Using Google's Apps for the Collaborative Construction, Refinement and Formalization of Knowledge

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Abstract - *The utility of knowledge depends on how it is developed, refined and tested. Where knowledge concerns more than one individual, its value is increased through social processes involving cycles of tacit and explicit sharing for intersubjective criticism. Sciences and many organizations have well developed processes for managing the tacit-explicit cycling to produce what Vines and Hall call "formal knowledge". Nousala and Hall have studied the emergence of informal communities concerned to develop and refine bodies of knowledge relating to particular issues. The present paper describes one such emergent community's use of ICT to facilitate knowledge formalization. Their most effective solution uses free Internet applications in the Google "cloud" made possible by changes to Google Docs only released in January 2010. Although involving several poorly documented "apps" and their "gadgets" the resulting architecture is surprisingly coherent, user friendly and apparently robust.*

Keywords: Epistemology, Knowledge management, Knowledge formalization, Google Apps, Communities of practice, Collaboration, Web 2.0

1 Introduction

Knowledge claims deemed to be scientific or produced in organizational contexts are reasonably considered to be more authoritative than unsupported beliefs of single individuals. Knowledge building in these contexts is a hierarchically complex social process involving cyclic exchanges between subjecttive knowledge in particular individuals and explicit knowledge that is available to those who need it. Several knowledge building cycles are well known in the knowledge management community [1],[2], [3],[4]. However, here we ground our understanding of knowledge growth on an evolutionary epistemology derived from our own extensions of Karl Popper's later work, e.g., [5].

Knowledge growth is facilitated and constrained by socially constructed paradigms [6]. When people work within established "normal" sciences, technological paradigms [7] or organizational structures [8] there are usually well developed organizational "routines" [9] or formal processes to review, authorize and formalize their knowledge claims [10]. In academic and scientific frameworks, the gold standard of knowledge formalization is the process of publishing in peer reviewed journals. Similarly, most large organizations have specific workflows, often supported by technology .by which knowledge is reviewed and authorized.

The development of new knowledge often takes place in small groups or teams of people facing common problems or with common interests. It is comparatively easy to form such teams within well established organizational frameworks or research disciplines where potential members probably already know one another and have much in common, but knowledge building in these circumstances is normally only incremental [12],[13],[14]. On the other hand, major innovation often takes place in groups comprised of individuals crossing organizational, disciplinary or geographic boundaries [15],[16],[17]. However, the existence of such boundaries minimize opportunities for face-to-face contact, which impedes the development of such boundary crossing groups.

Also, where innovative research interests do not easily fit within boundaries of established scientific paradigms or organizations, we have found it difficult to access existing organizational paths and technologies. Appropriate technologies making it easier to cross these barriers can help build knowledge [18] to form what Myhill et al. [19] called a "virtual research environment". When their paper was submitted in February 2009, there were "as yet, no fully-operational examples" using Web 2.0 technologies.

Here we describe just such an environment set up by an informal community interested in the theory, ontology and management of organizational knowledge (the TOMOK Group). Its 15 members cross four continents and a variety of disciplines ranging from philosophy and biology to computer science and technical translation. The majority are independent consultants in the broadly defined area of knowledge management. Many lack current academic affiliations, and face difficulties accessing the reference literature required as background for building formalized know-ledge, and lack ICT support facilities of large com-mercial and academic institutions. Effective technolo-gies solving these problems will revolutionize the cognitive processes of research [20].

2 Ontology and Epistemology

We are concerned to understand how technology can help facilitate the origin and growth of new knowledge to extend our understanding of the world. At the risk of oversimplifying what are actually very complex and contentious issues, three theoretical concerns are particularly relevant our project, (1) what is knowledge? (2) how does it grow through time? and (3) how do we determine what knowledge is trustworthy?

2.1 "Knowledge" is about the world

Knowledge that is useful tells us things we need to understand about the world we live in. Karl Popper in his later works defined knowledge as "solutions to problems" [5]. When a person must act in response to a problem, ready knowledge needs to be embodied in mental and physical dispositions that comprise the person's knowledge of the world. Polanyi called this embodied knowledge "personal" or "tacit" [21],[22].

2.2 Three worlds

Popper [5] posited three ontological domains for understanding various forms and locations of knowledge. Hall's biologically based interpretation of these worlds [23],[24],[25] is followed here. World 1 ("W1") is the dynamic domain of physics and chemistry (i.e., uninterpreted reality), world 2 ("W2") is the domain of living cognition and knowledge (i.e., Popper's "dispositions", Polanyi's "tacit" and perso-nal knowledge), and world 3 ("W3") is the domain of objective (i.e., explicitly codified) knowledge.

2.3 Evolutionary epistemology

Popper argued that knowledge grows through an iterated process of applying tentative solutions to a problem and selectively eliminating those that clearly fail (either through criticism or detriment as a conse-quence of the failure to those trying the solution) and where the solutions that worked in effect change the problem state by having solved the initial problem ([21] - Figure 1). $\mathbf{P_n}$ is a "problem situation" the living entity faces in the world, $\mathbf{TS_m}$ represent a range of "tentative solutions" or "tentative hypotheses" the entity may enact or propose. **TS**s may even be randomly generated (cf. Campbell's "blind variation" [26]). **EE** ("error elimination") represents a process by which **TS**s are tested or criticized against the world to selectively remove solutions or claims that don't work in practice (this is the converse to Campbell's "selective retention"[26]). $\mathbf{P_{n+1}}$ represents the changed problem situation remaining after a solution has been incorporated. As the entity iterates and re-iterates the process (the arrow indicating iteration is added), it constructs increasingly accurate representations of and responses to external reality, even where there is no possibility for knowledge to directly "reflect" external reality [5]. Thus, the utilities of different knowledge claims are determined by the extent to which working solutions to particular problems are constructed or identified and exploited [27].

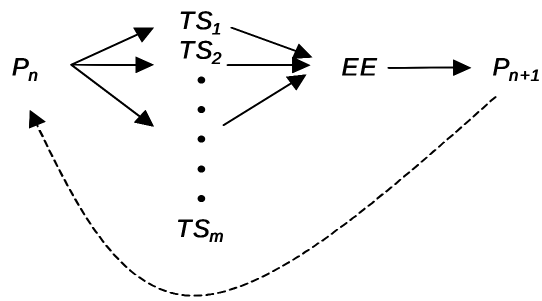

Figure 1. Popper's "general theory of evolution" (From [24] after [5] pp. 243),

Where scientific or organizational knowledge is concerned, this generic evolutionary process takes various forms at several levels in a hierarchically com-plex social environment involving single individuals, a group of collaborating individuals, a discipline, and the world-wide community.

At the personal level (Figure 2) knowledge growth involves building on existing sound knowledge, often sourced from W3, combined with current sense data as shown in the central boxes of the figure. This also involves tacit (verbal) knowledge exchanges in W2 with other individuals to make common sense [13]. Following Ong's [28] argument that speech is ephemeral (sound waves vanish in the instant of their expression and perception), even though spoken articulations are not tacit in Polanyi's sense [22], Hall places spoken exchanges of knowledge in W2. Indi-viduals may also explicitly codify their tentative understandings to make them available for intersub-jective consideration, criticism, testing and revision, as knowledge is cycled between W2 and W3.

2.4 Authentic and formal knowledge

A similar cyclical process as shown in Figure 2 can also take place at a supra-individual level in a group of collaborators with common interests [12]. However, where the collaborators are distributed in time and space, knowledge exchanges are increasingly mediated via digital and electronic technologies.

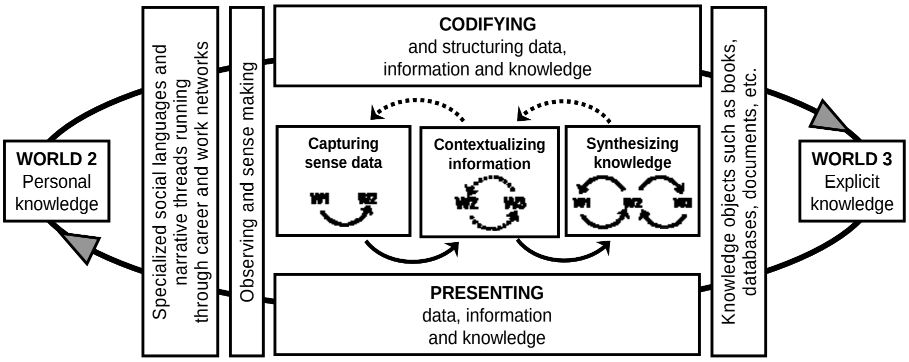

Figure 3. Knowledge construction at the personal level (after [10]).

As Figure 3 shows, a similar process of knowledge growth takes place on a still higher social level when an individual or collaboration submits a manuscript for publication in a disciplinary journal, or an organization seeks to give authority to a particular document. We see three major cycles. (1) An individual (or a small team of collaborators) codifies some knowledge claims in an explicit format that is discoverable and shareable, e.g., in a blog or on a file server, for intersubjective criticism. (2) If the draft makes sense to members of a wider community it may be informally adopted as "common knowledge". How-ever, with most common knowledge, we have no way to know how thoroughly the claim has been criticized and tested. (3) This consideration is answered in large organizations and academic communities by formal processes of independent review, author reconsider-ation, editorial acceptance or authorization, and formal publication. Knowledge claims that survive this stringently selective process represent the gold standard for an organization or discipline. The claims have not been proven true, but they have survived stringent tests designed to eliminate errors.

3 Where Technology Is Needed

By comparison to the slow and ponderous processes of managing the development of knowledge on paper, to maximally help collaborators, there are several ways a technology framework can speed and extend the cognitive work of building knowledge.

- *Rapidly discover and review relevant formal knowledge and mechanically link this with work in progress.* This ensures new knowledge builds on what is already known. What one collaborator discovers should be readily available to inform all collaborators. Copyright issues limit circulation of electronic copies of journal articles. Minimally, this requires password security limiting access to genuine collaborators.
- *Facilitate articulation of the knowledge in explicit*

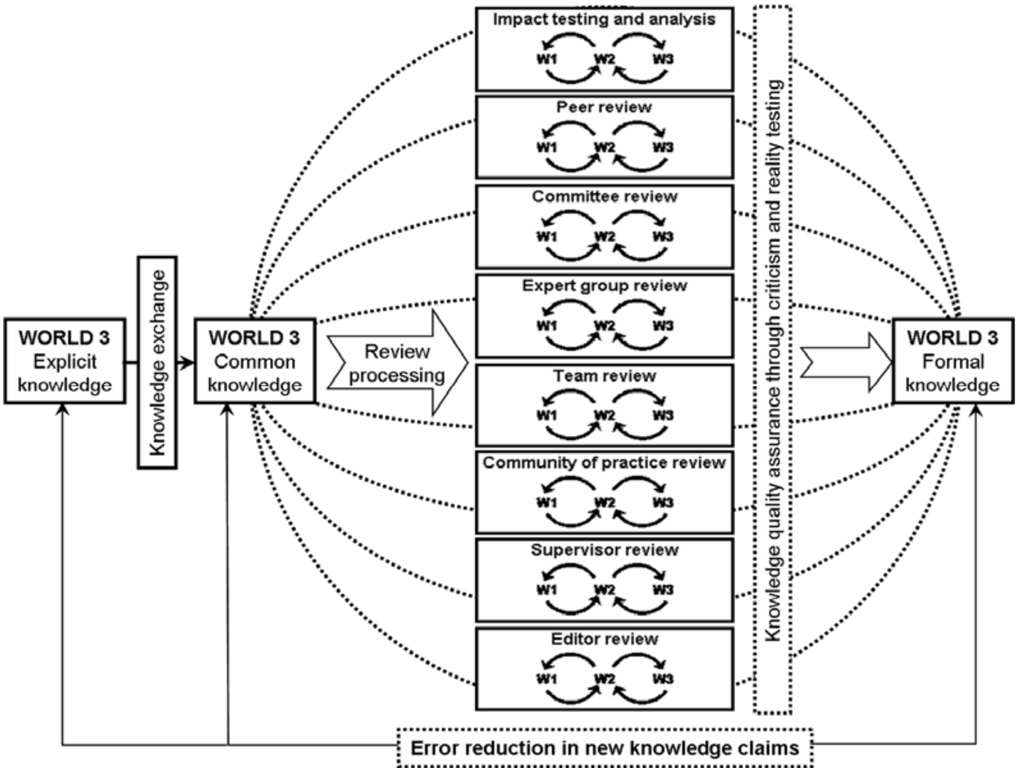

Figure 2. Social construction and formalization of knowledge (after [10]).

and readily shareable formats. Support technology should make it easy to externalize developing ideas.

- *Enable rapid asynchronous exchange and discussion of work in progress among widely distributed collaborators*. Today's collaborators may work anywhere in the world and are often away from their home resources. Exchanges may involve a variety of explicit media; from text, graphics, tabular material, and databases, through to recorded audio and video material.
- *File locking or other conflict prevention capabilities*. When more than one person is working on a document in a distributed environment, the support system should have a capability to prevent or at least recognize and warn of conflicting edits on the same document.
- *Support real-time dialogs via text and audio.*
- *Workflow management.* With potentially several people working on the same project, it is useful to have a capability to define, schedule and track the completion of project tasks.
- *Keep a record of the creative process.* Managing the versioning of developing documentation is especially important when several people work on the same documents. Given the tentative nature of many inputs, it is useful to know when they were made and who made them. It may be useful to revert to or re-apply deleted materials from prior versions. Work in progress also needs to be easily backed up so it can be retrieved from alternative sites should the main working environment fail.
- *Support informal and formal publishing processes.*
- *Provide easy access to formalized publications.*

Although TOMOK is centered in Melbourne, Australia, when it first began to coalesce in 2005 its members were already widely dispersed, with collaborators in the USA, France and other Australian states. Initially ideas were developed and honed primarily via email conversations accompanied by asynchronous exchange of documents. In 2007 it was decided that a multi-authored book, supported by an international conference, should be developed. Hall had more than 15 years experience working with collaborative content authoring and management systems in a defense engineering environment [29] and sought tools that would provide similar functionality for the TOMOK group.

We assessed several open source or otherwise inexpensive content management environments such as Wiki and other collaboration tools used in academic and knowledge management markets including edna Groups (http://tinyurl.com/656h8h), MediaWiki (http://tinyurl.com/9dkxk), Twiki (http://twiki.org/), Sakai (http://sakaiproject.org/), Xwiki (http://tinyurl. com/2a9bn2), and several others listed by WikiMatrix (http://tinyurl.com/fqc5m). None of the freely avail-able systems met all of our needs, and many required users to learn markup codes to format their words into documents.

The best solution found was BSCW, developed by Fraunhofer Institute of Technology, and marketed commercially by OrbiTeam (http://tinyurl.com/yhbz47h). BSCW met TOMOK's needs, was very well documented, and could be implemented in an unfunded university environment for no license fee. It is also available to anyone at no cost for three month trials. BSCW was implemented for the TOMOK group in a university environment, where we developed major resources to support the collaboration, including an electronic reference library of more than 2000 documents collected by collaborators, drafts and back-ground materials for some 10 papers, a wide range of presentations, and several funding proposals. BSCW proved the concept effectively, but due to support issues, the collaboration environment was unavailable for several months at a time. Thus, TOMOK members were reluctant to depend on BSCW as their primary support environment, and BSCW was abandoned early in 2009, and TOMOK fell back on standard email as a means of exchange. Due to busy schedules, even in Melbourne, we are lucky to get three collaborators together for a face-to-face once a month.

The situation improved in January 2010 when Google announced new functionality for their cloud computing [30],[31] document repository – DOCS (http://docs.google.com). Docs now offers equivalent repository functionality close to what TOMOK previously had in BSCW [32].

4 Google's Cloud Apps

After using them, it is clear that Google's cloud applications offer comprehensive technological support for research collaborations [33],[35] and additional advantages to unfunded groups such as TOMOK: (1) They are freely available to Web users, (2) require no local server hardware or administrative support, and (3) can be implemented with only moderate computer skills.

Google's apps used by TOMOK include:

- *Scholar* (http://scholar.google.com). For those seeking formal knowledge to build on, Google Search is *much* too inclusive – often returning millions of hits. Scholar (still claiming to be a beta product) specializes on content in the "deep" or hidden Web of formally published conference proceedings, journal articles and books available only to subscribers. For researchers with access to journals through library subscriptions now provides direct links via the subscription to electronic copies of formal journal articles. Based on tracing references from bibliographies of articles in hand, electronic copies of probably 75-80% of cited references can be directly accessed in seconds from a remote location via Scholar and network access to a high rank research library. For those without library privileges, Scholar also shows links to 25-40% of the articles that are openly published made available by their authors. Scholar offers other valuable tools such is providing citation links, the capabilities to limit searches to recent works, etc.

- *Accounts* (http://www.google.com/ accounts). A Google account must be opened by the user to establish a user ID and password as required for all controlled access. This is a single sign-on that at the user's discretion may remain active in all Google Apps until the user signs out. Signing up for a Google Account automatically creates a personal Gmail account (7 GB storage), a Docs storage area (1 GB free) and a Picassa Web Album storage area (1 GB free). Additional storage can be purchased that is shared across the three products, ranging from 20 GB at $5/year to 16 TB for $4096/yr [36]
- *Gmail* (http://mail.google.com). Anyone with a Google Account may specify an address for a personal Gmail account. Gmail can aggregate mail from a number of accounts, maintains threaded conversations and allows them to be identified by multiple tags (functionally equivalent to folders, without needing to save multiple copies. Compared to server-based email systems, the content search function is very fast. Gmail also offers instant messaging to support real time discussions.
- *Docs* (http://docs.google.com). Anyone with a Google Account also has a Docs space linked to that account. For those happy to accept the formatting limitations of Google's HTML [37] and its quirky formatting errors[1], one can create and edit documents, presentations and spread-sheets without any external applications other than the browser. Docs can also convert MS Office and PDF formats into editable HTML on upload and back into Office formats on download at the cost of destroying much of Office's formatting informat-ion. This made Docs unattractive to those inter-ested in formal publishing until the capacity to store any file in its native format was released in January 2010. Now, where the aim is formal publication, most files will be edited in their normal applications, and uploaded and down-loaded to Docs repository their native formats. additional to the limit on storage volume limit noted above, there are several other limitations [38], of which the limit of 5000 documents and presentations and 5000 images per "owner" may be the first to affect TOMOK. Files in Docs' reposi-tory are organized in hierarchical folders. File owners may "share" folders or individual docu-ments with named users (who must be signed-in with their Google ID and password to access shared documents) or share them with all members of a Google Group (see below).
- *Groups* (http://groups.google.com) is Google's app for establishing and managing discussion forums. It offers typical capabilities for this genre. Anyone may create a Group, which may be open to anyone to join or closed. A closed group may be listed publicly on the Web so anyone may request to join, or it may be private, where members must be invited to join. As for other Google apps, to access Group resources the user must be signed in by ID and password. Resources include a home page, threaded discussions (members have several delivery options), member profiles, an ability to create HTML pages, and a file folder. Pages may include text, graphics and links. From the point of view of a collaboration framework "shares" within Docs can be granted to all members of a Group simply by specifying the Group's email address[2].
- *Sites* (http://sites.google.com). Google Sites is the most flexibly useful App to support primary col-laboration in a virtual research environment. Sites provides highly configurable blog, Wiki and content management functions. Docs is the library, Sites is the workroom. Access is controlled at the Site level, and the whole site may be open to the world or closed for sharing. Anyone can create a site. "Owners" can do everything. "Collaborators" have edit and page creation capabilities. "Viewers" have view only access. The basic structure of a Site consists of HTML pages that may be structured hierarchically and that may also function as containers (folders) for files and dynamic objects. Pages are easily moved around to optimally structure Site content. The HTML editor is similar to that of Gmail, Groups, and Docs. Active objects such as Google documents, presentations, spread-sheets, forms, lists, etc, and a variety of other Google and third party "gadgets" can be inserted into pages. Google offers their own and third party Site templates page templates. For example the "file drawer" page template provides for viewing, uploading, downloading and automatic versioning and tracking of files. File drawers may arranged hierarchically as desired to maintain relationships between various aspects of a collaboration. Other page templates add a blog-like "announcement" page that members can post to and that can be abstracted to a "recent posts" gadget on another (generally higher-level) page. The list page tem-plate provides capabilities for a

[1] HTML tags may be displayed for manual correction, or the area with formatting problems may be selected and all tags removed using the T_x (Remove formatting) icon in the text editing toolbar)

[2] In our experience with a large Docs library containing several thousand files, it has taken a day or more for the Docs "share" access to propagate from adding a member to the Google Group membership to the time when the new member can actually access files in the Docs library.

small dynamic database. A “time tracker” gadget provides some workflow management capability.

- *Translator Toolkit* (http://translate.google.com.au). Google provides important infrastructure support to break down linguistic barriers as well as those of time and distance. Google has offered machine translation between languages for searches and web pages. The recently added Translator Toolkit provides an environment including an instant messaging capability where authors and readers working in different languages can collaborate on understanding and fluently translating documents. The TOMOK group has experimented with the Dutch to English translation of a PhD thesis by a Dutch author who has recently joined the group.
- *OffiSync* (http://www.offisync.com). OffiSync is a third party add-in for Microsoft Office products that provides an important technological capability for the virtual research environment. Dot Net capabilities are enabled allowing MS Office applications to directly edit Google document, presentation and spreadsheet formats in Docs and Sites' folder structures. A recently added capability allows OffiSync to work directly with MS Office formats stored in the Sites environment. We are told (pers. comm..) that OffiSync's next major release due out soon will provide the same editing capabilities against MS formats in the Docs Environment.

5 Practice and Conclusions

The components described above offer comprehensive technological support for collaborative work that substantially extends the cognitive abilities of individual and the group in terms to work across major human limitations to manage the volume and detail of information, geographic distance, asynchronous working hours, and even language. For example, in a paper environment it might take weeks or months in the physical library to build a comprehensive bibliographic survey of the existing literature for a project, and where the content of the survey would still only be available to the person who physically collected the literature. Using technological support provided by Google Apps, seamlessly joined by OffiSync to a Microsoft Office authoring environment, a more thorough background can be constructed in hours to a few days, where the content can be immediately shared with collaborators, wherever they are in the world. As a draft publication is written, citations to reference materials in the text are hot linked to full references in the text, that in turn, are hot linked to electronic copies of source documents in the Docs repository. In seconds, *any* collaborator can follow the link between the citation in the working draft and the content of the source reference. Additionally, combining Acrobat Standard's (not free) annotation capabilities, Site's “blogging” capability using the announcements function, and MS Word's commenting and review functions, the development of ideas and concepts by one collaborator can be shared explicitly almost immediately with other collaborators to assist in the development of a fully shared world view of the knowledge being developed. Because this idea development can be preserved in the version history it should be possible to rapidly add substantial value to the knowledge being developed by the collaborators.

On the whole, Sites and Docs, backed up by OffiSync, MS Office products and other Google Apps, offer an easily configurable and comprehensive support framework for a virtual research environment. For example, beginning with no knowledge of the products, it took little more than a month to construct a fully functional virtual research environment for the TOMOK group. This currently manages 8 separate collaborations, including the present paper (taken from first concept through bibliographic survey, and multiple drafts to completing the submission in 18 days). Using these capabilities, knowledge building truly becomes a post-human socio-technological cognitive process [20],[39].

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