represent three different ways of shaping that could occur independently.
Depth	An individual's perception of his/her level of expertise in the particular domain topic of the Wiki.	Reflective. The three indicators are interchangeable, sharing the same nomological network.
Breadth	An individual's frequency of reading or contributing to Wikis in domain areas not covered by his/her work-related Wiki.	Formative. The two indicators are two different non-interchangeable ways in which the individual could stay current with other domains: reading or contributing.
TMS	A contributor's assessment of the extent to which the Wiki community has differentiated, credible, and coordinated knowledge.	Formative. We modeled TMS as a second-order formative construct with three indicators for each of the three Lewis (2003) dimensions.

when the indicators draw on different nomological networks or have differing antecedents and consequences. Table 1 summarizes the key constructs, their definitions, and whether they were modeled as formative or reflective.

We included several control variables. When analyzing variance explained in Reuse, we included *Extent to which Others Accessed the Wiki (Access)* as a single item to ensure that reuse was not simply a function of the number of times the Wiki page was viewed, as suggested by Butler (2001). When analyzing variance explained in Shaping and Adding Contributions, we included three controls: *Number of Contributors to the Wiki Community (NumContr)* because of the wide variation in the sample, *Frequency with which the Individual Contributed to the Wiki (Freq)* to normalize for effects of individual differences in total contribution frequency, and *Extent to which the Individual felt that the Wiki Contributed to his/her Reputation (Reputation)* to account for motivational drive to contribute (Wasko and Faraj 2005). To measure Reputation, we used the three-item reflective scale of Wasko and Faraj (2005).

Results

We employed partial least squares (PLS) using PLS-Graph 3.0 (http://www.plsgraph.com), a components-based method for evaluating simultaneous equations, to test the hypotheses (Chin 1998). PLS allows for both formative and reflective indicators to be modeled. All items were standardized as recommended by Chin et al. (2003) to avoid computational errors. To evaluate the significance of path coefficients estimated by PLS-Graph, we employed bootstrap resampling using 500 subsamples (Chin et al. 2003). Below we follow the reporting standards of Ringle et al. (2012) and Gefen et al. (2011) in describing the PLS results.

Measurement Model Validation

We conducted several tests to verify instrument validity (Straub et al. 2004). We first submitted the measures for the two reflective constructs (Depth and Reputation) to an exploratory factor analysis using orthogonal rotation. All items loaded highly on their appropriate construct (all > 0.5 and significant at the $p < 0.1$ level) and cross-loadings were low (all < 0.2) indicating convergent validity. Composite reliability scores and Cronbach alphas were high (all > 0.8) indicating reliability of the measures. Formative constructs (Reuse, Adding, Shaping, TMS, and Breadth) were validated following Petter et al. (2007) and Cenfetelli and Bassellier (2009) by examining indicator weights for magnitude, sign, and significance; variance inflation factors (VIF), which might indicate multicollinearity among indicators; and loadings when indicator weights were not significant. We found no evidence of multicollinearity (all VIFs were lower than the 3.33 threshold suggested by Cenfetelli and Bassellier) and indicators demonstrated high significant weights to their respective formative construct and/or high significant loadings above 0.8. We verified that the square root of the average variance extracted was greater than 0.5 for each construct, and also greater than the interconstruct correlations, suggesting adequate discriminant validity (Gefen and Straub 2005). TMS was designed as a second-order construct following Chin et al., with three indicators each for the three first-order constructs forming the higher-order TMS construct.

Additionally, we tested for the effect of common method variance as directed by Podsakoff et al. (2003). We employed three different tests: the Harmon 1 factor approach using principal components analysis, the partial correlation approach based on the lowest observed correlation (Lindell and Whitney 2001), and the common method factor approach using PLS as described by Liang et al. (2007). No evidence of common method bias was found, suggesting minimal effect. Details of these analyses can be found in Appendix B.

Structural Model Results

Table 2 provides a summary of the hypotheses for the research model, how each was tested, and the results. The interaction terms were constructed for TMS-by-Depth and TMS-by-Breadth by multiplying standardized scores of the indicators for the interacting constructs to create a single product-sum indicator representing the interaction term as detailed in Goodhue et al. (2007).[4]

Since PLS does not provide overall goodness of fit statistics, we tested the hypotheses by comparing our hypothesized models against baseline models of control variables only and assessed the change in R^2 and effect size (Ringle et al. 2012). Effect sizes were calculated using the formula given by Mathieson et al. (2001). Cohen (1988) recommends interpreting these effect sizes as small (0.02), medium (0.15), or large (0.35), with small to medium effect sizes interpreted as indicating a modest influence of hypothesized constructs and medium to large effect sizes indicating a strong influence from hypothesized constructs compared to the possible influence of other (untested) factors. Note that we also compared our hypothesized model against a saturated model (all possible paths) and found that the saturated model did not offer better results (i.e. greater explanatory power).

Results for Hypothesis 1. To test for H1, we compared the baseline model of the control variable predicting to Reuse, to a model also including Adding and Shaping contributions. The results in Table 3, Row 1 indicate that including Adding and Shaping contributions as predictors for Reuse provides a significant change in R^2 ($\Delta = 0.17$, $p < 0.001$), a medium-large effect. The total R^2 for Reuse was 0.36. Standardized path coefficients for Adding and Shaping to Reuse were 0.30 and 0.23 respectively (both significant at the 0.001 level). PLS path coefficients are interpreted similar to the betas in a multiple regression. Results, therefore, indicate a significant effect of Adding on Reuse as expected from prior literature, but also an almost equally strong and significant independent effect of Shaping on Reuse.

Results for Hypotheses 2 and 3. To test for H2 and H3, we compared a model with Depth and Breadth as main effects on Adding and Shaping against a baseline model of controls. Table 3, Rows 2 and 3 indicate significant changes in R^2 for Adding and Shaping ($\Delta = 0.07$ and 008 respectively, $p < 0.001$), both small-medium effects. Path coefficients were modest, yet significant: 0.20 ($p < 0.01$) from Depth to Adding, and 0.17 ($p < 0.05$) from Breadth to Shaping. Since H2 and H3 argued that Adding would be exclusively affected by Knowledge Depth and not Breadth, and that Shaping would be exclusively affected by Knowledge Breadth and not Depth, we tested for alternative non-hypothesized paths. The alternative paths were not significant, providing further support for H2 and H3.

Results for Hypothesis 4. Finally, for H4, we assessed the moderation effects of TMS on the relationship between knowledge Depth/Breadth to Adding and Shaping, comparing this full model to a model with main effects only (Carte and Russell 2003; Goodhue et al. 2007). Results shown in Table 3, Rows 4 and 5 indicate a significant change in R^2 (both $\Delta = 0.06$, $p < 0.01$) with small–medium effect sizes. Even with these small-medium effect sizes, the total R^2 accounted for was 0.38 for Adding, and 0.30 for Shaping. Path coefficients for the interaction effects were significant (-0.16 for Depth × TMS, $p < 0.05$; 0.21 for Breadth × TMS, $p < 0.001$). However the negative coefficient for Depth × TMS was contrary to our expectations, prompting a *post hoc* analysis described below.

Figure 1 shows the standardized PLS path coefficients and R^2 values.

[4]We also completed the analysis with product-indicator interaction constructs as shown in Chin et al., which used 27 items (for Depth × 9 for TMS) and 18 items (2 for Breadth × 9 for TMS) for the moderator constructs. Goodhue et al. suggest that the product-indicator method may result in inflated path estimates and wider confidence intervals. Indeed, results indicated slightly higher path coefficients and R^2 values using the product-indicator method, but no differences in path significance. We thus continued our analysis using the product-sum method from Goodhue et al.

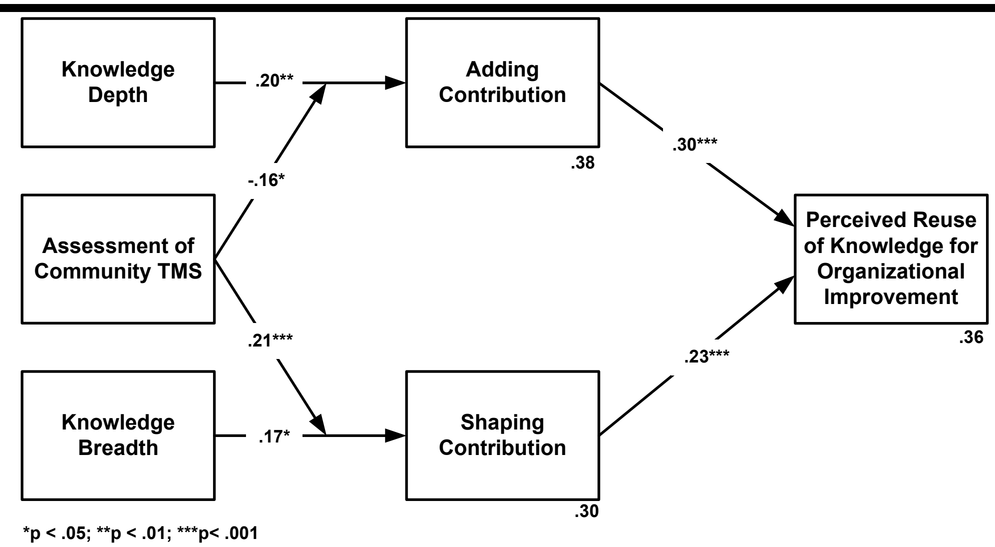
Table 2. Summary of Hypotheses and Results

Hypothesis	Testing Method	Result
H1: Content adding and shaping behaviors positively affect contributor perceptions about reuse of contributed knowledge for organizational improvement.	Comparison of the baseline model of the control variable only predicting to Reuse, to a model including Adding and Shaping.	Confirmed.
H2: Contributor knowledge depth positively affects contributor adding behavior.	Comparison of a baseline model of controls only predicting to Shaping and Adding as dependent variables model, to a model with Depth and Breadth as main effects on Shaping and Adding.	Confirmed.
H3: Contributor knowledge breadth positively affects contributor shaping behavior.		Confirmed.
H4: Contributor assessment of the Wiki community's TMS development level positively moderates the relationship between the contributor knowledge resources and the contributor shaping and adding behaviors.	Comparison of a model with knowledge Breadth and Depth as main effects only, to a full model with the moderation effect predicting to Adding and Shaping dependent variables.	Partially supported. TMS positively moderated the relationship between Breadth and Shaping, but negatively moderated the relationship between Depth and Adding.
Post hoc test because of H4 partial support of moderating effect of TMS.	Evaluate marginal means of Adding and Shaping for Hi/Lo TMS and Hi/Lo Depth and Breadth conditions.	Positive moderation for shaping contributions, but negative moderation for adding contributions.

Table 3. Change in R^2 and Effect Sizes from Model Comparisons

Test	Endogenous Constructs	Δ Change in R^2	Effect Size
Main Effects Model compared to Baseline Model (Controls Only)	Reuse	0.17***	.26 (medium-large)
	Adding	0.07***	.11 (small-medium)
	Shaping	0.08***	.11 (small-medium)
Interaction Effects Included	Adding	0.06**	.10 (small-medium)
	Shaping	0.06**	.09 (small-medium)

**p < .01; ***p < .001



Control variables with significant path coefficients: Access → Reuse (0.33, p < .001); Freq → Shaping (0.39, p < .001); Freq → Adding (0.30, p < .001); Reputation → Adding (0.18, p < .05); NumContr → Adding (-0.20, p < .05).

Figure 1. Structural Model with Path Coefficient and R^2 Values Reported from PLS

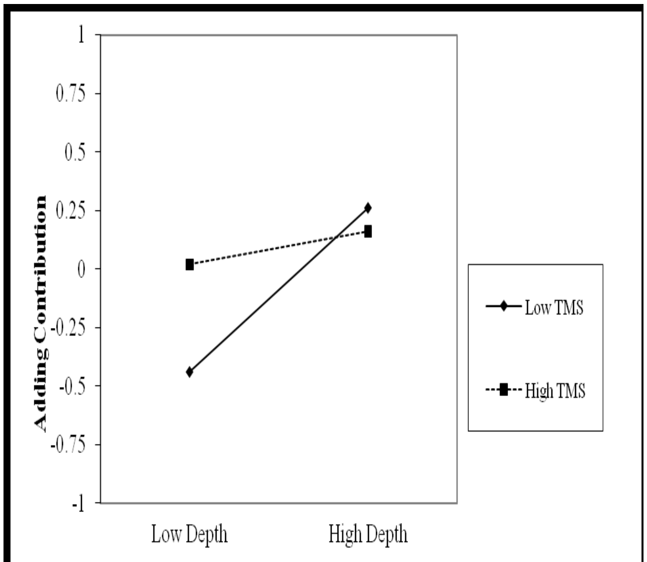


Figure 2. Interaction between Depth and TMS on Adding Contributions

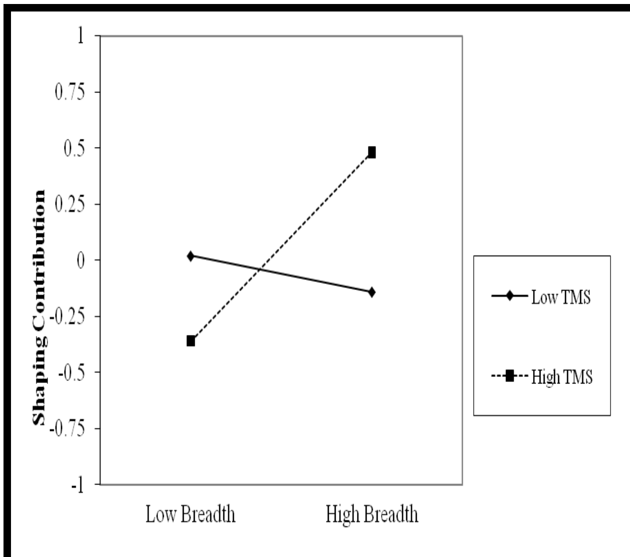


Figure 3. Interaction between Breadth and TMS on Shaping Contributions

Overall, the results lend support for the reconceptualization of knowledge management through adding and shaping, as summarized in Figure 1. They demonstrate the dual impact of both Adding and Shaping contributions on Reuse (H1), the relationship between Depth and Adding only (and not Shaping) (H2), the relationship between Breadth and Shaping only (and not Adding) (H3), and the moderated impact of TMS on Adding and Shaping (H4).

Post Hoc Analysis of Moderation Effects. As pointed out above, Hypothesis 4 was only partially supported. While introducing the moderation effect into the PLS model increased the percentage of variance accounted for in Adding and Shaping behaviors as hypothesized, the path coefficients for the TMS moderation effect shown in the structural model in Figure 1 indicated that the moderation was only positive, as hypothesized, for the relationship between Breadth and Shaping. Unexpectedly, TMS *negatively* moderated the relationship between Depth and Adding. To better interpret the unexpected interaction effects of TMS, we conducted a *post hoc* test by splitting the indicator and moderator terms into high and low groups based on median values, then graphed the marginal means of contribution behaviors for each high/low combination (Aiken and West 1991), as shown in Figures 2 and 3.

We investigated the slopes of the interaction curves for the high and low TMS conditions, using t-tests to determine if there was a significant difference for high versus low Depth and high versus low Breadth in each TMS condition. For Shaping contributions (Figure 3), we found, as hypothesized, a positive moderation: individuals made significantly more Shaping contributions with high Breadth than with low Breadth, provided they were in a Wiki community they assessed as having a highly developed TMS. When they assessed the Wiki community as having a poorly developed TMS, the differences in the extent of Shaping for high versus low Breadth were not significant. That is, as initially theorized, those with broader knowledge contributed their knowledge for Shaping when they felt the Wiki community had a more developed TMS.

For the relationship between Depth and Adding (Figure 2), the moderation effect was *opposite to our expectations*. In contrast to our initial theorizing, individuals with deep knowledge who felt their Wiki communities' TMS were well-developed were *not* more likely to contribute their deep knowledge than those who assessed their Wiki communities as having poorly developed TMS. Instead, individuals with *less* deep knowledge contributed what little they knew primarily when they considered the community's TMS to be well-developed. One explanation for this finding might be that those with little domain knowledge in communities with well-developed TMS may feel more welcomed and are able to more clearly understand how to contribute what little they know. This is similar to the behavior of novice open source contributors who, even with limited domain knowledge, contribute meaningfully by initially limiting their contributions to simple bug fixes (Stewart and Gosain 2006). In contrast to those with little expertise in the domain area of the Wiki, those with deeper knowledge contribute regardless of the TMS level of their communities, perhaps because they focus solely on contributing their deep knowledge regardless of the needs of the community.

An alternative reason for the negative moderation effect of TMS may be that the TMS level of the community may create different reasons for contributors to add their deep expertise. For a community with a well-developed TMS, those with deep knowledge may be able to quickly identify areas in which their expertise is needed, but when the community has a poorly developed TMS, those with deep knowledge may feel an even greater obligation to help the community, contributing their deep knowledge to improve the community.[5] These reasons for our unexpected findings are clearly speculative. Regardless of the explanation, this differential moderator effect of TMS for shaping and adding contributions is further evidence that shaping and adding contributions are affected differently by individuals' knowledge resources.

Limitations. This preliminary study has numerous limitations. Most important of these limitations is the operationalization of variables. Ideally, the dependent variable of reuse would have been measured objectively to avoid perceptual bias. Moreover, and again, ideally, the contribution behaviors and knowledge resources could also have been measured either objectively, or with triangulated sources. The sample is clearly biased toward self-selected, experienced, organizational Wiki users, and thus generalizability is of concern, particularly with the inability to accurately assess response rates. Finally, while the impact of common method bias has been minimized statistically, our reliance on a cross-sectional survey requires replication to increase confidence in internal validity.

Reframing Questions about Knowledge Reuse

We have made the argument that shaping and adding emerge as distinctive behaviors in an organizational KMS when users are afforded the opportunity to shape. We theorized that shaping affects knowledge reuse by providing individuals with the agency to integrate others' contributed domain knowledge and that, as a distinctive behavior, shaping is affected by different knowledge resources. We found support for our hypotheses, as shown in the model in Figure 1. Since the results are derived from a cross-sectional survey based on self-reports, we consider the results preliminary. Nevertheless, if future research replicates our findings, the model of knowledge reuse in Figure 1, which explicitly incorporates shaping as well as adding behaviors and three different knowledge resources, has several implications for research and theorizing about KMS and knowledge reuse.

One implication concerns the need to refine the knowledge-based view of the firm (Grant 1996a) as a theoretical basis for understanding how online knowledge is reused in a firm. The different effects of the different knowledge resources on different types of contributions suggest that the knowledge view of the firm needs to be refined to more explicitly take into account these differences. Without adding one's deep knowledge to a KMS, there is the danger of having well-organized knowledge of little substance or credibility being shared. However, without shaping the knowledge that is added, there is a danger of knowledge being *offered* for reuse but not actually *being* reused because it is disorganized and thus not useful. Research on the reuse of online knowledge needs to consider not only how knowledge is added, but how knowledge is shaped by users.

Given the different effects of knowledge resources on the two contribution behaviors of adding and shaping, IS scholars should consider incorporating shaping as an explicit contribution behavior when studying contexts in which users create and share knowledge online. Moreover, we examined only one measure of knowledge reuse, raising questions for future research on the role of shaping when other measures of success are examined. For example, if innovation was the measure of success, would shaping facilitate innovation? Some scholars would argue that shaping facilitates innovation because of the opportunities for recombination that integration provides (Faraj et al. 2011; Kogut and Zander 1992); however, could shaping hurt innovation because it organizes the information in the Wiki in ways that may make it hard for other users to find it when novel uses are being considered (Majchrzak et al. 2004)? Additional research is needed on the impact of shaping on different KMS outcomes.

The affordance of shaping points to a reconceptualization of knowledge as no longer the domain of specialized experts. The creation of knowledge repositories with high reuse value has been attributed in the past primarily to experts with deep specialized knowledge acquired through deliberate practice (Proctor and Dutta 1995). Yet, the importance of knowledge breadth in our findings suggests that knowledge with reuse value to the organization can be constructed by individuals with broad rather than specialized knowledge. By having broad knowledge integrated online via shaping, one's knowledge breath can become an important source of new knowledge. Thus, future theoretical explorations into the nature of

[5] We thank an anonymous reviewer for this insight.

community-based knowledge creation should consider looking at knowledge not only as the deep knowledge of a few specialists, but also as the ability to dynamically and effectively aggregate deep, broad, and meta-forms of knowledge into new constructions and insights (see Ericsson and Lehmann 1996).

Our findings may help to explain equivocal results from past research on knowledge resources that affect contributions to intranets. Some studies have found that an individual's knowledge depth is a crucial antecedent for the extent to which individuals add their knowledge (Constant et al. 1996; Kankanhalli et al. 2005), while others did not find a relationship between knowledge depth and adding (Roberts et al. 2006; Wasko and Faraj 2005). Given our preliminary findings, it may be that the different, seemingly conflicting results may both be correct. The importance of knowledge depth may depend on the form of the contribution behavior and the capabilities of the technology platform on which the KMS is based. When a KMS technology platform does not permit shaping, such as the one studied in Kankanhalli et al. (2005), a positive effect of knowledge depth on knowledge adding behavior may be found. When the KMS platform allows for shaping (as in some discussion forums), and when contributors make primarily shaping rather than adding contributions, knowledge depth may not affect contribution behavior. Unless future studies more clearly distinguish the types of contributions being made and the types of knowledge resources used, these past equivocal findings may be a reflection of inadequate detail in the theoretical model. Thus, our model addresses a gap in KMS literature by integrating three different knowledge resources into the same predictive model for reuse. In so doing, we offer insight into past equivocal results about the role of knowledge depth in explaining contribution behavior by demonstrating that the importance of knowledge depth is based on whether the contribution involves shaping or solely adding. In general, our model presumes a more complex relationship between knowledge resources, contribution behaviors, and reuse than previous research, recognizing the importance of shaping behavior and the knowledge resource of a community's TMS in predicting reuse when the KMS is supported by a Wiki.

The affordance of shaping also suggests that additional theory development is needed on what might be called the "politics of integration." Clearly, shaping can introduce negative aspects, such as hijacking a conversation, subverting or distorting arguments, or alienating participants. Evidence of these negative effects has been found in corporate-sponsored Wikis that are open to anonymous public contributions (Wagner and Majchrzak 2007). However, since individuals' identities are known in organizational intranet-based Wikis, research is needed to explore if the same politics and negative effects exist there. Further, research is also needed to explore the moderation effect of TMS given our unexpected findings of the negative effect of TMS on the relationship between knowledge depth and adding behavior.

Our findings offer three suggestions for designing KMS. Designing KMS to provide users with information about the community's TMS might encourage those with less knowledge depth to contribute. Designing KMS to provide information indicating whether shaping is needed might be based, for instance, on Wiki page length, access and update frequency, and indicators of duplication or redundancy. Such information might encourage those with knowledge breadth to contribute. Designing KMS to be integrated with all online documents at a company so that the Wiki could automatically track reuse by comparing Wiki content to content found in follow-on documents might help encourage contribution by informing contributors when their content was reused and process changes made.

In conclusion, while previous theories of knowledge reuse assumed that integration was done implicitly and/or limited to a few privileged individuals or organizational routines, Wikis help us to reflect on knowledge reuse when such an assumption is no longer warranted. Wikis make integrative behaviors explicit, broadly distributing to the entire community the opportunity to shape. This initial study on the knowledge antecedents and consequences of shaping demonstrates the opportunities for new theorizing about KMS that shaping promotes. Many provocative, theoretically interesting questions need yet to be explored. If everyone is given the opportunity to integrate, who decides to and when? Is there really a "power of the pen," whereby those who integrate also lead the discussion, or does open integration facilitate a further democratic distribution of power? Could open integration keep individuals from adding because of fear that their contribution may be modified? Could shaping, when permitted, be an important mechanism to explain how a KMS can become aligned with the organizational work processes for which it is intended, thereby helping to account for a key factor in successful KMS deployments? Clearly, the shaping affordance in organizational Wikis raises numerous new questions about the nature of organizational knowledge integration.

Acknowledgments

We would like to acknowledge the helpful comments of the review team. This research was sponsored by the Advanced Practices Council of the Society for Information Management in addition to the U.S. National Science Foundation (SES: 0725088) to the first author and a GRF grant from the Research Grants Council of the Hong Kong SAR, CityU (No. 9041464) to the second author.

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RESEARCH NOTE

THE IMPACT OF SHAPING ON KNOWLEDGE REUSE FOR ORGANIZATIONAL IMPROVEMENT WITH WIKIS

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Appendix A

The Impact of Shaping on Knowledge Reuse

Introduction

An increasing number of published accounts (e.g., Cress and Kimmerle 2008; Kane and Fichman 2009; Wagner and Majchrzak 2007; Yates et al. 2010) describe Wikis and their impact on knowledge aggregation from many contributors. In this appendix, we extend these accounts to explain the specific mechanisms that cause Wiki-based efforts to succeed in the creation and maintenance of knowledge assets where others failed before. We explain how shaping facilitates the integration of contributions of many, and ultimately results in the reconstruction of expertise. Our argument first identifies four invariant challenges of expertise capture and reuse that tend to be experienced regardless of the technology support. These challenges are: (1) the bottleneck of expertise, (2) lack of incentives, (3) knowledge contextuality, and (4) the bottleneck of maintenance. Concluding that the traditional expertise model underlying the design of earlier knowledge management systems (KMS) cannot address these challenges, we explain how conversational knowledge management (e.g., via discussion forums) has tackled some of the challenges, yet leaves others unanswered. Our argument then turns to Wikis, which, as we illustrate, have the potential to address the remaining challenges, and in so doing point to a new mechanism to deconstruct and then reconstruct expertise. We explain several shaping behaviors and argue for the importance of shaping to maintain an integrated knowledge asset.

Breakdown of the Expertise Model

Traditionally, expertise (or, in general, *knowledge*) has been the province of experts. Experts are experts, of course, because of their expertise. However, their usefulness as primary sources of organizational intelligence has faced bottlenecks that result in severe challenges, especially when there is an objective of knowledge capture and reuse. Namely,

- *Few experts, many tasks (bottleneck of expertise)*. The more specialized the expertise, the more limited the supply. This leaves the limited supply of experts in great demand, resulting in either not having the time to share expertise, insufficiently sharing expertise, or becoming a delaying factor in the compilation of knowledge (Wagner 2006).

- *Lack of incentive to share*. Despite any organizational rhetoric, experts will be able to assess whether the organization's reward system rewards sharing. If not sufficiently rewarded, which too often is the case, the expert's only rational behavior is to maintain personal expertise and thus not share (O'Dell and Grayson 1998).

- *Contextuality of knowledge*. In addition to the important dimensions of knowledge depth and breadth, knowledge use beyond narrow and well-structured tasks requires contextuality and knowledge variety so as to avoid narrowness and brittleness (Feigenbaum 1992). If a specific set of rules does not work, experts are able to modify knowledge they use to the unique characteristics of the situation, or alternatively use other knowledge. To capture an expert's knowledge in all its variety and contextuality is a formidable task, usually foregone in favor of either standard solutions (of value mainly for novices), or niche solutions for high impact special situations.

- *Maintenance trap*. Even if knowledge can be captured, its organizational reuse requires maintenance as new situations, distinctions and contra-indicative knowledge emerge. Consequently, increased knowledge capture can lead to so much increased maintenance that experts would only have time to maintain previously shared knowledge rather than create or share new knowledge (see Brooks 1995).

Not surprisingly then, the expertise model of knowledge management fails in many organizations and is replaced by sharing of finished documents, sharing of standard solutions, or well meant efforts to capture true expertise which relatively soon loses its value and becomes obsolete (see Hinds and Pfeffer 2003; Huysman and Wulf 2006; O'Dell and Grayson 1998).

Model of Conversational Knowledge Creation and Use

An alternative model of knowledge sharing and reuse emerged with the general availability of Web 2.0 technology, the *read-write web*, with discussion forums, chat rooms, or blogs. This model enabled conversations around knowledge—which were previously one-to-one (e.g., via e-mail) and possibly not recorded in machine-readable form (e.g., phone conversations)—to become persistent conversations into which many could join. Initially often in the form of a threaded conversation such as a discussion forum, knowledge was shared through conversation such as questions and answers. This model of knowledge sharing and reuse has characteristics that address several of the challenges of the expertise model (Wagner and Bolloju 2005). In particular,

- *Many knowledge providers/small contributions (thus overcoming the bottleneck of expertise challenge)*. The model relies not on a few experts who supply large quantities of knowledge, but on localized expertise. Every "thread" in the discussion can have its own expert or group of experts. Also, contributors can provide partial solutions, such that nobody alone answers a question, with a thread in its entirety providing a complete answer.

- *Small contributions/part of the work process (thus overcoming the challenge of a lack of incentive to share)*. Instead of significant engagement, contributors to conversational knowledge management solutions were able to share limited expertise, and in a format similar to answering an e-mail. Instead of answering to a single person, they could answer many people with the same effort. In fact, expert contributors liked it because there was the opportunity to answer once and then refer future questions about the same issue to the earlier answer.

In addition, the conversational model creates positive unintended consequences such as the online representation of meta-knowledge (Nevo and Wand 2005), which can fulfill the role of a transactive memory system held by members of small groups (e.g., Hollingshead 1998). Communication patterns in the threads demonstrate who asks and who answers, thus outlining clusters of shared interests and clusters of expertise which help, for instance, in off-line knowledge inquiries. The lack of this meta-knowledge frequently hampers reuse (O'Dell and Grayson 1998), yet without explicit representation, large, dynamic knowledge networks may simply "not know what they know."

The conversational model creates other consequences as well, albeit not as beneficial; specifically, the need to work with incomplete and inaccurate knowledge, as well as redundancy in the conversation. First, lacking the singular expertise of the expertise model, the conversational model brought partial answers and possibly not completely correct answers. Partial answers, as mentioned, are a side effect of people adding small units of meaningful insights. Hence, the knowledge user is required to compile a complete answer from the contributions of many. This results in inefficiencies, as every reader has to go through the process of re-summarizing the facts in a thread into a meaningful answer. Inaccuracies are a further challenge. Traditional knowledge repositories were usually "never wrong," while conversational knowledge repositories are "usually right," but often inexact. Human beings are accustomed to reasoning with inexact knowledge and do so quite efficiently; however in a business context they may have an expectation of "what is written is also correct."

The difficulty of creating exact conversational knowledge repositories relates to the second issue, namely that of redundancy. A thread in conversational knowledge is a time-based structure of information units. Newer units are not necessarily more relevant than old ones, and newer units may be written without full consideration of old ones. Wrong additions to the thread cannot easily be deleted, as they are embedded in a discussion sequence, whereby valuable replies might be lost when an incorrect message is removed. Hence, thread readers may find themselves in a position where the search for an answer requires the reading of an entire thread with conflicting information, repetition of the same answers and comments, comments that add little value, and comments that possibly divert from the original topic (forks). Attempts to overcome these weaknesses of threaded discussions within the medium led to features such as "sticky posts" (important comments that would remain at the top of a discussion thread), FAQs that extracted the most meaningful elements from threads into Q&A summaries, or simple human engineering, such as comments within a threaded dialog that reminded those asking questions that the question had been answered elsewhere ("read the archives"). Nevertheless, the time-oriented content organization and the limited ability to reorganize content (other than through stickies or FAQs) led to increased redundancy and poor integration, which made threads beyond certain lengths increasingly less valuable.

To lower redundancy and increase integration, a reorganization of the knowledge management system was thus needed. It needed to retain the conversational character, but change from time-orientation to content-orientation, and to integrate the flow of knowledge transactions into a single, nonredundant unit, rolling up all knowledge accumulating transactions into a single unit. Thus, rather than being able to look at and add to a "transaction file" of knowledge transactions, users needed a "master file" where they could update the status of the knowledge content (while the system would still track transactions in the background).

Wiki Model of Conversational Knowledge Management

A new model of conversational knowledge management was made possible by Wiki technology. Wiki technology allows multiple people to work on the same document without overwriting each other's changes, and with the advantage of keeping track of each other's contributions. The concepts of maintaining multiple versions of a document and tracking contributions in Wiki originates from similar mechanisms implemented in software version control systems. The principles of version control, enabling many people to view the newest version, control or manage concurrent write access to the newest version (for editing), and allow roll-back to a prior version in case the newest version suddenly becomes nonoperational, apply equally to software and content management in Wikis. Version control thus facilitates collaboration and integration of work products, but also supports *fail safing* (Ravichandran and Rai 1999) and recovery from errors.

With Wiki-enabled document collaboration, a Wiki contributor is able to access a Wiki page or subset thereof and edit it, changing the existing knowledge or adding new knowledge. This is done by simply clicking an *edit* button on a Wiki page and later clicking a *save* button. Once changes are completed, the page is released for others to see and further modify. To avoid edit loss through concurrent edits by multiple users, Wiki software frequently has built-in partial locking, warning, or edit merge mechanisms. These Wiki technical characteristics, combined with social engineering rules often referred to as the "Wiki way," enable a form of collaboration that retains the benefits of conversational knowledge management, while also leading to the creation of a single, integrated knowledge product with minimal redundancy and few errors. Whereas in the threaded model, a later contributor would have had to make corrections by posting "comment xyz is wrong, the correct answer is…," the Wiki model enables simple removal or correction of errors. Thus the patchwork of original version and comments in conversational knowledge management is replaced by a single version that integrates the original with all later updates.

Knowledge Deconstruction with Wikis

The content orientation provided by Wikis enabled a better structuring of the efforts of many, through a "deconstruction of the expert," as in Figure A1, an excerpt from a Wikitravel article on Los Angeles may help illustrate. The community around Wikitravel has developed a structured way to organize knowledge about its entries, which permits a deconstruction of the content into highly separable subunits. Consequently individual contributors can now add small knowledge components on a single sub-issue. This deconstruction logic is not simply flat, but contains multiple levels, as demonstrated by the content box in Figure A1, which shows the topics *Get in*, *Get around, See*, *Do*, *Buy*, and so on, several of which have subtopics indicated by [+] signs. Therefore, individual contributors can add depth to this breadth-oriented structure by offering detailed comments on how to get into the city, and so on. Furthermore, the design logic also considers knowledge variety or context by allowing contributors to specify alternate ways of "getting in," or different budget levels for food and accommodation. Travel expertise being thus deconstructed enables a multitude of contributors to add content to an integrated whole with some adding breadth, others depth, and others knowledge variation. Consequently, what might formerly have been the knowledge content associated with a single expert through deconstruction becomes a collaborative contribution sourced in a coordinated manner from a diverse user community. In corporate knowledge work contexts, the effort to compile expertise collectively is frequently quite similar, with team members adding knowledge to (semi-)structured documents such as design specifications, meeting memos, or procedure guidelines.

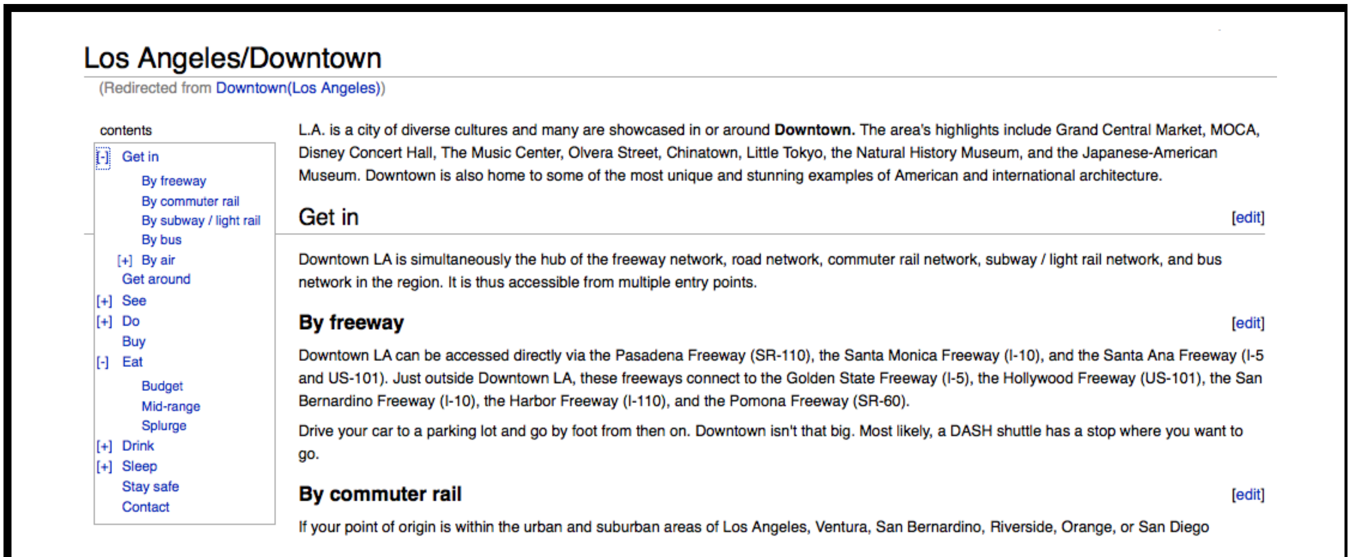

Figure 1. Knowledge Deconstruction in the Wikitravel Article on Los Angeles/Downtown

Knowledge Addition Versus Knowledge Shaping for Knowledge Reconstruction

While it is conceivable that integrated articles can be written in their entirety through deconstruction and strategic adding of content, even plain maintenance issues will require eventual replacement of outdated knowledge. Even more important, incorrect knowledge, poorly placed content, or even just poorly presented knowledge may need to be replaced. Factual inconsistencies need to be resolved. Statements of preferences may need to be identified as such, or balanced. Content duplication needs to be reduced to avoid redundancy and possible future content inconsistency. Content that becomes inappropriately placed, even with prior structuring, needs to be moved for better understanding and to improve future content additions. Sometimes the need for change arises immediately (e.g., the correction of incorrect knowledge) and sometimes the need develops over time (as subsequent additions increasingly discuss off-topic content for a particular aspect of the knowledge).

Addressing these problems is the purpose of knowledge shaping. Knowledge shaping does not add content per se and in fact will frequently even remove knowledge content. What it does is to modify content so that its informational value is raised or so that the ability to add further knowledge in the future is enhanced. Knowledge shaping, as such, is akin to refactoring in the software engineering world, in which software is modified without functional change in order to simplify the code, remove duplication, and improve future maintenance and additions. Just as refactoring in the software engineering world (Fowler 1999) is intended to improve code quality, shaping in a organizational Wiki environment is intended to raise the quality of knowledge content, reconstructing the expert. While this benefits future knowledge addition and integration efforts of contributors, it benefits even more the reuse efforts of those who seek to extract knowledge. As previously remarked, if knowledge is not properly integrated by contributors, it has to be integrated by every user at the time of knowledge reuse, in a sense making process. Given typical contributor-to-reader ratios of at least 1:4 for commercial Wikis (Yates et al. 2010) and 1:100 or more for public Wikis (Arthur 2006), the integration effort is multiplied by that factor and possibly allocated to individuals who understand the content less than those who contributed to it. Consequently, knowledge addition without shaping will soon render reuse infeasible, if not for contributors, then for knowledge consumption.

Shaping Behaviors

Shaping, as mentioned earlier, is an activity that changes a knowledge asset without adding domain knowledge, although it possibly still adds insight. In other words, shaping is a *refactoring* (Fowler 1999) of the knowledge asset. Software refactoring does not change the external functional behavior of the code, but improves readability and code complexity. Shaping does the same for Wiki knowledge assets. It removes duplication, removes inconsistencies, enforces content structures, standardizes language to reduce ambiguity, and even formulates high-level summaries that aggregate individual comments into more generalizable knowledge. For example, a company that maintains a Wiki of incident reports for product failures may at first permit free-format input of such reports. After a while, one of the contributors may observe patterns across the report writing, yet not complete consistency. Without changing the content of any incident report, the contributor may begin to reformulate some of the reports to adhere to a common structure, and thereafter formulate a template for new reports. Another contributor may observe, using the logic of induction, that the standardized incident reports, in aggregate, reveal a failure pattern. He or she may then write a high level summary report, which describes the pattern. Someone else, looking at the reports operationally, may observe that reports use terms such as *fault*, *failure*, *incident*, or *problem* interchangeably, and then standardize the terminology to reduce ambiguity. Overall, shaping behavior can thus be reflected through several types of activities, from the changing of words, to rewriting of paragraphs, to the break-up and recombination of paragraphs or whole articles, to the aggregation of paragraphs or articles to reveal higher-level patterns. No domain knowledge needs to be added, but understandability and insight should be increased, especially through the removal of ambiguities and inconsistencies, or the extraction of higher-level patterns. Future contributions become easier due to the use of templates and clarity of knowledge asset design.

In addition to shaping as refactoring and shaping as knowledge reconstruction, *shaping for reuse* is another beneficial knowledge management behavior. When knowledge is reused, the reuse context (i.e., the problem domain) and the user profile may well differ from the context in which the knowledge was originally created. Knowledge reusers, for instance, often possess less expertise than knowledge creators and may be overwhelmed by too much knowledge complexity. Thus, a one-size-fits-all solution of a traditional knowledge management system may not be applicable for the reuse situation. Whereas in conversational knowledge management this can be addressed through threaded discussions, albeit with the awkwardness arising from threading, Wiki shaping can suppress detail or suppress contextual information within a single integrated knowledge unit.

Unintended Consequences

The ability to shape can have unintended, positive side effects. First, research would suggest that the ability to shape is empowering (Denegri-Knott et al. 2006; Prahalad and Ramaswamy 2004). When a team member sees a problem in a shared knowledge asset, he or she now may not only sense a responsibility to correct it, but also the opportunity to do so. Second, seeing the imperfections of others' work, the "beauty of imperfection" (*wabi sabi*) may encourage contributors to participate, whereas before, the integrity of a seemingly finished knowledge asset discouraged participation. According to Powell (2004), *wabi sabi*, a Japanese term for describing aesthetics, implies that "nothing lasts, nothing is finished, and nothing is perfect." Third, the ability to change content, especially one's own, can change contributors' behavior based on risk considerations. Research has demonstrated asymmetric risk propensities for gains versus losses. The possibility to make a mistake without recourse to correct it would be considered a loss and could, because of asymmetry, outweigh the perceived gains of making positive contributions. Hence, especially risk-averse would-be contributors may choose not to contribute, simply to avoid mistakes. When error correction becomes low effort, and not just the knowledge originator's responsibility, perceived losses should loom less and thus favor increased contribution. At present only anecdotal evidence suggests the impact of risk aversion on Web 2.0 contributions. However, as a related issue concerning Wikipedia, a stronger sanctioning of content by the so-called *Deletionists* (who delete articles they deem inappropriate, thus destroying the efforts of others) appears to have affected loss perceptions in similar fashion and lowered participation rates and content contributions there (see *Economist* 2008). The latter example also identifies a risk of shaping, namely that the modification of others' content actually has negative side effects that discourage future contributions. Hence, part of the social engineering insight defined in the "Wiki way" (Leuf and Cunningham 2001) urges those who shape to "tread lightly" and to begin by taking care of their own content before affecting that of others.

Conclusion

In the end, it is not a single feature of Wiki technology that affords users the opportunity to deconstruct and reconstruct expertise in a manner that allows for organic knowledge growth and self-correction. The combination of topic or expertise orientation, rather than timeline-oriented content, plus the ease of change, immediacy of change, and version tracking with the ability to roll back older versions, together make shaping possible and feasible. Furthermore, the social engineering principles of the Wiki way make shaping acceptable, meaningful, and responsible. As a result, Wikis make it possible to address the challenges of expertise capture and reuse that other knowledge management approaches cannot (see Table A1). Table A1 differentiates between traditional knowledge management (e.g., through document repositories of software such as Lotus Notes, Microsoft Sharepoint, or Novell Groupwise), conversational knowledge management (e.g., with blogging and discussion forum features or products, such as IBM Connections forums, or Windows Live Writer blogging software) and Wiki based knowledge integration. Plus (+) signs in Table A1 indicate challenges that are addressed or potentially addressed, minus (–) signs indicate remaining problems.

Table A1. Overcoming Challenges of Expertise Capture and Reuse

Challenges Related to Expertise Capture and Reuse	Traditional Knowledge Management	Conversational Knowledge Management	Knowledge Integration with Wiki Technology
Bottleneck of Expertise	Reliance on few experts, scarcity, lead to limited knowledge capture, narrowness, brittleness. (–)	Large numbers of small contributions in aggregate create a substantial knowledge asset. (+) Yet knowledge is frequently inconsistent and repetitive, requiring repeat cognitive integration effort by knowledge reusers. (–)	Large numbers of small contributions in aggregate create a substantial knowledge asset. (+) Knowledge is topically oriented and can be well integrated by contributors, thus lowering reuse effort. (+)
Lack of Incentives	Unaligned interests, lead to lack of participation, limited knowledge capture, narrowness, brittleness. (–)	Contributors *individually* give away little, spend little effort, gain more from the aggregate contributions of many. (+) Time based knowledge organization reduces value of older contributions. (–)	Contributors *individually* give away little, spend little effort, gain more from the aggregate contributions of many. (+)
Knowledge Contextuality	Nature of knowledge as being contextual results in captured solutions being too generic, not useful as true expertise. (–)	Knowledge can be highly contextual, due to expertise of many. (+) Time based (thread based) conversational knowledge construction hampers integration, which weakens contextuality. (–)	Knowledge can be highly contextual, due to expertise of many. (+) Topic oriented knowledge structure enables high contextuality. (+)
Maintenance Bottleneck	Reliance on few experts, scarcity, plus centralized maintenance process lead to limited and delayed knowledge changes, further aiding the decay of knowledge in the KMS. (–)	Potential for knowledge *adding*, as old knowledge becomes outdated, through contributions of many. (+) Potential for increased inconsistency and replication over time leads to freezing of knowledge threads, lowering the value of past contributions. (–)	Addition of new knowledge, deletion of existing knowledge, through contributions of many. (+) Ability to shape and re-shape knowledge assets leads to knowledge assets that are highly integrated and improve, not decay, over time. (+)

The absence of negative signs (–) in the Wiki column is not meant to say that Wikis address all challenges associated with knowledge management and thus would provide an ideal solution. Instead, it indicates that certain challenges that existed with previous knowledge management approaches are addressed by Wiki-enabled knowledge integration. Other difficulties remain. For instance, another maintenance bottleneck may persist when too few organization members take on the task to maintain the knowledge, even though the members are afforded the ability to modify the knowledge with little effort.

Nevertheless, by addressing four important existing challenges, Wikis may lead us to a substantively new expertise model where expertise is not "the capability of an expert" (Bloom 1985), nor the shared property of a community of practice (Wenger 1998), but a superior form of knowledge organization (Chi et al. 1981) that can be possessed by a person, collective of persons, or knowledge artifact that properly deconstructs and reconstructs the capability to address knowledge needs in breadth, depth, and range of contexts or variations.

Are Wikis the only artifact that can appropriately codify expertise? No. First, even the Wiki model has shortcomings that will lead to expertise breakdowns, despite the positive representation in Table A1. Contributors may fail to maintain the Wiki, may disagree on content, or may overlook factual mistakes, illustrated by Wikis with incomplete and outdated contributions, edit wars, or inconsistencies within Wiki knowledge assets. Hence, they still fall short of the ideal of expertise reconstruction, despite the potential to overcome major challenges of knowledge capture and reuse. Second, once we better understand how expertise is most suitably codified, technologies that offer better affordances to do so may emerge. At present, however, neither the traditional expertise model of knowledge sharing, nor the conversational model around time-line based and persistent conversations, address the need to reconstruct knowledge depth, breadth, and diversity as adequately as Wikis can.

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Appendix B

Instrument Validity

This appendix describes our instrument validation steps, with the following subsections: measures, reliability and construct validity, and assessment of common method bias.

Measures

Table B1. Measures

Items	Mean (SD)
Extent to Which Individual Perceives Own Wiki Contributions are Reused for Organizational Improvement: (Reuse) *To what extent would you say your knowledge-sharing on this wiki has helped your organization to: 1 = no extent; 7 = great extent*	
1. Improve work processes	4.44 (1.35)
2. Increase collaboration efficiency	4.72 (1.34)
3. Increase knowledge reuse	5.02 (1.34)
Extent to Which Individual Makes Adding Contributions: (Adding) *Think about the contributions you have made to this wiki. How often have your contributions been: 1 = almost never, 7 = all the time*	
1. New pages	5.04 (1.39)
2. Added content to existing pages	5.42 (1.12)
Extent to Which Individual Makes Shaping Contributions: (Shaping) *Think about the contributions you have made to this wiki. How often have your contributions been: 1 = almost never; 7 = all the time*	
3. Rewrites of whole paragraphs	2.32 (1.29)
4. Reorganization of a set of pages	2.86 (1.50)
5. Integration of ideas on existing pages	3.53 (1.53)
Degree of Individual's Knowledge Depth: (Depth) *Think about the work you do that uses the wiki. To what extent would you say that: 1 = no extent; 7 = great extent*	
1. You are an expert on the work	4.63 (1.19)
2. Others using the wiki look to you for your expertise	4.36 (1.26)
3. Your expertise is sought after by others in your organization	4.33 (1.24)
Degree of Individual's Knowledge Breadth: (Breadth)	
1. Think about the work you do that uses the wiki. How often do you contribute to wikis that deal with other projects or disciplines? 1 = almost never; 7 = all the time	2.71(1.61)
2. How many different wikis do you read on a regular basis? (open-ended response)	3.46 (2.85)
Individual's Assessment of the Transactive Memory Systems Development of the Wiki Community (TMS) *Think about the set of people contributing to this wiki. To what extent do you think each person: 1 = no extent; 7 = great extent*	
1. Has specialized knowledge of some aspect of the work being performed with the wiki *(Diff1)*	4.94 (1.34)
2. Has knowledge about an aspect of the work that no other contributor has (*Diff2)*	4.79 (1.36)
3. Knows which contributors have expertise in specific areas *(Diff3)*	4.70 (1.25)
4. Feels comfortable accepting suggestions made by other contributors *(Cred1)*	4.87 (1.20)
5. Trusts that other contributors' knowledge is credible *(Cred2)*	5.23 (1.13)
6. Has confidence relying on the information in this wiki *(Cred3)*	5.20 (1.28)
7. Works together in a well-coordinated fashion *(Coord1)*	4.57 (1.32)
8. Has few misunderstandings about what to do *(Coord2)*	4.28 (1.16)
9. Accomplishes tasks with the other contributors smoothly and efficiently *(Coord3)*	4.53 (1.11)

Table B1. Measures (Continued)	
Items	**Mean (SD)**
Control: Extent of Reputation Received to Individual from Wiki Use: *(Reputation) To what extent has using this wiki helped you to: 1 = no extent; 7 = great extent*	
1. Earn respect from others for your ideas	3.64 (1.48)
2. Improved your status in your profession	3.23 (1.56)
3. Improved your reputation in your company	3.49 (1.50)
Control: Extent of Access of Wiki by Others: (Access) *In a typical week, how often do you think this wiki is accessed (for reading or writing)? 1 = hardly ever; 7 = all the time*	5.83 (1.39)
Control: Frequency of Individual's Contributions to Wiki: (Freq) *How often do you contribute to this wiki: 1 = less than once a month; 7 = more than once a day*	4.56 (1.87)
Control: Number of Contributors to the Wiki: (NumContr) *About how many individuals participate in the wiki on a regular basis as contributors? (open-ended response)*	37.02 (76.51)

Reliability and Construct Validity

We first tested for evidence of reliability and validity for the Reflective Latent Constructs (Depth and Reputation). Table B2 shows each construct, its factor loadings (with significance level), composite reliability, and Cronbach's alpha. Factor loadings were generated via Principal Components Analysis (PCA) in SPSS. Gefen and Straub (2005) explain that factor loadings should be > .6 for the appropriate construct, and cross-loadings should be < .4. Fornell and Larcker (1981) recommend a minimum composite reliability of .6, and George and Mallery (2003) suggest the following rules of thumb for evaluating alpha coefficients" "> .9 excellent, > .8 good, > .7 acceptable, > .6 questionable, > .5 poor, < .5 unacceptable." PCA results indicate good convergent validity with all loadings above .8 and all cross-loadings below .2. Composite reliabilities and Cronbach alphas were in both cases above .8, providing evidence of adequate reliability for the two reflective constructs.

Table B2. Factor Loadings, Composite Reliability, and Cronbach's Alpha for Reflective Constructs

	Component	
	Depth	**Reputation**
Depth1	.859	.134
Depth2	.902	.201
Depth3	.887	.106
Reputation1	.131	.896
Reputation2	.162	.920
Reputation3	.154	.917
Composite Reliability	0.923	0.919
Cronbach Alpha	0.876	0.913

To assess construct validity of formative constructs (Reuse, Shaping, Adding, TMS, and Breadth), we evaluated indicator weights and loadings; we calculated variance inflation factors (VIFs) using linear regression in SPSS regressing the set of indicators on each indicator in turn; and we examined intra-construct correlations, following Cenfetelli and Bassellier (2009). For TMS, we first constructed three first-order formative factors for the Lewis (2003) dimensions of Differentiated Knowledge (Diff), Credibility (Cred), and Coordination (Coord) and assessed validity for these constructs. Then, following Chin et al. (2003), we constructed the second-order formative TMS construct using all nine TMS indicators and used the second-order construct to test hypotheses in the structural model.

According to Cenfetelli and Bassellier, indicators of well-specified formative constructs will have significant weights. Nonsignificant weights may be caused by multicollinearity, indicated by high VIFs (above 3.33). In the absence of multicollinearity, indicators with nonsignificant weights but high loadings have high absolute (though low relative) influence on the construct and should be retained in the model. While some indicators do have low weights (e.g. Reuse3, Adding1, Shaping1), all indicators have high loadings (above .65) and VIFs below 3.33, indicating no multicollinearity. The exception is indicator Diff2, which has low weight and a loading of 0.544. We retained this item since removing it did not materially change the results. Overall, results indicate acceptable construct validity.

Table B3. Validity of Formative Constructs

Indicator	Weight	t-stat	p-value	R^2	VIF	Loading
Construct: Reuse						
Reuse1	0.400	2.5416	< 0.05	0.546	2.203	0.890
Reuse2	0.454	2.2759	< 0.05	0.584	2.404	0.916
Reuse3	0.295	1.1280	0.26	0.468	1.880	0.828
Construct: Adding						
Indicator	**Weight**	**t-stat**	**p-value**	**R^2**	**VIF**	**Loading**
Adding1	0.096	0.4286	0.67	0.411	1.698	0.936
Adding2	0.936	6.1635	< 0.001	0.411	1.698	0.696
Construct: Shaping						
Indicator	**Weight**	**t-stat**	**p-value**	**R^2**	**VIF**	**Loading**
Shaping1	0.044	0.730	0.47	0.416	1.712	0.677
Shaping2	0.354	1.471	0.14	0.415	1.709	0.822
Shaping3	0.711	4.905	< 0.001	0.470	1.887	0.956
Construct: Breadth						
Indicator	**Weight**	**t-stat**	**p-value**	**R^2**	**VIF**	**Loading**
Breadth1	0.353	5.0774	< 0.001	0.090	1.099	0.743
Breadth2	0.775	7.4900	< 0.001	0.090	1.099	0.952
Construct: Differentiated Knowledge (Part of TMS)						
Indicator	**Weight**	**t-stat**	**p-value**	**R^2**	**VIF**	**Loading**
Diff1	0.221	1.968	< 0.05	0.550	2.222	0.651
Diff2	0.046	0.091	0.93	0.517	2.070	0.544
Diff3	0.853	5.218	< 0.001	0.225	1.290	0.974
Construct: Credibility (Part of TMS)						
Indicator	**Weight**	**t-stat**	**p-value**	**R^2**	**VIF**	**Loading**
Cred1	0.419	0.937	0.35	0.496	1.984	0.881
Cred2	0.401	1.260	0.21	0.553	2.237	0.896
Cred3	0.328	2.879	< 0.01	0.449	1.815	0.828
Construct: Coordination (Part of TMS)						
Indicator	**Weight**	**t-stat**	**p-value**	**R^2**	**VIF**	**Loading**
Coord1	0.627	5.524	< 0.001	0.434	1.767	0.917
Coord2	0.057	1.853	0.07	0.481	1.927	0.655
Coord3	0.529	1.518	0.13	0.506	2.024	0.875

Finally, we assessed discriminant validity. Correlations between constructs should be below .50 (Cohen 1988). With the exception of a control variable, Reputation with Reuse, the correlations are below .50. Additionally, for reflective constructs, the square root of the AVE should be at least .50 and larger than the correlation with any other construct. This is demonstrated in Table B4. Thus, we conclude there is adequate evidence of discriminant validity.

Table B4. Evidence of Discriminant Validity (Square-Root of AVE is shown in bold on the diagonals for multi-item reflective constructs)

		1	2	3	4	5	6	7	8	9
1	Reuse	**Form**								
2	Adding	0.37**	**Form**							
3	Shaping	0.31**	0.45**	**Form**						
4	Depth	0.23*	0.36**	0.20*	**0.89**					
5	TMS	0.37**	0.29**	0.08	0.30**	**Form**				
6	Breadth	0.20*	0.17*	0.20*	0.07	0.00	**Form**			
7	Reputation (CTRL)	0.54**	0.36**	0.23**	0.33**	0.36**	0.17*	**0.92**		
8	Freq (CTRL)	0.38**	0.48**	0.44**	0.27**	0.22*	0.26**	0.37**	**–**	
9	Access (CTRL)	0.43**	0.15	0.12	0.18*	0.18*	0.04	0.30**	0.34**	–
10	NumContr (CTRL)	0.02	-0.01	0.05	0.04	-0.10	-0.01	0.09	-0.11	0.16

**p < .01, *p < .05

Assessment of Common Method Bias

We tested for common method bias (CMB) using three techniques recommended by Podsakoff et al. (2003). We first employed the Harmon 1-factor test using principal components analysis in SPSS. Results indicated that there was not a single factor that explained variability in the indicators. We next employed a partial correlation approach as described by Lindell and Whitney (2001). In this approach, construct correlations are compared to partial correlations which are corrected for the correlation with a theoretically-justified construct. We found no changes in significance after accounting for the distinct construct, suggesting the effect of CMB is minimal. Finally, we used PLS to test for CMB using the common factor approach, as described by Liang et al. (2007). We created a model with a single common method construct. We then modeled each of the 22 indicators (controls not included) as a single-indicator construct with paths to the common method construct and the theoretically justified constructs. Table B5 shows the comparison of the simulated loadings based on path coefficients between the single item constructs and the theoretically justified constructs, and between the single item constructs and the common method factor. As expected, loadings on their appropriate constructs were both high,and highly significant (all $p < 0.001$). Loadings on the common method factor were low and in almost all cases nonsignificant, indicating the effect of CMB is minimal.

Table B5. Test for Common Method Bias in Primary Model Constructs Using the Common Method Factor Approach

Indicator	Theoretical Construct Loading	T-stat	P-value	Common Method Factor Loading	T-stat	P-value
Reuse1	0.948	24.008	p < .001	-0.086	1.601	p = .11
Reuse2	0.823	18.553	p < .001	0.121	2.229	p < .05
Reuse3	0.879	18.730	p < .001	-0.050	0.779	p = .44
Adding1	0.933	28.766	p < .001	-0.139	2.436	p < .05
Adding2	0.899	53.158	p < .001	0.084	3.530	p < .001
Shaping1	0.794	21.712	p < .001	0.133	2.761	p < .01
Shaping2	0.88	30.256	p < .001	-0.012	0.339	p = .74
Shaping3	0.907	27.800	p < .001	-0.125	2.796	p < .01
Breadth1	0.847	30.476	p < .001	0.040	0.815	p = .42
Breadth2	0.886	45.385	p < .001	-0.038	0.836	p = .40
Depth1	0.862	27.126	p < .001	0.016	0.364	p = .72
Depth2	0.891	33.279	p < .001	0.063	1.486	p = .14
Depth3	0.934	32.197	p < .001	-0.083	1.607	p = .11

Table B5. Test for Common Method Bias in Primary Model Constructs Using the Common Method Factor Approach (Continued)

Indicator	Theoretical Construct Loading	T-stat	P-value	Common Method Factor Loading	T-stat	P-value
Diff2	0.535	3.853	p < .001	0.021	0.139	p = .89
Diff3	0.623	6.542	p < .001	0.143	1.510	p = .13
Cred1	0.722	7.688	p < .001	0.049	0.449	p = .65
Cred2	0.736	8.093	p < .001	0.030	0.300	p = .76
Cred3	0.678	6.504	p < .001	0.086	0.753	p = .45
Coord1	0.744	8.230	p < .001	0.035	0.338	p = .74
Coord2	0.907	8.421	p < .001	-0.262	2.118	p < .05
Coord3	0.887	9.493	p < .001	-0.140	1.419	p = .16

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