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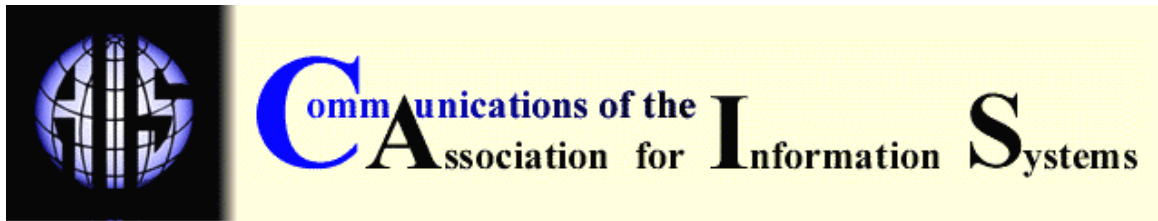
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WIKIS FOR TEACHING AND LEARNING

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ABSTRACT

An academic course presents an opportunity for all participants to collaborate for improving their knowledge. This collective improvement of knowledge is typically documented via material provided by the instructor and notes and assignments prepared by students. Over the course of a semester, these materials provide not only the collective knowledge in that course, but also provide a chronological history of how the knowledge base evolved. The focus of this study is wiki collaboration in teaching & learning contexts.

A wiki is a medium in which a group of individuals can work together asynchronously on an idea and easily capture the essence in a reusable format. Technically, a wiki is a collection of hyperlinked Web pages that are assembled with wiki software. With wikis, the line between reader and contributor is intentionally blurred. Further, wiki use reflects the view of an instructor as one who facilitates information sharing among learners rather than simply transmitting knowledge from themselves to their students. Our initial motivation to explore the usefulness of wikis for teaching and learning was driven by the fact that wikis provide a medium in which several individuals could asynchronously work together on an idea and easily capture the essence in a reusable format. We found that: (1) Wikis can be used for a variety of tasks ranging from business analyses to analyzing policy positions to serving as a signup sheet for students to self organize; (2) Instructor support and facilitation is key; and (3) Ease-of-use issues are present but do not preclude success.

KEYWORDS

wiki, collaboration, knowledge creation, knowledge management, conversational technology, computer-mediated communications, instructional technology, open source, open authoring

I. INTRODUCTION

"The basic (idea) of the Web is that (of) an information space through which people can communicate, but communicate in a special way: communicate by sharing their knowledge in a pool. The idea was not just that it should be a big browsing medium. The idea was that everybody would be putting their ideas in, as well as taking them out."
[Berners-Lee, 1999]

To students and professors alike, an academic course is an experience in which all participants collaborate to improve their knowledge. The collective knowledge is typically documented via a mix of lecture slides and notes, writings submitted by individuals and teams, and various synchronous and asynchronous online media. In this tutorial, we focus on the collaborative activities in teaching that can be enhanced by wiki technology. Wikis are a relatively new medium that enable a group to develop, refine, and improve a body of knowledge asynchronously in full view of all participants.

Groups can collaborate in many ways and can use a variety of tools to facilitate their joint work. We ground our discussion of wikis by placing it in the context of suitable technology for models of learning, as described by Leidner and Jarvenpaa [1995]. Others have studied wikis (e.g. [Auger et al., 2004; Bergin, 2002; EDUCAUSE, 2005; Godwin-Jones, 2003; Raman et al., 2005]) and other forms of conversational technologies [Wagner, 2004] such as email, blogs, and discussion forums.

This tutorial emerged from the experience of faculty and students at San Francisco State University (SFSU) between January 2005 and June 2006. Both faculty and students at SFSU are still in the early stages of adoption. The purpose of the tutorial is to present ideas on how wikis can help facilitate student collaboration in learning contexts, as well as to share our experience in what did and didn't work well with wikis. This tutorial is neither a how-to-use-the-technology guide nor a comprehensive evaluation of the technology.

What initially motivated us to explore the usefulness of wikis was the fact that they provided a medium in which several individuals could asynchronously work together on an idea and easily capture the essence in a reusable format. Wikis also provide a chronological history of the evolution of the knowledge base. These capabilities seemed incredibly useful for team projects in academic courses, for non-seat-time learning, and for working with research colleagues in some contexts. This latter use is beyond the scope of work described in this paper.

The paper is organized as follows. Section II describes the wiki tool and associated social phenomenon. Section III provides a conceptual discussion of wikis for teaching. Section IV and Appendix 1 include a discussion of alternative technologies for knowledge management, and highlight the comparative advantages of wikis. Section V describes thirteen experimental cases of wiki use in teaching at San Francisco State University. References to practical experience at other universities are also made in the paper. Finally, Section VI draws conclusions from the conceptual and practical discussions to reiterate the comparative advantages of wiki use in student learning.

II. WHAT IS A WIKI?

The wiki name was reportedly taken from the Hawaiian term "wikiwiki," which means "fast, speedy; to hurry, hasten; quick, fast, swift" [Leuf and Cunningham, 2001a]. Quickness is implicit in wikis because the user can simultaneously read and edit content. This idea was also the intent of some of the early Web browsers such as Amaya, where the editing was also done within the browser [W3C, 2006].

A "wiki is a freely expandable collection of interlinked Web pages, a hypertext system for storing and modifying information – a database, where each page is easily edited by any user with a forms-capable Web browser client" [Leuf and Cunningham, 2001a]. An author can plant the seed of an idea in a wiki and, if it attracts a sufficiently large body of contributors, return one week later to see how the idea grew.¹

Cunningham developed the first wiki in 1995 to serve as repository and communications mechanism for software engineers [Delgadillo, 2004]. Wikis were gradually adopted for other public contexts (e.g. Wikipedia, Wikitravel), educational contexts (e.g. CoWeb at Georgia Tech), and business contexts.

A wiki can be viewed as a community-owned and operated Web site. Anyone in the community has the right to read, modify, and delete content. This concept is distinct from a typical Web site in which only a designated few author(s) or editors can generate content; everyone else is a reader or

¹This "seed" sentence is paraphrased from Bishop [2004].

commentator. Wikis are distinct from blogs and discussion forums in that the latter two tend to have predefined, chronological structures that all content fits into. In some ways, a wiki follows a *tabula rasa* or blank sheet approach where most of the complex knowledge is constructed out of simple ideas [Henson and Borthwick, 1984]. A wiki is more like a space in which contributors can define and refine both structure and content. The open authoring that takes place in public wikis resembles the development of open source software [Markus et al., 2000].

In the language of Cheung et al. [2005], a wiki community can be characterized in terms of motive, cardinality of interaction, source of content, and autonomy.

- The *motive* is to exchange information and knowledge.
- The *cardinality of interaction* is many-to-many because wikis “harness the combined resources of all community participants for the potential benefit of all.” The many-to-many characteristic distinguishes wikis from blogs or email [Wagner, 2004].
- The *content* is generated through group interaction.
- Wikis represent an intermediate level of *autonomy* in that they involve a community effort, but there are not well-defined rules for engaging the community of a given wiki (on a team project) or a wiki article (in the case of a large public wiki).

Anthony et al. [2005] found that contributions of “high quality content to Wikipedia suggest that open source production enables exploitation of untapped productive resources that overcome barriers to efficient production of collective goods.” In Wikipedia, a free encyclopedia found on the Web at <http://www.wikipedia.org> [Wikipedia, 2006a], and arguably the world’s largest wiki, anyone with Web access can create a wiki article and/or modify content on an existing wiki article. The result is that Wikipedia is filled with useful content, and has a high signal-to-noise ratio [Nature, 2006].

VERSIONING CAPABILITY

The self-refining nature of content produced by individuals collaborating with a wiki is meticulously tracked by the wiki’s versioning capability. Figure 1 shows an example of versioning with the “7 July 2005 London bombings” wiki article that first appeared on Wikipedia [2005] at 9:18am on that date; and by 11:00am the same day was modified more than 300 times by almost 100 unique contributors.

Wiki versioning is powered by a server-based application that retains changes in content by tracking the differences, often referred to as *diff*. Each version is the result of the original, and subsequent modifications. Versioning is useful to:

- Monitor the content’s development
- Permit rollbacks in the event that document modifications need to be undone
- Gauge extent to which individuals contributed to the development of a wiki article

The tracking feature found in popular word processing tools (e.g. Microsoft Word) provides a more limited ability to monitor changes to a document.

- [\(cur\)](#) [\(last\)](#) ☐ [09:38, 7 July 2005 Morwen](#) (*looking more like terrorists*)
- [\(cur\)](#) [\(last\)](#) ☐ [09:37, 7 July 2005 Rich Farmbrough](#) **m**
- [\(cur\)](#) [\(last\)](#) ☐ [09:37, 7 July 2005 222.153.37.150](#) (*→External links*)
- [\(cur\)](#) [\(last\)](#) ☐ [09:37, 7 July 2005 222.153.37.150](#) (*→External links*)
- [\(cur\)](#) [\(last\)](#) ☐ [09:37, 7 July 2005 Merovingian](#) **m** (*wording*)
- [\(cur\)](#) [\(last\)](#) ☐ [09:36, 7 July 2005 Morwen](#)
- [\(cur\)](#) [\(last\)](#) ☐ [09:35, 7 July 2005 84.176.202.137](#)
- [\(cur\)](#) [\(last\)](#) ☐ [09:32, 7 July 2005 Morwen](#) **m** (*London Underground power surge incident moved to London Underground explosions*)
- [\(cur\)](#) [\(last\)](#) ☐ [09:30, 7 July 2005 Merovingian](#) **m** (*→External link*)
- [\(cur\)](#) [\(last\)](#) ☐ [09:29, 7 July 2005 Morwen](#) (*+fr again*)
- [\(cur\)](#) [\(last\)](#) ☐ [09:28, 7 July 2005 Morwen](#)
- [\(cur\)](#) [\(last\)](#) ☐ [09:28, 7 July 2005 Vberger](#) **m** (*+fr*)
- [\(cur\)](#) [\(last\)](#) ☐ [09:21, 7 July 2005 Morwen](#)
- [\(cur\)](#) [\(last\)](#) ☐ [09:18, 7 July 2005 Morwen](#) (*start*)

Figure 1. Sample Excerpt of Wikipedia Version History

Figure 2 illustrates the *diff* capability. The first two lines existed in version 2 of the wiki article. In version 3, the second line was modified (i.e. How does) and an additional line was added (i.e. A lot depends ...). Lines of text from earlier versions are denoted with a “-” prefix, and new or modified lines are denoted with a “+” prefix.

Differences between version 3 and 2 of Long-term assignment.

This will be an ongoing journal for the rest of the semester.

-How does an inline editor improve or hinder the process of writing a journal? We don't know yet.

+How does an inline editor improve or hinder the process of writing a journal?

+A lot depends on how the editor is implemented. For example, a HTML based editor is usually very useful.

Figure 2. Illustrative Diff Example

VANDALISM CONCERNS

When coherent and interesting content is posted, why isn't it vandalized [LATimes, 2004]? Public wiki sites are, in fact, subject to frequent vandalism and inaccuracies [Viegas et al., 2004]. A wiki works best when an active wiki community collectively and continually monitors content changes. In the total set of readers, a vocal minority is interested in maintaining the quality of any given wiki article. For example, if someone deletes the four page article on UNICEF from Wikipedia, then in all likelihood it'll be corrected within minutes or hours.

A wiki's version history allows work that was deleted or vandalized to be rolled back relatively easily. With Wikipedia, for example, individuals interested in monitoring a given article can quickly be informed of changes via email updates or RSS feeds [Godwin-Jones, 2003].

SIMULTANEITY ISSUES

Wikis enable asynchronous communications to be conducted in different physical spaces. Given the technological mechanism that wikis use for updating content, simultaneous or synchronous collaboration may create problems when two users attempt to update the same content [Wagner, 2004]. Some wiki implementations deal with this situation by using locks (to preclude overwriting newer content), notifications (to notify users of potential conflict) and graceful workarounds.

COMMON EDITOR CAPABILITY

Wiki users edit content via a word processor-like tool *within* a browser. The end-user views the editor and the Web page as being part of one application. This client-based editor is completely independent from a desktop word processing application such as Microsoft Word. Users can edit rich-text wiki articles within a browser from anywhere on the Internet. Use of the universal client (a Web browser) for writing relieves groups of collaborators from needing to agree on a single word processing or text processing tool and version.

The editor is usually implemented using Javascript, which is well-supported in popular browsers such as Mozilla Firefox, Opera and Microsoft Internet Explorer. This limitation does create a limitation, though, for users of browsers that do not support Javascript or who turned Javascript off in their browsers.² Figure 3 shows several WYSIWYG editors that have been implemented within web browsers.

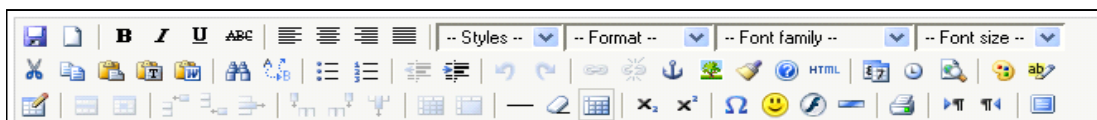
(a) Moodle Wiki HTML editor



(b) Wikipedia editor



(c) TinyMCE editor



(d) FCKEditor

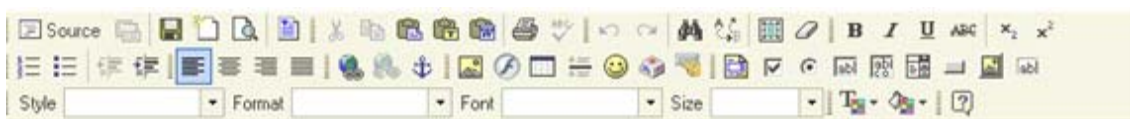


Figure 3. Sample Web Browser Editors

Although we did not conduct formal usability studies on the rich text interface, it seems intuitive that having wiki editors with a familiar WYSIWYG word processing interface greatly simplifies user adoption. These editors are capable of such tasks as formatting, hyperlinking, embedding images, copying, and

² Javascript was implemented into browsers in 1995 as a client-side language to enhance the browser experience Benson [1999].

pastings.³ Most of these editors use HTML to store wiki page formatting internally, and HTML is portable across Web platforms and word processors.

ACCESS CONTROL

Access control for wikis refers to read and write (or edit) access to wiki content. The three broad forms of access control policies for wikis are:

- A wiki that allows *anyone* to read and write wiki content is the most open type of wiki.
- A wiki that allows *anyone* to read but only selected (and therefore authenticated) users to write content. This form is sometimes referred to as a fishbowl wiki [MeatballWiki]
- A wiki that allows only selected users to read and write content.

In practice, how the term *anyone* is defined in these three wiki access control policies depends on the context in which the wiki is made available to online users.

- If the wiki is a module within a broader information system (IS), then *anyone* likely refers to users that are authenticated by the broader IS.
- If the wiki is a standalone application, then *anyone* potentially refers to all WWW users.

Some wiki administrators establish blocking policies that restrict based on userid or source Internet Protocol (IP) address. Wikipedia, for example, identifies a long list of reasons why a block might be issued, including [Wikipedia, 2006c]: vandalism, excessive reverts, personal attacks which place users in danger, posting personal details, disruptive behavior, and bots.

SCALABILITY & STABILITY CONCERNS

The emergence and rapid growth of Wikipedia demonstrates the viability and scalability of the wiki approach for collaborative undertakings.⁴ This is related to but distinct from the scalability or stability of the underlying wiki technology platform. [Wagner, 2004] states that a “possible hindrance to the rapid adoption of wikis is the relative instability of their architecture. Many wiki software packages are currently under development as open source, with frequent updates, bug patches, and new version releases.”

Wiki technology is still maturing but whether or not a particular wiki package is open source software does not imply a level of architectural stability. Quite to the contrary, some argue that the open source software development process leads to greater architectural stability than proprietary software [Feller and Fitzgerald, 2000; Fitzgerald and Kenny, 2003; Menasce, 2003].

III. WIKI BENEFITS IN TEACHING

“Wikis might be the easiest and most effective Web-based collaboration tool in any instructional portfolio.” [EDUCAUSE, 2005]

“In the virtual learning environment, the instructor provides visions for directions, orients the chaotic situation that results from multiple individuals simultaneously creating and

³ Specific browsers may have issues with some editors. For example, at the time of this writing, the FCKEditor project does not support the editor in the Safari web browser -- the default Web browser for Mac OSX.[0]

⁴ The (near) exponential growth of the English language version of Wikipedia is given in [http://en.wikipedia.org/wiki/Wikipedia:Modelling_Wikipedia's_growth]. URL last accessed 2 August 2006.

sharing knowledge, and sets the deadline by which visions will be realized.” [Leidner and Jarvenpaa, 1995]

We focus on facilitating collaboration and knowledge creation among peers in a teaching and learning context that extends over time and distance. Leidner and Jarvenpaa [1995] provide an excellent theoretical framework with which to understand the role and benefits of using wikis in such a context. Their premise is that the effectiveness of information technology in teaching and learning is a function of how well that technology supports a model of learning and the appropriateness of that model to the particular learning situation.

A wiki is a type of groupware that supports asynchronous communications across distances. Such groupware can be used to establish virtual learning spaces, or environments, that facilitate collaboration across time, interruptions, and distance. Leidner and Jarvenpaa [1995] argue that this type of information technology supports the collaborative learning model, which is a derivative of the constructivist model [Bencze, 2005; Huitt, 2003]. The constructivist model emphasizes student-centered learning. The premise of collaboration is that “learning emerges through shared understandings of more than one learner.” One instructional implication of this model is that the instructor’s role focuses on facilitating information sharing among learners rather than on transmitting knowledge from themselves to students.

From a teaching perspective, the wiki also facilitates the cognitive information processing model of learning. This model is another extension of the constructivist model and stresses the importance of individual learning styles. The versioning capability of wikis provides instructors with the ability to monitor student collaborations over time, and to step in and provide assistance as deemed appropriate.

Beyond learning course content itself, information systems designed for collaboration are known to facilitate teamwork – an important learning objective in and of itself in many teaching contexts [Alavi and Leidner, 2001].

A growing literature documents instructors’ specific experiences with wikis, and their understanding of why wikis are beneficial in teaching and learning contexts; e.g. [Auger et al., 2004; Bergin, 2002; EDUCAUSE, 2005; Godwin-Jones, 2003; Raman et al., 2005]. In Section V, we describe the experience of a number of SFSU faculty with wikis in teaching.

For now, consider a simple example to contrast two scenarios in which students are to collaborate on an analysis and written deliverable document. Scenario A is one in which students do not use a wiki, scenario B is with the wiki.

Scenario A

Step 1	Students meet to discuss project requirements and to divide up the task.
Step 2	Students analyze the situation either as a group or individually.
Step 3	Each student individually works on his/her own section(s) of the report until it is completed.
Step 4	Each student distributes his/her respective write-up to other teammates or to the designated editor.
Step 5	Someone collects all written pieces and assembles a single document.
Step 6	Someone edits the document to improve its readability.
Step 7	Someone submits the document to the professor for review. If interested in understanding the contribution of each member, the instructor must depend on student input.

Scenario B

Step 1	Students meet to discuss project requirements and to divide up the task.
Step 2	Students analyze the situation as a group or individually.
Step 3	Each student individually works on his/her own section(s) of the report. They put their (draft) write ups on the wiki. Each student also can read and refine teammates' sections as they progress.
Step 4	The instructor can review the document when it is deemed complete, or when it is being written. If interested in understanding which group members contributed which elements, the professor can review the version history of the Wiki.

This simple example illustrates how a wiki can be helpful. The downside of Scenario A is that it limits the opportunity for collaboration made possible by Scenario B. Scenario B permits the group to make individual contributions and to refine the work of others. That is, all work is shared as it is written. Surely, feedback loops could be instituted in Scenario A but they become cumbersome and time-consuming once the document is assembled into one piece. One team member would refine the document, and then send it to the next. In Scenario B, everyone can review, refine and create on an on-going basis.

But won't this simultaneous reviewing, refining, and creating lead to chaos or completely unstructured and incoherent text [Leuf and Cunningham, 2001b]? That is possible, but the large public wikis (e.g. Wikipedia) demonstrate the viability of this approach. On the scale of a small team in a class, it should be easier to establish a few ground rules or to designate an editor to oversee the evolving report. With a team wiki, a large proportion of readers and contributors have a vested interest in the quality of any given wiki article.

The following list demonstrates other possible uses of wikis for student collaboration. The examples are from the literature and from unpublished experience and ideas at SFSU:

- Application of concepts to real-world scenarios
- Business and technology analyses
- Frequently Asked Questions (FAQs) [Bergin, 2002]
- Glossary [Schneider, 2003]
- Hints on how to use the course software effectively [Bergin, 2002]
- Home pages for students [Bergin, 2002]
- Icebreaker exercise [Auger et al., 2004]
- Knowledge management system experience [Raman et al., 2005]
- Literature review
- Living encyclopedia about university or university community⁵
- Peer review of writing exercise
- Personal portfolios [Higdon, 2006]
- Signup sheet [Gill, 2005]
- Student journaling [Higdon, 2006]
- Syndicating / Aggregating web resources [Higdon, 2006]

Aside from the specific learning objectives achieved through successful implementation of such assignments, two other aspects of wikis that benefit students are:

- They work with a live document rather one sequentially exchanged by collaborators; and
- They have access to the document history for reflection and for reverting to earlier versions if necessary.

⁵ Case Western University's Case Wiki (<http://www.case.edu>) is an excellent example of such a wiki that students could potentially contribute to as part of a class assignment.

WIKI SETUP

Depending on the specific wiki software at hand, the instructor is offered many degrees of freedom when structuring the wiki for a specific learning activity. The examples users listed above reflect one degree of freedom. How the instructor “stages” the wiki is another, and finally the authentication, authorization and accounting (AAA) troika from information security is another degree of freedom [Aboba et al., 2000; Egan and Mather, 2005]

The instructor can stage the wiki in a number of ways. This pedagogical choice should be based on the objectives of the assignment. For example, if one of the objectives is for the students to structure an unstructured problem, then the instructor could establish a wiki without structure or content. If one of the objectives is to encourage development of predetermined ideas, then the instructor could seed the wiki with an initial outline in the form of page stubs. Each page stub would then be expanded into a wiki page. Or, if one of the objectives is to encourage analysis of an existing argument or situation, then the instructor could establish a wiki with both structure and content that the students would interpret and refine.

*Authentication, Authorization and Accounting (AAA).*⁶ As discussed previously, access control for wikis refers to read and write (or edit) access to wiki content. The applicability of the access control policies to teaching and learning contexts are illustrated below:

- A wiki that allows *anyone on the WWW to read and write* wiki content is the most open type of wiki.
 - e.g. Wikipedia. An assignment in which students collaborate with the broader Wikipedia audience on specific topics. Users contributing to Wikipedia are given the option of authenticating so that their content is associated with the identity.⁷
- A wiki that allows *anyone on the WWW to read, but only authenticated users to write* content is relatively more common in educational contexts.
 - e.g., Case Western Reserve University’s Case Wiki [University, 2006] in which all wiki content is viewable by anyone, but only members of the university may create and modify content.
 - e.g., a biology class at Oregon State University in which anyone may view wiki content but only current students may modify wiki content [Bledsoe, 2006].
 - Student home pages, student portfolios

Wikis that are a module within a learning management system such as Moodle [Moodle, 2006] or Blackboard [Blackboard, 2006] authenticate a user prior to providing them access to online class materials and resources (e.g. wiki). Keep in mind that the instructor is given read and write access to all student wiki content.

- A wiki that allows *anyone in the class to read and write* wiki content.
 - e.g., a class in which all enrolled students collaborate on one wiki, but no one outside of the class receives access.
 - e.g., icebreaker exercises, FAQs, Hints on using course software
- A wiki that allows *anyone in the class to read, but only a defined team of students to write* wiki content.

⁶ Availability of these capabilities depends on the wiki technology and the setup of this software by the system administrator.

⁷ Some Wikipedia pages are locked or require authentication prior to editing.

- e.g., a class in which there are multiple teams, each with a fishbowl wiki. Only team members may create content, but other teams' members may read content.
- e.g., student home pages, student portfolios
- A wiki that allows *only a defined team of students to read and write* wiki content.
 - e.g., a class with multiple teams, each with their own workspace.
- A wiki that allows *only a given student to read and write* wiki content.
 - e.g., student journals, sandbox [Wikipedia, 2006d]

The Moodle Wiki, for example, is the DFWiki module implemented in the Moodle Learning Management System (LMS). From a pedagogical viewpoint, a wiki is an activity within the Moodle learning management system. With an integrated system such as this, a student authenticated for the LMS is already authenticated for the wiki. If the wiki is implemented outside the LMS, then separate authentications may be required for the wiki and LMS; unless the organization managing both applications implemented a federated login capability.

The wiki version history represents the accounting element of the AAA troika. The version history can be used for forensic purposes after the assignment is completed, or for "monitoring rather than leading the knowledge creation process" [Leidner and Jarvenpaa, 1995].

Training is also an important aspect of setup that involves the wiki tool but is focused on setting up students, as it were, rather than setting up the technological infrastructure.

STUDENT FLEXIBILITY

In addition to the instructor options laid out above, students can be given additional flexibility as well. For example, if the wiki-based assignment does not dictate a specific structure of wiki content, then students can either put all content into a single wiki page or split the content into a set of hyperlinked pages (each of which represents an article or section of a broader piece). The tradeoffs with each approach are:

- Putting all wiki content into a single wiki article
 - An upside of this approach is that it is similar to preparing a document in a traditional word processor.
 - Downsides are that lengthy content can become unwieldy in some wiki editors, and a very lengthy wiki page may not fit into the memory allotted to the browser.
- Splitting wiki content into hyperlinked wiki pages
 - Typically a better way to structure wiki content.
 - It helps to modularize the content, a natural fallout if the content is outlined at the outset or later after the body of knowledge develops somewhat. Modularity may also make it easier to divide responsibilities so that a given team member is assigned primary (but not exclusive) responsibility for that section.
 - It is easier to edit shorter pieces in many wiki editors.
 - The wiki content can more easily be worked on simultaneously by team members.

Another aspect of student flexibility is the manner in which students collaborate within the wiki itself. Collaboration invariably involves editing, reworking, or refactoring wiki content so that it reads better.⁸ A wiki etiquette policy helps frame reasonable behavior when one contributor modifies the content of another. Wikipedia [2006b] and American [2006] are two examples of wiki etiquette policies that demonstrate this concept; though neither should be interpreted as universally appropriate for all wikis.

⁸ For purposes of this argument, distinctions between reworking and refactoring are not key.

In addition to using the wiki to create content that will end up in a submitted deliverable, students can use the wiki to share ideas during the process; meta-writing in a sense. In this way the wiki can serve as the ultimate “yellow sticky” to post ideas to share while they are on one’s mind. This approach should help reduce idea leakage by maintaining such ideas in a central location, thereby producing a better final product.

ASSESSING OUTCOMES

To paraphrase Turoff [1998], the challenge of using wikis to benefit teaching and learning is simultaneously to maximize synergies, learning, stimulation, and varied expertise while minimizing domination, free riding, information overload, conformance pressures, coordination problems, evaluation apprehension, and incomplete task analysis. This goal can be operationalized with a transparent grading or assessment mechanism. A study of assessing wiki content is an important extension of this paper.

IV. ALTERNATIVE TECHNOLOGIES

Wikis are one of several technologies used for facilitating collaboration and knowledge creation among peers in a teaching and learning context that extends over time and distance. Wagner [2004] identifies nine types of conversational technologies that can be used to manage knowledge and that can be (or have been) used in teaching and learning contexts:

electronic mail	internet chat & instant messaging	Group Decision Support Systems (GDSS)
static & database-backed web pages	video & audio streaming	weblogs
discussion forums	video & audio conferencing,	

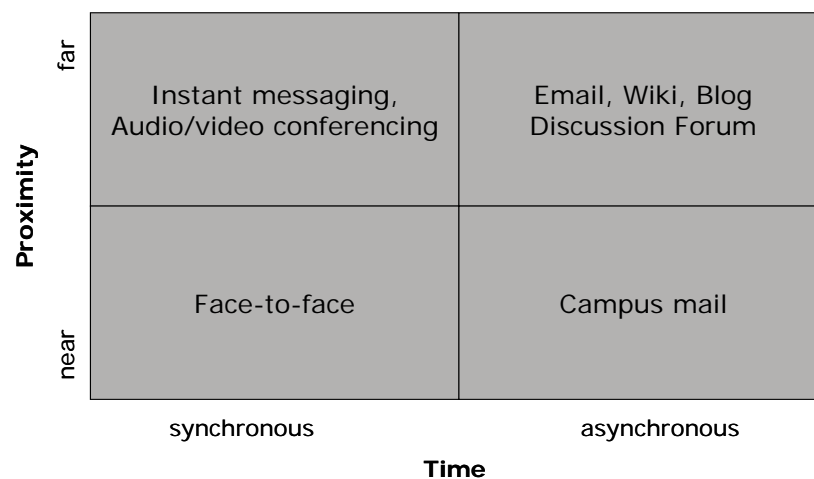


Figure 4. Comparison of wiki to other collaboration contexts

These conversational technologies (described in Appendix I) are used when participants are not physically in the same location. The techniques match the environment in which student teams frequently operate. Conversational knowledge creation is an approach that can be characterized as fast-paced and suitable for environments with decentralized information. Knowledge is decentralized because all team members contribute to the analysis [Malhotra, 2000]. Conversational technologies are a subset of computer-mediated communications tools [Warkentin et al., 1997].

Figure 4 shows several collaboration tools or media in a two dimensional space (proximity and time) and is similar to the comparison of conversational technologies in [Wagner, 2004]. Wikis fall into the quadrant of asynchronous communication conducted in different physical spaces.

V. SFSU WIKI EXPERIENCE

The discussion of wikis in teaching thus far draws from theoretical frameworks, instructional planning, and practical experience at San Francisco State University (SFSU) and other institutions. In this analysis, we explore thirteen cases in which wikis were used for teaching at San Francisco State University. Several of the cases are actually composite cases that reflect several similar uses (and setups) of wikis in teaching.

In each case, wikis were used to facilitate collaboration and knowledge creation among peers in a teaching and learning context. The dataset is drawn from the preliminary experience that ten faculty from four SFSU Colleges (Business, Education, Health & Human Services, Humanities) gained with wikis in teaching during the January 2005 to June 2006 time period. Eight of these faculty were interviewed face-to-face or via electronic mail; the other two are the authors of this paper.

Table 1 summarizes the setup and learning objectives for each case. An analysis of instructor effectiveness and student learning is then provided. This information is largely based on self-assessment during and after the wiki use. The cases are presented in no particular order.

All wikis described in these cases were used in online courses established within the Moodle Learning Management System (LMS) implemented at SFSU. Students are authenticated prior to being granted access to the LMS, and then provided with access to courses in which they are enrolled.

Several themes arose from an analysis of these SFSU cases of wikis in teaching. The reader is reminded that this assessment of wiki use is both preliminary and informal. An important extension to this study is a more thorough and formal analysis of wiki effectiveness in teaching.

MOTIVATION

Students were significantly more inclined to participate with the wiki when such use was mandated by the instructor and backed up by an explicit assessment or grading scheme. Wiki use varied when its use was optional. In Cases A and D, where teams were given wikis as a private workspace, a minority of teams opted to use the wiki to improve team productivity. Cases G and H were similar in that the entire class was provided with a space to share course notes, but had different outcomes. In Case G, designated student facilitators voluntarily posted chapter summaries to the wiki, along with discussion questions and their own answers to the questions. A subset of the other students pitched in to help answer questions. In Case H, though, no students were designated as facilitators or leads on topics that might be posted to the wiki. The rationale was to see if students would spontaneously treat the wiki as a valuable and shared resource. The outcome was a resounding no. In Case M, where students were provided personal and private wikis to practice with wiki technological features, several students participated.

The limited use of wikis when that use was voluntary can be partially explained by the findings of Leidner and Jarvenpaa [1995] who summarize literature stating that collaboration in a virtual learning space, such as a wiki, may be more effective for mature, motivated learners. Another factor is that the wiki is a new technology to many students. Based on the SFSU experience, we identified two other potential rationales for student hesitation to employ wiki technology for collaboration in learning.

- Some students with minimal professional work experience were intimidated by working with a new technology in which their activity is easily monitored by others (e.g. versioning).

Table 1 – San Francisco State University Wiki in Teaching Cases

Case	Wiki Use	Description
A	For teams to undertake a business and/or and technology analysis	<ul style="list-style-type: none"> • Instructor established wiki for each team without structure or content. Instructor did not participate in wiki. • Only a defined team of students could read and write wiki content. • Wiki use was required in some classes, and voluntary in others.
B	For everyone in class to apply selected course concepts to real-world situations	<ul style="list-style-type: none"> • Instructor established and structured single wiki for entire class. Then, seeded it with course concepts (e.g. [Alter., 2006; Porter, 2001]) and list of real-world scenarios to which students were to apply the concepts. • Anyone in the class could read and write wiki content. • Wiki use was required on repeated occasions to ensure that students not only contributed new content but were motivated to rework others' content.
C	For everyone in class to develop a literature review for graduate research	<ul style="list-style-type: none"> • Instructor initially established wiki for class without structure, then periodically participated to add structure. • Anyone in class could read and write wiki content. • Wiki use was required on repeated occasions. Instructor defined phases that alternated student contributions and instructor contributions.
D	For teams to communicate during online simulation games	<ul style="list-style-type: none"> • Instructor established wiki for each team without structure or content. Instructor did not participate in wiki. • Only a defined team of students could read and write wiki content. • Wiki use was voluntary.
E	For teams to undertake a needs assessment	<ul style="list-style-type: none"> • Instructor established wiki for each team with an introductory page that outlined project steps. Instructor did not participate in wiki. • Anyone in the class could read, but only a defined team of students could write wiki content. • Wiki use was mandatory.
F	For signup sheet in which students self-organize into project teams	<ul style="list-style-type: none"> • Instructor established single wiki for entire class with placeholders for teams and team members. • Anyone in the class could read and write wiki content. • Teams had to ensure that all team members were listed on wiki, but this information could be provided by self-designated team leader.

Case	Wiki Use	Description
G	For summarizing assigned readings	<ul style="list-style-type: none"> • Instructor established and seeded wiki with one student's summary. • Anyone in the class could read and write wiki content. • Wiki use was voluntary.
H	For sharing class notes and study strategies	<ul style="list-style-type: none"> • Instructor established and seeded wiki with suggested topics. No other structure provided. • Anyone in the class could read and write wiki content. • Wiki use was voluntary.
I	For posting a project summary	<ul style="list-style-type: none"> • Instructor established wiki with no structure or content. • Anyone in the class could read, but only a defined team of students could write wiki content. • Wiki use was mandatory.
J	For teams to prepare social policy positions in preparation for a debate	<ul style="list-style-type: none"> • Instructor established wiki with minimal, initial structure. • Only a defined team of students could read and write wiki content. • Wiki use was voluntary.
K	For teams to compose student workbooks	<ul style="list-style-type: none"> • Instructor established wiki for each team with initial page of instructions in wiki. • Anyone in the class could read, but only defined team of students could write wiki content. • Wiki use was mandatory.
L	For communicating with students and to distribute materials to students	<ul style="list-style-type: none"> • Instructor established wiki with structure and content. • Anyone in the class could read the wiki, but only the instructor could write wiki content. • Wiki use was mandatory.
M	For individuals to practice with the wiki technology in privacy; sometimes referred to as a sandbox.	<ul style="list-style-type: none"> • Instructor established wiki with no structure or content for each student. • Only a given student to read and write wiki content. • Wiki use was voluntary.

- On the other hand, some students with extensive professional work experience (e.g. executive MBA students) hesitated because they were comfortable with other communications tools they used (e.g. electronic mail) and did not see value in learning yet another new communications tool for the classroom.

Two tentative takeaway lessons, therefore, are:

- Mandate wiki use if it is very important and if you want to ensure that all students participate.
- Promote wiki use in the classroom if you want to encourage a greater number of students to participate.

Raman et al. [2005] argues that a grading policy might be a vital factor when using technology to support discovery learning. This argument supports the first takeaway message. The second takeaway is consistent with a Yoo [2005] remark that wiki use should be connected to on-going discussions in the classroom, and Siegel et al. [1986] who state that if computer support is appropriately integrated into the task at hand, it will likely encourage more equitable participation among members.

AGGREGATION, NOT COLLABORATION

Unless strongly guided to do otherwise, students tended to accumulate or aggregate content on wiki pages rather than truly collaborate. This finding was based on observations of the version history maintained by the wiki. The distinction between aggregating and collaborating is that collaborating requires one student to modify the content posted by another student (i.e. rework earlier writings by others), whereas aggregating is simply adding content to an existing wiki page.

The SFSU wiki cases demonstrate several techniques to encourage collaboration over aggregation. Case B is a composite case. For one of the case B situations, students were instructed to make two substantive contributions to the wiki during a six week period, but to ensure at least a two week period between the minimum contributions. The rationale for spacing contributions was to ensure that at least one of them was made at a time when the wiki content was sufficiently mature so that students would find it easier to modify existing content on a wiki page rather than add new content to the page. In Case C, the intent was for students to perform peer reviews of each others literature reviews, thus ensuring that students responded directly to each others work.⁹

WIKI USABILITY, OR EASE OF USE

Wiki usability refers to the ease with which students were able to use the wiki technology to undertake the stated assignment goals. The SFSU case analyses indicate that wiki usability, or ease of use, are a function of the software user interface and the stability of the wiki as an information system. A well-designed software user interface generally minimizes the importance of prior familiarity and/or training provided by the instructor. Wikis are sufficiently new to most students so that training on the mechanics of wiki usage is warranted in most cases [Raman et al., 2005].

Training is particularly true when writing or behavioral conventions differ from those typically found in wiki user communities. Case C raised an example of this difference when students (and the instructor) encountered a conflict between the use of square brackets in MLA style formats and the use of square brackets in wiki software to denote a new wiki page.

⁹ This aspect of the assignment was not ultimately implemented as other technological and ease of use issues intervened.

An unstable wiki information system tends to exacerbate any existing usability issues due to an increased level of frustration that users experience. The DFwiki module in the SFSU Moodle LMS exhibited several notable problems.¹⁰ “The HTML code sometimes became corrupted when pasting content from a word processing software. Also, the version history was truncated.

In cases where wiki use is voluntary, perceived ease of issues tend to drive students to opt out from wiki use, whereas in mandated wiki use cases students generally persevered until the instructor opts out. Case C exemplifies this.

STUDENT PERCEPTION OF WIKI VALUE

An informal survey of several sets of SFSU students indicated that while many students did not agree that the wiki is a useful tool for learning subject matter in a course, they did wish to use a wiki in another course. We interpret this as “we encountered problems with the wiki but can imagine it being quite useful.” Several specific points were raised by students:

- *Provides a live working document* - students can create and refine all parts of the document asynchronously
- *Provides history of evolving document* - students see steady progress, and also permits return to earlier version or recapture of deleted content
- *See changes from collaborators* - students can monitor contributions throughout the time period rather than just at the end
- *Encourages dialogue while writing* – improves quality of deliverable
- *Team members can participate from remote locations* – convenient for many SFSU students since they spend a minimal amount of time physically on campus due to work and home situations far from campus.
- *Difficult to keep track of updates* – some students found it more useful to write dates near each update to ensure that another team member noticed them, rather than rely on the version history

INSTRUCTOR PERCEPTION OF WIKI VALUE

All instructors indicated that using wikis in teaching can be effective, if set up suitably. In addition to the themes already described, we list a number of other setup issues that were highlighted as being important by faculty. Some of these actions were taken from cases documented in Table 1, while others are based on lessons learned and identified as steps for subsequent uses of the wiki in teaching.

- Understand wiki limitations and design the assignment with these in mind. For example, split up large collaborative manuscripts into a set of hyperlinked wiki pages or articles. Two drivers of this approach are:
 1. It will better enable multiple students to work simultaneously with the wiki content; and
 2. It is less likely to crash a wiki system that is incapable of handling large wiki documents.
- Setup an example wiki beforehand to help students conceptualize the use of wikis in their course.
- Create and distribute a how-to-use wiki guide to address ease of use issues.

¹⁰ This problem was resolved by SFSU's academic technology staff

- Consider serving as a quasi-team member to provide greater feedback for the collaborative wiki.
- Be more explicit about wiki usage expectations.
- Be more systematic in requiring that individuals post materials to the wiki for review and refinement by others.

NEW WIKI FEATURES SOUGHT

Finally, we identify three types of desirable features that would increase the value of wikis for teaching and learning:

- Distinguish between save and submit to increase the assessment value of the wiki version history. Submit would entail save plus placing entry in version history.
- Handle data forms other than text; e.g. graphics, multimedia
- Include an equation editor.

VI. CONCLUDING REMARKS

Collaboration is a fundamental aspect of the academic environment. Collaboration in academic courses with wikis is an experiment worth continuing. We found that wiki-based materials provided not only the collective knowledge in a course but also provided a chronological history of the knowledge base as it evolved. Our initial motivation to explore the usefulness of wikis was driven by the search for a medium in which several individuals could asynchronously work together on an idea and easily capture the essence in a reusable format. We found that the benefits and challenges were well beyond a collective chronological document.

In the teaching and learning contexts, we find that the instructor's role hinges on facilitating information sharing among learners rather than simply transmitting knowledge from themselves to their students as a one-way mechanism. From a teaching perspective, the wiki model facilitates a cognitive information processing model of learning. As an extension of the constructivist model, it stresses the importance of individual learning styles. In addition, the versioning capability of wikis to some extent provides instructors with the ability to monitor student collaborations over time, and to step in and provide assistance as deemed appropriate. Of course, the various methods of providing support and feedback depend on the course and the teaching model being used.

In terms of wiki use, we found that they can be used for a variety of tasks ranging from sign-up sheet for students to self-organize, to analyzing policy positions. We observed that unless strongly guided to do otherwise, students tended to accumulate or aggregate content on wiki pages rather than truly collaborate. It appears that support and facilitation are key to successful use of wikis. Some student observations were worth mentioning. Students found the capability to create and refine all parts of the document asynchronously as being very useful. Through the history of the document, students were able to see steady progress. Students could monitor contributions throughout the time period rather than just at the end. This ability encouraged dialogue while writing, leading to an overall improvement in the quality of the deliverable. Participation from remote locations was an additional advantage. We believe that supporting remote participant plays a special role in our case since SFSU, is an urban commuter campus.

Technically, we found that wikis can scale up fairly well. Wikipedia stands as a strong example of being a very large wiki-based repository. This finding is related to but distinct from the scalability or stability of the underlying wiki technology platform. We did find problems with editor implementations and with bugs in versioning, but presumably these technological issues will be resolved by improving the software over time.

SFSU, our institution, is a nontraditional campus community in terms of ethnic and age diversity, and in terms of the limited amount of time that students spend on campus when not attending

classes. This campus profile frequently makes it difficult for teams of students to meet as often as they'd like or they should. While it would be ideal if students just found a way to meet more often, a wiki tool that complements such face-to-face collaboration with a mechanism to collaborate remotely and asynchronously on a written product provides value worth exploring. We anticipate wider adoption and experimentation of wikis on the SFSU campus and other campuses like it. Giving SFSU students who live and work all over the San Francisco Bay Area additional opportunities to come together and discuss what they're learning is a positive step. We are confident that the wiki tool can enhance the learning environment in our courses.

We look forward to learning how others have fared with wikis in the teaching and learning context.

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Editor's Note: The following reference list contains hyperlinks to World Wide Web pages. Readers who have the ability to access the Web directly from their word processor or are reading the paper on the Web, can gain direct access to these linked references. Readers are warned, however, that

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APPENDIX I. ALTERNATIVE TECHNOLOGIES

We offer a concise analysis of alternative technologies to highlight the comparative disadvantages of each for facilitating collaboration amongst peers to establish a common body of knowledge in a teaching and learning context that extends over time and distance. The points raised are restricted to this scope, and do not address the advantages of these technologies for other objectives, other contexts, or as complements to a wiki.

ELECTRONIC MAIL, DISCUSSION FORUMS, AND WEBLOGS

A thread or sequence of contributions is an inherent part of the knowledge stored with electronic mail, discussion forum, and weblog (blog) technologies. The separation of messages is a key comparative disadvantage if the purpose is collaboration among students to establish a common body of knowledge with whatever structure they deem appropriate to that body.

A group can certainly collaborate via a series of electronic mail communications to create a body of knowledge, but someone must read through the entire chronological thread to pull together a mental picture of the current body of knowledge reflected by that thread. In a wiki, the article's version history is, in effect, equivalent to the thread in an electronic mail conversation. A team member can read the latest version of the wiki article to pull together a mental picture of the current body of knowledge reflected by that thread. Earlier versions are accessible if a historical perspective is desirable, but is not required. A similar argument can be made for discussion forums.

For a blog, the author initiates a posting and all related comments are associated with the original posting. Blogs are therefore most useful when an author seeks to state an opinion and then asks readers to respond to this opinion, but not change the original posting. Again, the group of collaborators is not at liberty to restructure the common body of knowledge completely.

Using a wiki incorrectly can also be detrimental. Consider the *LA Times* which in 2005 opted to post their editorials on a wiki rather than a blog.¹¹ Restricting readers to responding to the editor's content, rather than allowing readers to modify the editor's content, would have been a more suitable approach.

STATIC AND DATABASE-BACKED WEB PAGES

A web site, whether static or backed by a database, typically involves a few designated authors or editors that can generate content. Everyone else is deemed a reader or commentator. One might then ask how web pages are different than the fishbowl wiki described under Access Control, above. Therein lies the simplicity of creating and editing content on a wiki. Wiki content is typically created using a markup language that is simpler than a more general purpose markup language such as HTML or XHTML. The goal is ease of use rather than full functionality.

INTERNET CHAT & INTERNET MESSAGING

Chatting and messaging occur in real-time, which preclude collaborations over an extended period of time in which participants are not simultaneously available.

VIDEO AND AUDIO STREAMING

Streaming is inherently one way. A collection of streams would need to be assembled to even approach a collaborative effort. The difficulty then would be building a common body of knowledge from this set of streams.

VIDEO AND AUDIO CONFERENCING

This technology shares the real-time disadvantages of messaging and the information retrieval disadvantages of streaming.

GDSS

Group Decision Support Systems (GDSS) have been used for many years to facilitate brainstorming and consensus building [Gray, 1981; Power, 2003]. The primary distinction of GDSS from the other conversational technologies is that GDSS typically uses a problem-solving approach. The contrast between the structured collaboration methods that GDSS supports through software and the incompatibility of such features with a wiki is striking.

WEB-BASED COLLABORATIVE AUTHORING TOOL

A relatively new conversational technology is emerging, the web-based collaborative authoring tool that includes a mix of desktop word processing, wiki, and other features. Writely [2006], for example, provides a collaborative authoring environment with word processing features, checkout mechanisms to manage simultaneity issues, and access controls.

LIST OF ACRONYMS

CSU	California State University
DHCP	Dynamic Host Configuration Protocol
GDSS	Group Decision Support System
IP	Internet Protocol
LMS	Learning Management System

¹¹ See <http://www.latimes.com/news/opinion/editorials/la-wiki-splash,0,2142604,print.htmlstory> .

SFSU

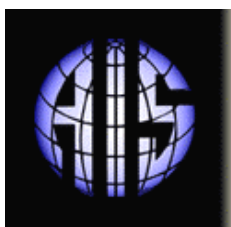
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