Chapter 5
Wiki Technology and Emergency Response:
An Action Research Study

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ABSTRACT

This paper is about the design and implementation of a wiki-based knowledge management system for improving emergency response. Most organizations face difficult challenges in managing knowledge for emergency response, but it is crucial for response effectiveness that such challenges be overcome. Organizational members must share the knowledge needed to plan for emergencies. They also must be able during an emergency to access relevant plans and communicate about their responses to it. This study, which employed action research methods, suggests that wiki technology can be used to manage knowledge for emergency response. It also suggests that effective use of a knowledge management system for emergency response requires thorough training, a knowledge-sharing culture, and a good fit between emergency-response tasks and system capabilities.

1. INTRODUCTION

Knowledge management is about making knowledge available to those who need it. Knowledge management systems help organizations make good use of what they know, connecting knowledge sources and knowledge users. Emergency response involves making plans and preparations before an emergency, as well taking action during it and analyzing what happened afterwards.

It might seem natural for knowledge management systems to be used to support emergency

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response, but a review of the relevant research literature shows that most studies to date have been focused more generally on how knowledge management systems affect organizational performance and competitiveness (Von Krogh, 1998; Hackbarth, 1998; Davenport & Prusak, 1998; Alavi & Leidner, 2001; Jennex & Olfman, 2005, 2006). Yet, recent emergencies (such as the 9/11 terrorist attacks, subsequent anthrax events, the Slammer worm attack on the Internet, the London subway bombings, the 2004 tsunami, and Hurricane Katrina) have spurred interest in research about how to support emergency response in broader terms. A small, but growing, body of research has focused on understanding how knowledge management systems can support emergency response.

How relevant are knowledge management systems to emergency response? Can knowledge management systems be designed specifically to support emergency response in an organizational context? What should a knowledge management system for emergency response include? What do emerging social software technologies, such as wikis, have to offer in the design of knowledge management systems for emergency response?

These questions motivated the study reported here: to create a knowledge management system to support emergency response, specifically the planning and preparation that must occur before an emergency occurs. The study involved using a wiki to develop a knowledge management system for emergency-response activities of the Claremont University Consortium. The Consortium (CUC) is located in Southern California and comprises seven colleges. It exists to help its members, seven co-located private colleges, with common needs, including campus safety, facilities management, library, payroll, textbooks, and emergency response.

The objectives of this research were to understand: (1) what attributes a knowledge management system for emergency response should have; (2) whether a wiki can be used to develop such a knowledge management system; and (3) if such a system is an effective way to support knowledge management for emergency response.

The paper proceeds as follows. Section 2 provides an overview of knowledge management. Section 3 provides an overview of emergency-response systems. Section 4 briefly examines the relationship between emergency response and knowledge management. Section 5 provides an overview of wikis and their role in supporting knowledge management in organizations. Sections 6 through 9 provide the details of our case study. Sections 10 through 12 present implications for theory and practice, as well as conclusions.

2. KNOWLEDGE MANAGEMENT

Davenport and Prusak (1998) define knowledge as an evolving mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. Knowledge often becomes embedded in documents or repositories, as well as in organizational routines, processes, practices, and norms. Knowledge is also about meaning, in the sense that it is context-specific (Huber, Davenport, & King 1998). Jennex (2006) extends the concepts of context to also include associated culture that provides frameworks for understanding and using knowledge. A simpler definition of knowledge is that it is the how and why of something. Gaining knowledge is gaining insight into how and why things happen. To be useful, this knowledge must be framed in context and culture, providing the information and data needed to explain how the knowledge was generated, what it means, and how it should be used.

Jennex (2005b) defines knowledge management as "the practice of selectively applying knowledge from previous experiences of decision-making to current and future decision making activities with the express purpose of

improving the organization's effectiveness." Knowledge management is an action discipline; knowledge needs to be used and applied for knowledge management to have an impact. Inherent in knowledge management is communication between knowledge creators and/or possessors and knowledge users. A knowledge management system is a system developed to aid knowledge users in identifying, sharing, retrieving, and using knowledge they need.

Alavi and Leidner (2001, p. 114) define a knowledge management system as "Information Technology-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application." They observe that not all knowledge management initiatives will implement an information technology solution, but they support information technology as an enabler of knowledge management. Additionally, they discuss various perspectives on knowledge that help to determine how a knowledge management system should be designed and used to support knowledge management.

Maier (2002) expands on the information technology concept for the knowledge management system by calling it an Information and Communication Technology system that supports the functions of knowledge creation, construction, identification, capturing, acquisition, selection, valuation, organization, linking, structuring, formalization, visualization, distribution, retention, maintenance, refinement, evolution, accessing, search, and application.

Jennex (2005a) uses a view on systems similar to Churchman's (1979) to expand the concept of knowledge management systems to include users, as well as processes for capturing, storing, searching, retrieving, and re-using knowledge. This expanded view of a knowledge management system is used here.

3. EMERGENCY RESPONSE AND KNOWLEDGE MANAGEMENT

Decisions made during emergencies can be improved by using knowledge from past events to generate current and future response procedures (Turoff, 2002). Analysis of past emergency events for lessons learned and the understanding of what works best in given situations (both examples of knowledge) enables emergency managers to prepare planned responses as a counter to the stress of the emergency.

Integration of knowledge management concepts into an emergency-response system is a recent development (Jennex, 2006; Jennex & Raman, 2009). Specifically, researchers describe that an emergency-response system should support the following features that are also inherent in any knowledge management system:

- Enable individuals and groups to create, share, disseminate, and store knowledge (Turoff & Hiltz, 1995; Turoff, Chumer, & Van de Walle, 2004, Jennex & Raman, 2009).
- Offer the ability to document experiences and lessons that have been learned to the overall organizational memory for dealing with crisis situations (Lee & Bui, 2000; Murphy & Jennex, 2006)
- Support asynchronous and collaborative work (Campbell, DeWalle, Turoff, & Deek, 2004; Murphy & Jennex, 2006, White et al., 2008, Jennex & Raman, 2009).
- Provide emergency-response knowledge that is relevant, accurate, and presented in a timely manner (Turoff, 2002; Turoff et al., 2004; Jennex, 2004).
- Enhance the overall communication process between people involved in emergency response by inserting more structure into the manner in which knowledge is organized and documented (Turoff & Hiltz, 1995; Turoff et al., 2004; Jennex, 2004, Jennex & Raman, 2009).

Wikis are proposed as knowledge management systems to support emergency response by increasing connectivity and collaboration (Jennex, 2006; Raman, Ryan, & Olfman, 2006; White et al., 2008; Jennex & Raman, 2009). A wiki (defined below) allows users to add and edit content collaboratively (Parliament of Victoria, 2005; Wikipedia, 2006). Wikis originated in 1994 (Cunningham, 2005), but only recently come have become popular as content management systems (Mattison, 2003). Recent research has found that wikis are useful for knowledge management; they improve knowledge connectivity by providing content management with knowledge exchange, communication, and collaboration capabilities, including support for leaderless development and collaboration as exampled by Hurricane Katrina response (Murphy & Jennex, 2006; Palen, Hiltz, & Liu, 2007). These and other recent disasters show the value of wikis as a public forum for knowledge sharing and communication (Palen, Hiltz, & Liu, 2007) although there is the issue of building trust in these systems between users who do not know each other (Eryilmaz, Cochran, & Kasemvilas, 2009; Buscher, Mogensen, & Kristensen, 2009). Vazey and Richards (2006) found that wikis can improve decision making and knowledge acquisition. This applies to decision making in an emergency context as well (Jennex, 2006). Finally, White et al. (2008) list several emergency response applications where wikis have been applied. However, these applications are focused on knowledge sharing/exchange and were not used for emergency organization internal planning and training, the focus of this paper.

4. WIKIS

'Wiki' is a Hawaiian word that means 'quick' and is used by the information systems community to refer to an open source, collaborative content management system. Wikis were first implemented by the Portland Pattern Repository group to create a seamless database that enabled their members to create, edit, store, and structure content (text and graphics) in Web format (Wagner, 2004; Leuf & Cunningham, 2001).

Wikis run over the World Wide Web and are browser independent. The hypertext transfer protocol (HTTP) governs the communication process between the client and server within a wiki.

Wiki communities consist of registered members who can edit any page within the wiki website without any additional functional support from the web browser. Members establish topic associations by using hyper-linking capabilities inherent in any wiki.

The value of wikis is greatest when members actively engage in collaborative editing, sharing of knowledge, and creating new pages within a given wiki (Leuf & Cunningham, 2001). The ability of wikis to support the creation, modification, storage, and dissemination of knowledge by many people together has led to wikis being accepted as a collaborative knowledge management technology (Wagner, 2004; Leuf & Cunningham, 2001).

Wiki technology can also address knowledge management goals for emergency response through the capability of wikis to enable:

- Creation and revision of emergency-response Web pages;
- Storage, search, and retrieval of emergency-response-related paperwork, lessons from tabletop sessions, images, and presentations;
- Facilitation of online discussions and collaboration of emergency-response managers, planners, system designers, experts, responders, and other users.

Other conversational technologies can be used to support knowledge management for emergency response (e.g., e-mail, Web pages, discussion forums, chat, streaming media, video/audio conferencing, and group decision support systems [Wagner, 2004, p. 269]). However, we

felt that wiki technology is a superior technology for use in supporting emergency response for the following reasons:

- It is available as an open-source technology.
- It is easy to learn and understand.
- It has simple functions for viewing and updating information.
- It supports collaborative authoring and document sharing.
- It allows asynchronous work by its users.
- It can serve as a repository. Wiki pages, once created, are persistent and updateable.

5. METHODOLOGY

This study was conducted as action research. Action research is an accepted methodology within information systems research (Susman & Evered, 1978; Baskerville & Wood-Harper, 1998; Davison et al., 2004; Lindgren et al., 2004).

Lindgren et al. (2004) classify action research as an interventionist method that "allows the researcher to test a working hypothesis about the phenomenon of interest by implementing and assessing change in real-world setting" (p. 441). They further assert that action research is appropriate when researchers emphasize creating a change as an outcome of the research endeavor.

Butler and Murphy (2007) report a participative action research study to design a knowledge management system. They describe the building of the Knowledge Asset Development System (KADS) for a United Nations agency. Some of the features of the system include a knowledge map of the knowledge asset, a set of questions and answers, external resources to supplement these questions and answers, and a list of experts of the knowledge asset network. The action research process was informed by ontological design ("with its emphasis on theory, participation and discussion" [p. 152]) and performed by working with a knowledge asset coordinator from one of the agency's country offices and users working on a contraceptive logistics systems.

As mentioned, the objective of this study was to design, implement, and evaluate a system that could change the overall preparedness, communication, and knowledge management processes for emergency response within CUC. The lead author was directly involved with them in resolving issues inherent in their emergency-response communication and knowledge management process; that is, between the college consortium and its members. This led to a working hypothesis that the design and implementation of a Web-based knowledge management system could overcome the challenges faced by CUC as they prepare to respond to emergencies.

A formal, five-step canonical action research process (Davidson et al. 2004) was initiated by the lead author and approved by the CUC Board. The researchers, in collaboration with the Chief Executive Officer and the organization's Information Technology department, chose wiki technology as the basis for improvement efforts. The project was implemented over a two-year period (2003-2005), based on the following research tasks: *problem formulation* (December 2003-August 2004); *action planning* (September – November 2004); *intervention* (November 2004 - January 2005); *evaluation* (February-March 2005); and *specification of learning outcomes* (April – July 2005).

5.1 Research Setting

During the study, the lead author worked at CUC as the Emergency Preparedness Assistant, reporting to the Chief Executive Officer (CEO) and Chief Administrative Officer (CAO), starting in December 2002 as a part-time staff member. The researcher spent 3-8 hours per week working on emergency-response issues. His job function included setting meeting agendas for emergency-response meetings, keeping the minutes for the meetings, helping to develop emergency-response

policies; answering questions about emergency response from both CUC and its members, and so on.

It quickly became clear to the lead author that existing knowledge about emergency response was poorly organized. The majority of it was stored in paper-based manuals, with some of it outdated.

The previous Emergency Preparedness Assistant had accumulated ten years of information about emergency-response activities and plans on fifteen 3½-inch storage disks. The lead author had to determine what information was on these disks. It included staff-contact information, inventory information, and emergency-response organizational structure, some up-to-date and some not. It was clear that emergency-response knowledge had to be managed better.

In December 2003, the lead author met the CEO and CAO, stating his intention to undertake this study and create—with his newly-formed project team (i.e., his co-authors)—a Web-based emergency-response system for the organization. He introduced the concept of action research to the CEO, suggesting that the team would use a five-step process, based on the canonical action research methodology (Susman and Evered 1978). The five steps proposed were problem diagnosis, action planning, intervention, evaluation, and specification of learning outcomes. These steps and ideas were approved by the CEO. The researcher was asked to begin a formal problem diagnosis. This meeting marked the formal beginning of the project—called the Emergency Management System [EMS] project—and involved the entities listed in Table 1.

5.2 Problem Diagnosis

The researcher interviewed ten representatives from the MACC and the CCERC to begin to understand the issues in emergency response for CUC and its members. The interviewees were selected based on their regular participation in emergency-response meetings and drills. The interviews were recorded, and then transcribed and analyzed using open coding (Neuman, 2003).

Table 1. Entities involved in the EMS project

Entity	Role in the EMS Project
Claremont University Consortium (CUC)	• Offers central services to its members, including campus safety, facilities management, library, payroll, textbooks, and emergency response. • Employer of the project sponsor (viz., the CEO).
Claremont Colleges (CUC members)	• Members of the consortium. • Each has an emergency-response plan, facilitated by an Emergency Operations Center (EOC). • Each provides a representative from its EOC to the Multi-Agency Coordination Center (MACC). These are the end users of the EMS.
Emergency Operations Center (EOC)	• Plans for emergency response. • Active before, during, and after emergencies. • Separate EOCs exist for the consortium and every member college.
Multi-Agency Coordination Center (MACC)	• Coordinates emergency response activities at CUC. • Activate only during emergencies.
Claremont Colleges Emergency Readiness Committee (CCERC)	• A 'think tank' for the MACC. • Sets the policies and initiatives for the MACC.
Consultant	• Employed by CUC to assist in drills and emergency simulations. • Ensured that the EMS would be aligned with CUC's objectives. • Reviewed system model accuracy and project progress with researchers.
IT Department	• Supports the information and communication processes for emergencies. • Worked with the researchers during system development.

The interview questions specifically sought understanding about the following issues:

1. Understanding of terminology, committees, roles, and responsibilities.
2. Satisfaction with how the MACC and the EOCs respond during emergencies.
3. Concerns about emergency-response information.
4. Sources of knowledge used currently.
5. Satisfaction with the existing knowledge base for emergency response.
6. The role of information technology in emergency response.

Analysis of the initial interviews and follow-on interactions with CUC suggested that the top three concerns about emergency-response knowledge were: (1) information overload; (2) outdated information; and (3) an over-reliance on paper-based documentation.

Overall, respondents were interested in a Web-based system that could better structure emergency-response knowledge. Supporting comments include:

Having information that every service could use would be important. ...(emergency-response information should) be put in such a way that it is easy and simple to use ...the single easiest and powerful way is to use electronic media. ...having something simple for everyone to look at is a start.

We need to devise systems and programs that would enhance our internal and external communication systems. There needs to be joint communication and training efforts. Practice together, sharing of information e.g. Web, audio conferencing and such. There needs to be a combination of hardware and software use. Hardware, e.g. use of ID cards. In terms of software, we have availability of things like wiki, E-log and so on, which can help in some of the issues. Web based information for both staff and outsiders and the public can be enhanced. In summary, there is significant potential for IT but this would involve resources and training.

To improve to emergency-response initiatives the team recommended designing and implementing a Web-based knowledge management system. Examples of comments received in response to this recommendation include:

We have way too much of information. Everyone works with computers the idea is not technology when something happens, but how it can be used to plan and coordinate efforts in preparing for an emergency situation.

The CEO had the following to say:

There are always flaws and it would be naïve to say that all information sources are accurate; however, over the past several months, the information sources have become much more accurate. Conciseness in emergency-response instructions would eliminate a lot of information overload. This is something over which CUC has little or no control. The binders that we have cannot guide immediate action, as we need information that is quick and relevant when something happens. When an emergency does occur, we are both transmission (from the MACC to colleges) and receiving information (from colleges to the MACC). We don't have time to rely on binders when things happen very quickly.

The result was the decision to proceed with designing and developing the EMS.

5.3 Action Planning: Why Wiki?

The key activities involved during the action planning stage were: (1) determining the user requirements for the proposed system; (2) developing criteria to guide design decisions; and (3) proposing a system given available options and these criteria.

A total of twenty six people were interviewed by the research team to gather their perceptions

about creating the EMS and to identify its basic functionality. Detailed requirements, not presented here, were developed.

Action planning involved selecting an approach for designing and developing the EMS. However, the research team did not disregard theory while making design decisions (Davidson et al. 2004). The team used prior work by Alavi and Leidner (2001), Burnell et al. (2004), Jennex and Olfman (2006), Lawrence and Lorsch (1967), Miller (1956), and Turoff et al. (2002, 2004) to guide its decisions. The research team considered a total of seven knowledge management systems technologies as classified by Gupta and Sharma (2004). The technologies considered include document management systems, expert systems, groupware (a wiki being one example), decision support systems, semantic networks, databases, and simulation tools. The team felt that some kind of groupware application might work well to support the emergency-response efforts for CUC.

After considering the various choices within the groupware category, the team opted for a wiki-based approach. Three reasons led to this decision. First, the CEO stressed that the project would not have any budget to spend on technology; this mandated the use of open source tools. Second, wikis have the capabilities needed for the project—ease of use and support for collaborative development of knowledge. Third, the research team had experience working with wikis.

5.4 Intervention: Specific Implementation of Wiki Technology

Once the wiki approach was selected, the team had to select a specific wiki implementation. The software that drives a wiki is the wiki engine (Kille, 2006). A variety of free wiki engines (sometimes called wiki clones) are available from the Web. Examples of the more popular wiki clones are, Wiki (the original wiki [Leuf & Cunningham, 2001]), TikiWiki (www.TikiWiki.org), JOSWiki (a wiki based on Java operating system), and Plone (a content management system; www.plone.org). Although wikis are easy to use once installed, the installation stage can require experience with databases and server configuration. Individuals and corporations may not have these skills, or the intention of managing a wiki using an internal server. In this context, services from a variety of wiki hosts or wiki farms can be obtained. Wiki hosts or farms, operate wikis for their clients as a for-fee service. Examples of wiki farms are Seedwiki (http://www.seedwiki.com), JotSpot (http://www.jot.com), and Socialtext (http://www.socialtext.com) (Kille, 2006).

TikiWiki was selected as the engine based on the team's experience using it. Tikiwiki 1.7.4 was installed on a test server. The system was migrated to a production server hosted by the IT department. Tikiwiki bundles together the requirements for a Web server (Apache), a database server (mySQL) and front-end Web pages (written in Python). We selected particular components of the wiki that we expected to support user requirements.

The goal in the intervention phase was to implement a system having features needed to manage knowledge about emergency response at CUC. Wiki technology can be customized according to the requirements of the targeted users or wiki community (Leuf and Cunningham 2001). The administrator can create modules related to the different requirements. In this case, the wiki prototype had a total of six modules. The nature of these modules, objectives, and key functions within them are summarized in Table 2. The modules were developed based on feedback from MACC members and the consultant.

Overall, the technology was to be used to support the use by the MACC and the EOCs of knowledge from different sources, including emergency-response plans, weather reports, lessons from drills, training materials, and information about emergency supplies.

The system was functionally tested by two IT department staff members. The main objective of functional testing was to ensure that: (1) the

Table 2. Key system features

Module	Module objectives	Functions
MACC Information	This module offers quick links to information about the status of supplies and resources, such as debris-removal equipment, housing, first aid kits, and food.	Responders in charge of supplies can regularly update this information. This information can also be shared though the MACC, for all phases of emergency-response
Consortium Links	This module provides access to emergency-notification protocols, phone directories, and meeting note summaries.	Allows MACC members to easily update/edit the system, and share this knowledge with all consortium members.
Calendar of Events	Information about meetings, meeting summaries, drills training events and other related activities. Assists EOCs and the MACC to coordinate activities.	Allows the MACC and EOC members to update and share information.
Emergency knowledge base	This module has links to local weather conditions, transcripts from drill sessions, and governmental emergency-response agencies.	MACC and colleges EOC members can update and add relevant links share knowledge with one another via the wiki.
Maps	This module offers links to maps of member colleges and service units within CUC.	The maps can be embedded with building specific information, such as where hazardous material is located and where emergency supplies are maintained.
Situation board	This module permits real-time updating and knowledge sharing between the MACC and EOCs during a crisis.	Wiki pages can be edited by anyone from anywhere and shared instantaneously.

system could support different user groups, i.e., administrators, users, and casual browsers; (2) the identification and password protection feature was functioning well; and (3) all links were operational.

The consultant verified that the links and page formats for the system were realistic and supported basic requirements. An internal planning meeting was held with the consultant, the IT staff members, and the researchers. The purpose of the meeting was to make sure that the IT department staff members were comfortable with TikiWiki, and able to provide support to end users. The role of the consultant was to make sure that the modules created on the system were relevant to emergency response in general. He also provided input about information needed for each module. Adjustments to the design from this meeting were to remove modules for recent updates and calendar, and to replace them with modules for a MACC Situation Board and a Knowledge Base.

5.5 Evaluation

The prototype of the EMS was demonstrated in January 2005. The CEO, two IT Department personnel, representatives from the MACC, the Operations Chief, and the consultant were present in this session. The general response from attendees was that the system could facilitate the emergency-response communication and coordination process by:

- Providing a common platform to document information.
- Maintaining knowledge about what is happening across the colleges.
- Allowing EOCs to shop for resources needed during an emergency.
- Enabling a more effective documentation process for emergency-related policies.
- Making people aware of who was doing what in an emergency.
- Providing users with knowledge that is needed rapidly.

- Offering users an alternative process for sharing knowledge about emergency response.

It was decided, with the support and endorsement of the CEO, that the system be used to facilitate a campus-wide earthquake drill in February that year. The MACC members were to use the system as part of their emergency training during this event.

The demonstration we closed with the following question:

Do you people think that we can sell this to the members involved in emergency preparedness at the All Colleges level?

The Operations Chief remarked:

I think as I mentioned earlier, we are light years ahead with this system. I don't think we need to sell this; I am going to inform the group [MACC] that this is how we are going to proceed in the future. I don't wish to delay in implementing this system, I am telling them this is what we need to do.

Another member said:

I like the system in that it consolidates information in a single space. We also need to give access to our representative to the city [the MACC sends one of its members to represent the consortium at the City emergency operations center]. He needs to know how to use the system as it can be used remotely. Having access to the city would help him get a bigger picture of what is happening here.

A systems training session was conducted on February 14, 2005 for all MACC members, prior to use during the earthquake drill. The training session audience was fourteen people from four different colleges and the consortium. The CEO and the CAO were also present. The lead author led the session, with support from the consultant.

The system was then used during the drill, which presented the scenario of the consortium having been hit by a 6.9 magnitude earthquake. The MACC was activated. The Operations Coordinator posted key information about the situation on the home page of the system. Fifteen drill participants from several colleges reported to the MACC and were asked to use the system to report the situation, campus action, and status of their respective resources, based on a predetermined set of scenarios for each college. The MACC Situation Board module was supposed to guide emergency-response coordination between the MACC and the respective EOCs.

System effectiveness was evaluated through a series of one-on-one interviews with MACC members. An instrument had been developed to facilitate the evaluation process, and this was used to guide the interview sessions. Thirteen individuals were interviewed. These individuals were selected based on the following:

- Regularity of participating in emergency response activities.
- Familiarity with emergency response at the consortium.
- Attendance at both the February 14 training and the February 17 drill.
- Key positions held within the MACC.
- Willingness to participate in the interview process.

The instrument had two parts. In part one, the respondents were asked to indicate their perspectives about the usability of the system based on ten statements. The statements, based on the work of Brooke's Systems Usability Scale (1996), are:

1. I think that I would like to use this system frequently.
2. I found this system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.

5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

Respondents were asked to provide ratings for this set of statements, as well as to discuss (in an open-ended response) any aspects of the system with which they were uncomfortable. Ratings involve a five-point scale: Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), and Strongly Agree (5). Ratings were reversed, as appropriate, to adjust for statement direction.

Part two of the instrument had two open-ended questions to ascertain (1) if the system would be useful to capture knowledge about emergency response; and (2) if it would enable people involved in emergency response to share knowledge.

The emergency knowledge management system received an average score of 69.5 points, of a possible 100. Stated differently, in terms of its usability, the system scored approximately 70%. A maximum score of 100% means that the system is very simple to use. A score of 70% means that the system could be improved from the users' perspective. Although the respondents were able to use the system during the drill, they indicated that the system could be improved in terms of overall structure and design. In addition, they mentioned that more training and familiarity with wiki technology were needed. The following statements are quotes from interviewees about aspects of the system they were not comfortable with.

One respondent called for better navigation:

We need to have more links such as link to traffic updates. When we had our drill the other day, I was sitting next to one of the campus safety officers. He had pointed out that the action list where we have the list for All Schools laid out in one page, could end up a list that is simply too long. Every school is on the same page. It might make more sense to break the page down or create new pages by school, but this is subject to further discussion. In the event of a real emergency that list could be very long and might be too hard to manage. I could see why they want everything on one page, but it could become cumbersome or time consuming if all this information was on one page. That would be one aspect that I am not totally comfortable with the system.

Another suggested that an e-mail feature inbuilt within the wiki would be useful:

There needs to be an easier way to send an e-mail message. This feature will make the system less cumbersome. For me to send an e-mail using the system based on the training, I need to open a smaller e-mail window and keep another window for the emergency management system. This was cumbersome. In an ideal world there should be a way for us to send an e-mail message to anyone, and this should be done via the system itself. This can prevent one from needing to shrink a particular window that can be cumbersome. And if one were upset or anxious during an emergency this could become even more cumbersome.

Several respondents stressed on the need for more training:

I have nothing in particular to comment, at this time. But I may need some technical support to show me how to create links both within the system and also how to use and develop external links. Perhaps some example in the form of writing will help.

I think that there must be an easier way of going between screens. If you can somehow lock the navigation bar on the left then this might help

us further. Because you do have to go pretty far down the MACC Situation Board pages, we may need tabs on top of the system to smooth out the navigation process. These can be incorporated for future training sessions.

I guess that it's just a matter of getting used to the navigational aspect of the technology and becoming more familiar with it. I guess more training is needed.

The many different screens were a hindrance. It would have been nice to be able to stay on one screen for the most part, and just use a single click to get to another screen. In editing the screens, we had to weed down through everyone else's fields especially the case on the resources page. I think navigation can probably be improved overall in the future.

The majority of the users requested a written step-by-step "cheat sheet" that guides how each module can be used. Particularly, they requested guidelines for creating new pages (links) and also editing information in a given page.

5.5.1 Knowledge Capture

In general, the members felt that system would be useful to capture knowledge about emergency response. Following are examples of the responses that we received.

One respondent described the notion of the system as a knowledge book. Nevertheless, she was quick to point out on the importance of knowledge sharing.

I think that it will help us create an archive of every actual emergency drill, and also any other related activities that we conduct. This tells me that the system might serve as a useful knowledge book, or "book of knowledge" so to speak. People must be willing to contribute to this book though.

In general the respondents agreed that the features in the wiki were useful to capture knowledge about emergency response.

Yes the EMS can support information and knowledge capture about emergencies. The central location to post information and other documentation that is up there, such as all the PDF files that I have given you [referring to one of the researchers], will be a useful information base.

Yes, the system can help us capture information/knowledge about emergency planning and response.

Certainly, the scribe could copy and paste information into any Microsoft program such as Excel or Microsoft Word for later usage.

Yes, it is smart to be on the computers because much of the communication/information with our campuses and the world outside can easily be obtained if the MACC rep is connected to a computer.

There are many links that reflect the capability of this. It does give us more accurate information. Now we have a written record of everything that is done and by whom.

Yes, as long as people are willing to follow the plan and keep to it, we should be on track.

The system provides a common platform/space, structuring of information.

One respondent stressed the fit between the task and the technology:

Yes, the system can support information and knowledge capture, but technology should support the nature of tasks we have in that room, and not hinder it.

5.5.2 Knowledge Sharing

In general, the members felt that the system would enable people involved in emergency response to share knowledge with one another. However, issues such as need for training and the existence of a knowledge-sharing culture must be considered.

One respondent said:

As mentioned, easy access to the system and a fairly direct way to input ideas will allow people to share knowledge about emergency preparedness with each other. It will; it will allow them to populate the database or to fill in the blanks.

Another suggested the importance of having an overall objective of using the system to support knowledge sharing efforts:

Yes the system can support knowledge sharing, but there needs to be a clear "big picture" page that is one click away. We will be so busy entering information that an update page should not be a hurdle to find knowledge that we need.

Other responses were:

Yes the system can support emergency knowledge sharing efforts. Once the system can import and export information via e-mail, and other programs, it is really simple to do that. You can get an idea of what's happening and answers to your questions from the system, when required.

Yes the system supports knowledge sharing efforts. The system has useful refreshing abilities, and allows sharing of information and knowledge with each other instantaneously. It provides timely information and therefore can help better communication between the EOCs and the MACC.

Two respondents stressed the importance of a knowledge-sharing culture:

The system is a useful communication tool, and when and if people share information, we can use this to support reporting functions as well.

Yes, the technology can support this effort. However, frankly, I don't think all the members from the various colleges have a knowledge-sharing culture. Based on my experience here, my guess is that people need to share more information about emergency planning with each other. It seems easier to share with some relative to others. I guess we are comfortable with speaking directly with people, and may not be willing to share information in an open platform. This needs to change though. People must be willing to share information with each other.

The above findings support the viewpoint of Butler and Murphy (2007) who suggest that tools for knowledge management should include features based on 'practical theory' and insights from hermeneutics. One consideration is to foster a knowledge-sharing culture at CUC, maximizing the value of the EMS.

9. CHANGES MADE IN RESPONSE TO USER FEEDBACK

The lead researcher left his position with CUC after completing his doctoral study in 2005. Before leaving the organization, the research team took the following measures and provided several recommendations to CUC. First, the team developed a written document that explains the purpose and use of every module in the emergent management system. The team suggested that this document be used to guide training on emergency response, as well as how the system could be further developed. Second, the led researcher trained his successor in the use of the system and what needs to be done to enhance its usability, particularly in terms of navigational aspects.

It has been almost two years since the original system was implemented. It has been improved significantly, with respect to overall flow, documentation, and navigation. The system, as it is today, inherits many features from the original EMS. These features include codification of expert information on emergency-response issues, blogs, and links to relevant resources.

10. CONTRIBUTIONS TO THEORY

Turoff et al. (2004) provide researchers and systems designers with a framework for designing systems to support emergency response. The authors discuss nine premises:

- The system must be used in training and simulations.
- The system must consolidate information and prevent information overload.
- The system must enable responders to document their learning and experiences, e.g., an organizational crisis management memory should exist.
- The system must integrate information and knowledge from various sources.
- The system should support collaborative work and ensure unrestricted access to responders and planners.
- The system should specify the role and responsibility for people involved in emergency management, and how these roles might evolve during an actual emergency.
- The system must provide valid and timely information.
- The system must support and enable free-flow of exchanging information.
- The system must enable people and entities involved in emergency management to coordinate with each other.

Turoff et al. (2004) does not explicitly mention that the design of emergency-response systems should be based on sound knowledge management principles. However, one could argue that these nine premises, as described above, are closely linked to the goals of knowledge management (Murphy & Jennex, 2006).

This study indicates that an organization's culture and effective utilization of any emergency-response system within the organization may be related. The authors accurately mention that any system designed to support emergency management must support free exchange of knowledge and information. The authors take a systems-design perspective in discussing this premise. The outcome of this project suggests that, although a particular technology can support free sharing of knowledge, the notion of "sharing" will only exist in organizations where a "sharing culture" is nurtured (Davenport & Prusak, 1998; Jennex & Olfman, 2005).

Turoff et al. (2004) does not explicitly discuss the notion of fit between task and technology in the context of emergency response. The project findings propose that successful implementation of an emergency-management system is contingent on the ability of the system to blend with the nature of tasks involved in emergency response. This is consistent with Jennex and Olfman (2001) design recommendations for task and knowledge capture fit in a knowledge management system. During the project-closing meeting with the researcher, the CEO remarked:

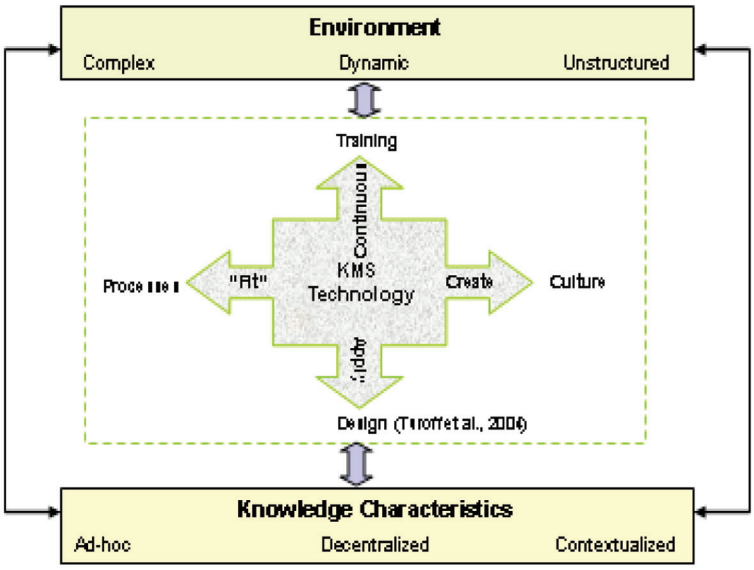
The system itself is fine, but the MACC Chair and the Operations Coordinator still have to decide about our response and task of decision making cannot be replaced by the system, albeit can be supported by the system. In addition everyone can have access to a common set of information. This means everyone (with reference to the Emergency Operation Centers) can act prematurely and go

talk directly to one another, without going thorough the central body (the MACC) to coordinate efforts. For example during the drill, someone asked, if we need a particular resource and know that someone else has it, why do we need to go through the MACC? This is a valid question. But, the point is, there might be another request for the same resource that is far more urgent that yours, and the MACC has to coordinate this. So, this could be a pitfall of a system. Unless protocols for using the system are established to support the tasks that have been designed, we could face problems in the future.

Figure 1 illustrates how the project findings can further inform theory about systems for emergency response. This study suggests that the environment faced by emergency responders is complex, dynamic, and unstructured. This assertion echoes the work of Burnell et al. (2004). The majority of literature about emergency-response systems does not clearly state that systems designed to support emergency response are associated to knowledge management. This study suggests that the environment faced by emergency responders forces them to deal with the following characteristics of knowledge:

- Knowledge for emergency response is used as needed when an emergency occurs; its *use may be ad hoc*. Individuals and groups involved in emergency response can not necessarily plan responses to all particular situations before-hand so need the ability to locate and utilize relevant knowledge.
- The knowledge repositories to respond to a particular crisis tend to be predominantly *decentralized*. In this case, knowledge resides within eight different emergency operations centers, plus the MACC.
- Emergency response requires responders to deal with knowledge that is highly *contextualized*. Every crisis is unique and requires a different set of ideas and response initiatives (Burnell et al. 2004).

Figure 1. Impact on theory



Given the above, the findings of this study suggest that any system designed to support emergency response organizations should be closely linked to ideas inherent within the domain of knowledge management. A particular technology selected to support emergency response should be appropriate for knowledge that is ad hoc, decentralized, and contextualized.

This study suggests that wiki technology is a good option for a system to manage emergency-response knowledge. It is appropriate for knowledge that is dynamic and decentralized (Wagner, 2004). Nevertheless, technology alone is not sufficient to foster effective emergency-response initiatives. The system should be designed to support emergency responders and must be used in every drill and emergency-training activities (Turoff et al., 2004; Jennex, 2008). We add that in addition to effective design and training considerations, two additional factors are required when thinking about emergency-response systems:

- A good "fit" between the knowledge management system and the existing emergency-response policies must be sought. Stated differently, the technology should support, not hinder, emergency-response initiatives.
- There is a need to foster a knowledge-sharing culture between various entities involved in a given emergency-response organization structure. In the case of CUC, this refers to the willingness of different emergency operation centers to share information/knowledge with one another.

11. PRACTICAL IMPLICATIONS

Emergency response is important for every organization (Kostman, 2004; Van Kirk, 2004). This study contributes to organizations that want to use IT to aid in emergency response. Although technology cannot prevent emergency situations from occurring, it can help organizations be ready to handle such situations. The Homeland Security Office recently released a comprehensive document stressing the importance of establishing a comprehensive emergency-response plan for both government and the private sector in the United States. This document is called the National Incident Management Systems (NIMS).

Key NIMS elements, as stated in the FEMA Web site (http://www.fema.gov/nims/), include: (1) Incident Command System (ICS); (2) Preparedness; (3) Communications and Information Management; (4) Joint Information Systems; and (5) NIMS integration center. The focus of this project was to assist CUC in enhancing items (1) and (2). The project can be extended to other entities within the Claremont Colleges. In addition, other organizations with similar emergency-response structure to that of CUC, can model findings and recommendations based on the outcome of this project. Entities that establish a comprehensive emergency response based on NIMS guidelines stand a better chance of receiving federal funding for emergency-related activities and claim for post-emergency reimbursement. Our study suggests that, if designed and implemented properly, wiki technology can support the communication and information management requirements in relation to emergency planning and response.

The nature of wikis promotes several aspects of knowledge management for emergency response. These include the capability of most wiki tools to support multi-author creation and revision of Web pages; storage and retrieval of related documents, images, and presentations; searching of these; management of changes to them; and online discussions during a crisis situation.

The system in this project used an instantiation of wiki technology called Tikiwiki. Tikiwiki is one of hundreds of wiki technology implementations. It was chosen because it is an open source implementation with many additional features to complement the wiki itself. In the two years since this decision was made, the market of wiki products

has continued to grow. Some of them are now much easier to install, administer, and use. Their capabilities are greater, as are their interfaces with other software tools. In this study, however, wiki technology appeared to have several drawbacks.

First, the technology was not as intuitive as we expected. Becoming familiar with it took more time than it should have. Not everyone involved in the drill and training in the project was comfortable with the technology. They were more used to "read-only" Web-based systems. The power of wiki technology lies in its ability to capture dynamic changes within its pages based on the edit function. Using and working with this editing capability might require some time and sufficient training, depending on the implementation of wiki chosen.

Second, wiki technology has numerous capabilities and features. Customizing the relevant features so as to support emergency-response activities optimally was not that intuitive, even for the researchers who had reasonable experience with the technology and emergency response. Depending on the 'flavor' of wiki selected, this could be a problem for the design of emergency-response systems.

Third, wiki technology is available open-source. Organizations that intend to develop systems to support emergency response have the option of purchasing off-the-shelf systems that come with vendor support. If financial resources are available, but technical expertise is not, this might be a superior option for some organizations.

12. CONCLUSION

This study uses wiki technology to understand important issues in designing knowledge management systems to support emergency response. Specifically, an action research study was conducted to understand if wikis can be used to implement a knowledge management system and if such a system can support knowledge management for an emergency response organization. The study suggests that effective implementation and use of a wiki to support knowledge management for emergency response is contingent upon familiarity of both emergency planners and responders with the technology, level of planning involved prior to system implementation and use in an actual emergency, continuous training with the systems, establishing a fit between task and technology, and the willingness of members to share knowledge with one another. Organizations similar in emergency-response structure to the consortium examined should be able to apply the findings and recommendations from this project. Entities that establish a comprehensive emergency-response plan stand a better chance of receiving federal funding for emergency-related activities and claims for post-emergency reimbursement. Wiki technology, based on our experience, if designed and implemented properly, can provide a cost effective technology to support emergency response within a multi-entity organizational environment.

Additionally, it is also concluded that wikis used for knowledge management for an emergency response organization also needs to be able to be integrated into an overall Social Network Site as proposed by Plotnick, White, and Plummer (2009) and White et al. (2009). Knowledge management is also about leveraging what the organization knows and improving connectivity between knowledge sources and knowledge users (Jennex, 2009). While a wiki accomplishes this, it is expected that a Social Network Site integrating several social communication media will do this better.

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