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RESEARCH NOTE

The Impact of Shaping on Knowledge Reuse for Organizational Improvement with Wikis

Ann Majchrzak
Information Systems, Marshall School of Business, University of Southern California, Los Angeles, CA 90089 U.S.A.
Esade Business School, Universidad Ramon Llull, Barcelona, SPAIN {majchrza@usc.edu}

Christian Wagner
School of Creative Media and Department of Information Systems, City University of Hong Kong,
Tat Chee Avenue, Kowloon, Hong Kong SAR {c.wagner@cityu.edu.hk}

Dave Yates
United States Air Force {hdjryates@gmail.com}

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.

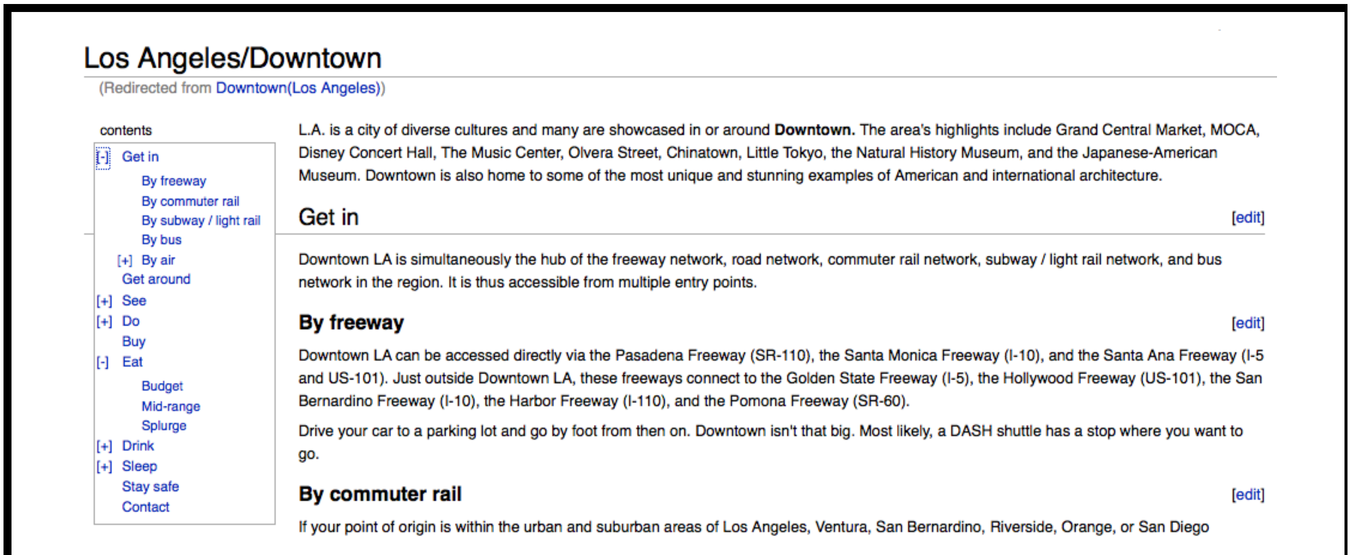

Figure 1. Knowledge Deconstruction in the Wikitravel Article on Los Angeles/Downtown

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.

References

Arthur, C. 2006. "What Is the 1% Rule?," *The Guardian*, July 20 (available online at http://www.guardian.co.uk/technology/2006/jul/20/guardianweeklytechnologysection2.).

Bloom, B. S. 1985. *Developing Talent in Young People*, New York: Ballantine.

Brooks, F. P. 1995. *The Mythical Man-month*, Boston: Addison-Wesley.

Chi, M. T. H., Feltovich, P. J., and Glaser, R. 1981. "Categorization and Representation of Physics Problems by Experts and Novices," *Cognitive Science* (5:2), pp. 121-152.

Cress, U., and Kimmerle, J. 2008. "A Systemic and Cognitive View on Collaborative Knowledge Building with Wikis," *International Journal of Computer-Supported Collaborative Learning* (3:2), pp. 105-122.

Denegri-Knott, J., Zwick, D., and Schroeder, J. E. 2006. "Mapping Consumer Power: An Integrative Framework for Marketing and Consumer Research," *European Journal of Marketing* (40:9/10), pp. 950-971.

Economist. 2008. "The Battle for Wikipedia's Soul," *The Economist,* March 6 (available online at http://www.economist.com/printedition/displaystory.cfm?story_id=10789354).

Feigenbaum, E. A. 1992. "Expert Systems: Principles and Practice," in *The Encyclopedia of Computer Science,* B. W. Wah (ed.), New York: Wiley.

Fowler, M. 1999. *Refactoring. Improving the Design of Existing Code*, Boston: Addison-Wesley.

Hinds, P. J., and Pfeffer, J. 2003. "Why Organizations Don't 'Know What They Know': Cognitive and Motivational Factors Affecting the Transfer of Expertise," in *Beyond Knowledge Management: Sharing Expertise*, M. Ackerman, V. Pipek, and V. Wulf (eds.), Cambridge, MA: MIT Press, pp. 3-26.

Hollingshead, A. B. 1998. "Retrieval Processes in Transactive Memory Systems" *Journal of Personality and Social Psychology* (74:3), pp. 659-671.

Huysman, M., and Wulf, V. 2006. "IT to Support Knowledge Sharing in Communities, Towards a Social Capital Analysis," *Journal of Information Technology* (21), pp. 40-51.

Kane, G. C., and Fichman, R. G. 2009. "The Shoemaker's Children: Using Wikis for Information Systems Teaching, Research, and Publication," *MIS Quarterly* (33:1), pp. 1-22.

Leuf, B., and Cunningham, W. 2001. *The Wiki Way: Quick Collaboration on the Web*, Boston: Addison Wesley.

Nevo, D., and Wand, Y. 2005. "Organizational Memory Information Systems: A Transactive Memory Approach," *Decision Support Systems* (39), pp. 549-562.

O'Dell C., and Grayson, C. J. 1998. "If Only We Knew What We Know: Identification and Transfer of Internal Best Practices," *California Management Review* (40:3), pp. 154-174.

Prahalad, C. K., and Ramaswamy, V. 2004. "Co-creating Unique Value with Customers," *Strategy & Leadership* (32:3), pp. 4-9.

Powell, R. R. 2004. *Wabi Sabi Simple: Create Beauty. Value Imperfection. Live Deeply*, Avon, MA: Adams Media.

Ravichandran, T., and Rai, A. 1999. "Total Quality Management in Information Systems Development: Key Constructs and Relationships," *Journal of Management Information Systems* (16:3), pp. 119-155.

Wagner, C., and Bolloju, N. 2005. "Supporting Knowledge Management in Organizations with Conversational Technologies: Discussion Forums, Weblogs and Wikis," *Journal of Database Management* (16:2), pp. i-viii.

Wagner, C. 2006. "Breaking the Knowledge Acquisition Bottleneck Through Conversational Knowledge Management," *Information Resources Management Journal* (19:1), pp. 70-83.

Wagner, C., and Majchrzak, A. 2007. "Enabling Customer-Centricity Using Wikis and the Wiki Way," *Journal of Management Information Systems* (23:3), pp. 17-43.

Wegner, D. M. 1987. "Transactive Memory: A Contemporary Analysis of the Group Mind," in *Theories of Group Behavior*, B. Mullen and G. R. Goethals (eds.), New York: Springer-Verlag, pp. 185-208.

Yates, D., Wagner, C. and Majchrzak, A. 2010. "Factors Affecting Shapers of Organizational Wikis," *Journal of the American Society for Information Science and Technology* (61:3), pp. 543-554.

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

References

Cenfetelli, R. T., and Bassellier, G. 2009. "Interpretation of Formative Measurement in Information Systems Research," *MIS Quarterly* (33:4), pp. 689-707.

Chin, W. W., Marcolin, B. L., and Newsted, P. R. 2003. "A Partial Least Squares Latent Variable Modeling Approach for Measuring Interaction Effects," *Information Systems Research* (14:2), pp. 189-217.

Cohen, J. 1988. *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.), Hillsdale, NJ: Erlbaum.

Fornell, C., and Larcker, D. 1981. "Evaluating Structural Equation Models with Unobservable Variables and Measurement Error," *Journal of Marketing Research* (18), pp. 39-50.

Gefen, D., and Straub, D. 2005. "A Practical Guide to Factorial Validity Using PLSGraph: Tutorial and Annotated Example," *Communications of the AIS* (16), pp. 91-109.

George, G., and Mallery, P. 2003. *SPSS for Windows Step by Step: A Simple Guide and Reference, 11.0 Update,* Boston: Allyn & Bacon.

Lewis, K. 2003. "Measuring Transactive Memory Systems in the Field: Scale Development and Validation," *Journal of Applied Psychology* (88:4), pp. 587-604.

Liang, H., Saraf, N., Hu, Q., and Xue, Y. 2007. "Assimilation of Enterprise Systems: The Effect of Institutional Pressures and the Mediating Role of Top Management," *MIS Quarterly* (31:1), pp. 59-87.

Lindell, M. K., and Whitney, D. J. 2001. "Accounting for Common Method Variance in Cross-sectional Research Designs," *Journal of Applied Psychology* (86:1), pp. 114-121.

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., and Podsakoff, N. P. 2003. "Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies," *Journal of Applied Psychology* (88:5), pp. 879-903.