KNOWLEDGE PORTAL AS A NEW PARADIGM FOR SCIENTIFIC PUBLISHING AND COLLABORATION

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SUMMARY: *This paper addresses the newly emerging paradigm of scientific knowledge dissemination and collaboration. The paper is based on the particular area of knowledge collaboration in the Architectural, Engineering, Construction and Facilities Management (AEC/FM) industry, including knowledge sharing and technology transfer in the area of environmentally friendly concrete materials. The research and scientific community is moving away from the old "information spread" model for dissemination of scientific information, where knowledge is channelled through paper-based refereed academic journals and conference proceedings. Researchers are becoming involved in publishing their articles in online-refereed journals that provide free or low fee access to scientific information. In this paper the authors propose some general architecture and design guidelines for online, collaborative research environments (Knowledge Portals) in the AEC/FM industry. These virtual, collaborative spaces are becoming an essential part of the modern scientific publishing and knowledge transfer processes within professional communities of practice. The proposed model of the Knowledge Portal for the AEC/FM industry could also serve as a generic model in designing virtual research collaborative environments for other areas of knowledge sharing and collaboration. The paper describes existing technological solutions, adapted by online communities of practice, for maintaining corporate knowledge portals, scientific publishing and knowledge exchange spaces and proposes generic architecture and design principles for a generic Knowledge Portal. As an essential part of the Knowledge Portal, and a sample case study of knowledge dissemination, the paper describes existing stand-alone and Web-based digital collections of research data in the area of environmentally friendly concrete.*

KEYWORDS: *collaboration, digital repository, interface design for collaboration, knowledge portal, virtual community of practice*

1. BACKGROUND

This paper addresses the newly emerging paradigm of scientific knowledge dissemination and collaboration. The paper presents a case study based on the particular area of knowledge collaboration in the Architectural, Engineering, Construction and Facilities Management (AEC/FM) industry, including knowledge sharing and technology transfer in the area of environmentally friendly concrete materials.

The research and scientific community is currently in the process of moving away from the old "information spread" model for the dissemination of scientific information (Klein and Gwaltney, 1991), where knowledge is channelled through paper-based, refereed, academic journals and conference proceedings, following the traditional Garvey-Griffith model (Garvey and Griffitth, 1972) of scientific communication as shown in Fig. 1.

Researchers are becoming increasingly involved in publishing their articles in online-refereed journals that provide free or low fee access to scientific information (Case, 2001, Gudnason et al, 2002). In addition, a new publishing paradigm for scientific, technical and medical information based on the Semantic Web technologies and XML is currently being proposed (Rzepa and Murray-Rust, 2001). This emerging model of scientific communication, based on Hurd's vision for scientific publishing in 2020 (Hurd, 2000), is presented in Fig. 2.

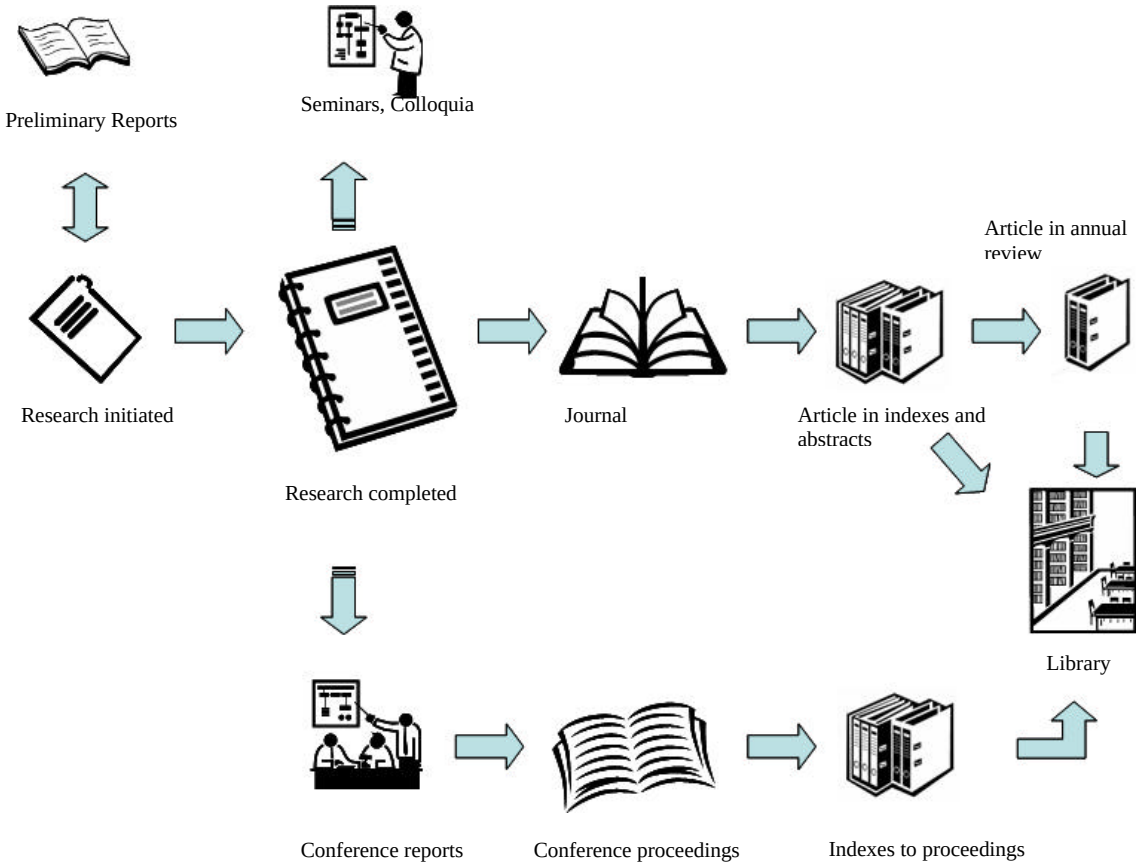


FIG. 1: Garvey-Griffith traditional scientific dissemination model

However, the "Model for 2020", proposed by Hurd, does not reflect the importance of Internet technology in creating new venues for research collaboration, knowledge creation and knowledge dissemination to a broader professional community of practice. The model in Fig. 2 mostly emphasises the use of Web-accessible research-related information (RRI) repositories and does not consider new venues of knowledge creation and dissemination provided by online research collaborative environments. The newly emerging model, of the online research collaborative environment, that constitutes an essential part of the new paradigm of scientific publishing and knowledge transfer, is the subject of this paper.

2. KNOWLEDGE PORTAL MODEL

Communities of practice are communities of professionals and others who share knowledge and resources (Wengler, 1998). Wengler states that the key to a successful knowledge dissemination strategy is to channel the knowledge to the communities of practice and at the same time provide means for information exchange and peer-to-peer collaboration (Wengler, 2000). One of the models for a virtual collaborative research environment that provides means for both, knowledge sharing and collaboration is the "Knowledge Portal" model (Kondratova and Goldfarb, 2003). Within the model the Knowledge Portal site provides, for scientists, practitioners and private companies, free access to the Discussion Forum and to the Virtual Laboratory, as well as to the Digital Repository of research and scientific information. The high level architecture of the Knowledge

Portal is presented in Fig. 3. In essence, the proposed Knowledge Portal model enables the basic community of practice portal requirements. These include a conversation space for online discussions on a variety of topics, as well as, a facility for posing questions to the community (Discussion Forum), a shared workspace for synchronous electronic collaboration, discussion or meeting (Virtual Laboratory), and a document repository to be used as a knowledge base (Repository) (USAID, 2004).

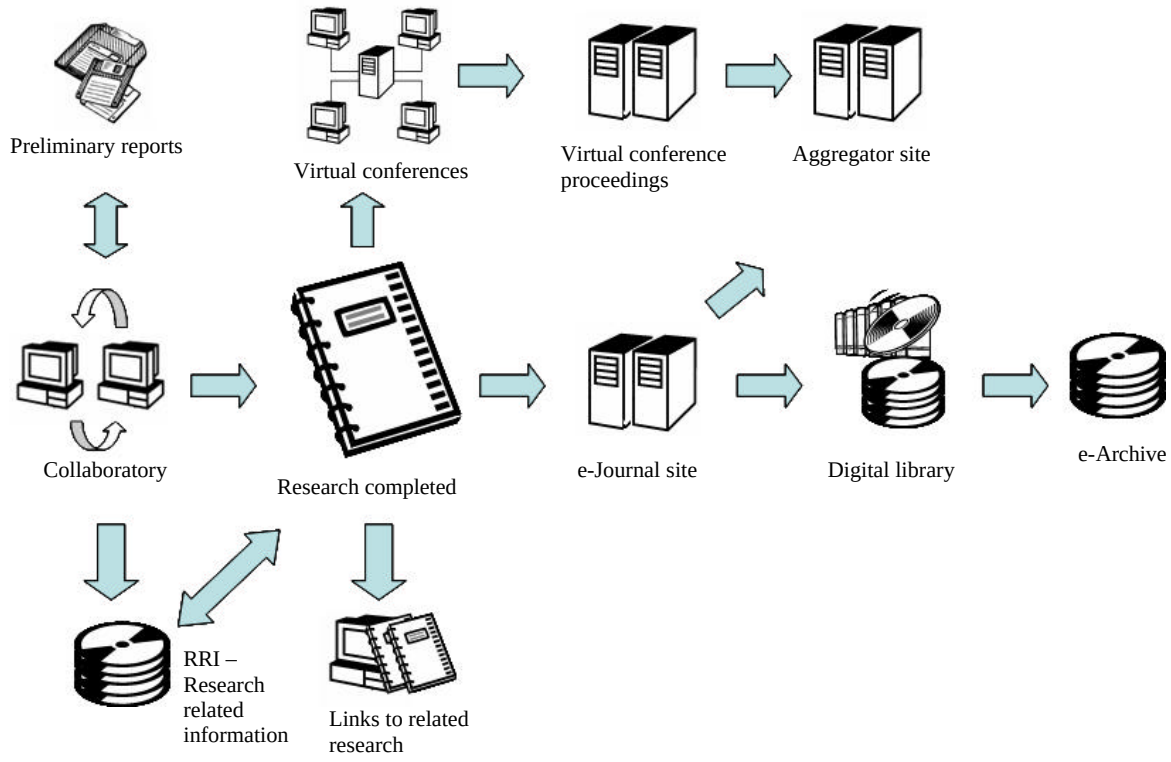


FIG. 2: Emerging scientific dissemination model (the Model for 2020)

It is important to highlight some noticeable similarities between the functionality of the Knowledge Portal and the functionality offered by the scientific dissemination "Model for 2020" in Fig. 2. The overriding concept of the Virtual Laboratory in Fig. 3 is similar to the Collaboratory in Fig. 2, and the Repository includes some features of the Research Related Information Repository. The Databases, Tools and Software of the Knowledge Portal in Fig. 3 can potentially be encompassed within the Collaboratory in Fig. 2. However, the two most unique and valuable features of the Knowledge Portal: the Discussion Forum and the Learning Resources are missing from the Hurd's "Model for 2020" (Hurd, 2000)

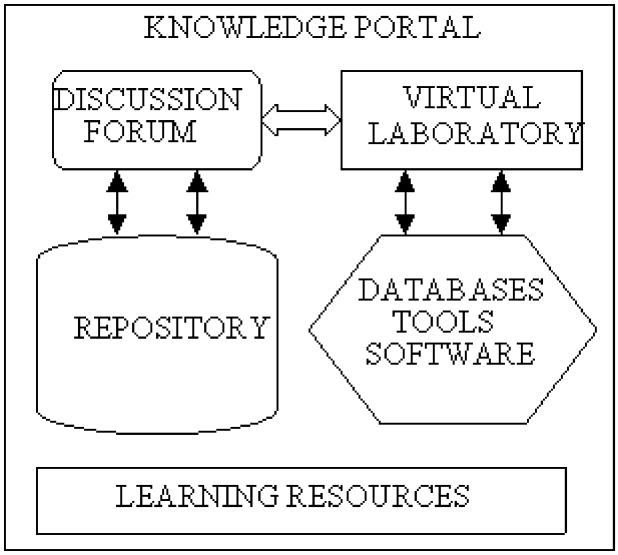


FIG. 3: Knowledge Portal model

By providing a Forum for discussions and Learning Resources for reference, the Knowledge Portal creates the opportunity for all members of the community of practice to directly and actively participate in the knowledge creation and scientific dissemination process. The Virtual Laboratory, as part of the Knowledge Portal, enables joint research work on common documents, databases, projects, and contains domain-specific software tools. UNESCO's Electronic Support for Cooperative Scientific Research Project, http://www.unesco.org/webworld/build_info/virt_lab.html , introduces a similar concept of a Virtual Laboratory, as a virtual space for researchers from all over the world to conduct joint research projects. In order for a Discussion Forum, within the Knowledge Portal, to be a place where scientific discussion, knowledge sharing and exchange will happen and new knowledge will be created, the Discussion Forum must be supported by a comprehensive digital knowledge Repository. The participating research organizations, private companies, and industry practitioners can submit artefacts (raw data, research results, photographs, reports and preprint papers) into this Repository.

A peer review process of submissions, by content experts from the user community, should be undertaken to assure the quality of submissions. A similar approach to the portal repository, with quality control provided by the content experts, is adapted by the oneFish research community, http://www.onefish.org. This community maintains an Internet Portal that provides access to information on fisheries and aquatic research worldwide.

The oneFish community effectively facilitates more efficient application of research-based knowledge to the issues and constraints of sustainable development. Within the oneFish Knowledge community Portal, knowledge objects (artefacts) can be submitted into the repository by any member of the community. As a necessary element of the screening process, volunteer topic editors assess the quality, value and relevance of knowledge objects submitted to a particular topic Inbox. These editors have the authority to either accept or reject knowledge objects, or forward them to a more appropriate topic. They can edit, move or de-link knowledge object metadata within the topic area, as well as suggest additional links between knowledge objects within a topic and other related topics.

Despite the seemingly large workload for the topic editor, there are more than twenty subject experts that are currently working on content submitted to the oneFish repository. As our investigation shows, there are several factors that make this activity attractive for future editors. These factors include seeing first hand the cutting edge knowledge and information submitted and raising your profile in the global research community by displaying a biography and photo online. Similar incentives for active participation are listed, together with altruistic reasons, for the members of the open-source developers community (Hars and Ou, 2002).

Knowledge sharing in virtual organizations and communities of practice is facing major challenges and defeats due to a misalignment between the incentives system and the objective of creating value through knowledge sharing (for example, keeping rigid academic promotion criteria). As well, private companies and their employees tend to be inherently hostile to knowledge sharing (Husted and Michailova, 2002). To overcome this knowledge-sharing hostility, some organizations utilize innovative knowledge-sharing tools such as, Xerox Company's "Docushare" tool for document sharing by virtual teams. The design of this particular tool is based on the findings of anthropological studies on the subject of how laboratory scientists work individually and in groups. Clearly, there is a need for similar studies and tool development for virtual collaborative spaces on the Internet, that are intended to serve as knowledge creation and sharing spaces not for employees of the individual company, or a group of companies, but by the diverse participants in professional communities of practice.

3. THE EVOLUTION OF KNOWLEDGE DISSEMINATION – A CASE STUDY

In this section of the paper we discuss the evolution of knowledge dissemination and two digital collections of research results (off-line and online) related to the topic of the environmentally friendly concrete materials, specifically, to lightweight concrete. The importance of knowledge transfer in the area of environmentally friendly and durable concrete is emphasized by Mehta: "…the greatest challenge that the concrete industry faces during the 21st century is to achieve a sustainable pattern of growth" (Mehta, 2001). The task is tremendous, but it can be accomplished by making an industry-wide paradigm shift to the culture of conservation of energy and materials. Research on "sustainable" concrete is being done in a large number of countries and the results are largely positive, but what seems to be lacking is the dissemination of this knowledge to a broader audience (Plenge, 2001). The following is the history of knowledge dissemination for research results from a unique, long-term, natural exposure site for concrete.

3.1 Concrete research at Treat Island exposure site

The Treat Island natural weathering exposure site dates back to 1937 and is the most comprehensive long-term concrete exposure research site in the world. Today, approximately 40 test programs are active at Treat Island. Some of the concretes investigated include concrete made using lightweight aggregates made out of clay, shale and industrial by-products, supplementary cementing materials, and blended cements. Treat Island research programs are administered by the United States Army Corps of Engineers, Waterways Experimental Station. Sponsors of the research programs at Treat Island include the U.S. Bureau of Reclamation, the US Army Corps of Engineers, the Canadian Centre for Mineral and Energy Resources (CANMET), the Construction Productivity Advancement Research program (CPAR), and private industry, with about 40% of specimens from Canadian agencies.

3.2 Knowledge dissemination mechanisms

Until 1995, the unique research findings of various research programs at Treat Island were not easily accessible to the broader engineering community. To present these findings, visitations to the exposure site were scheduled on even numbered years. A few scientists and engineers, invited by the Corps of Engineers, attended this event. The dissemination of results of the studies completed in previous years was confined to annual research reports and a relatively limited number of technical papers that needed to be brought to the attention of researchers, practicing professionals and of the construction industry, following the venue presented in Fig. 1.

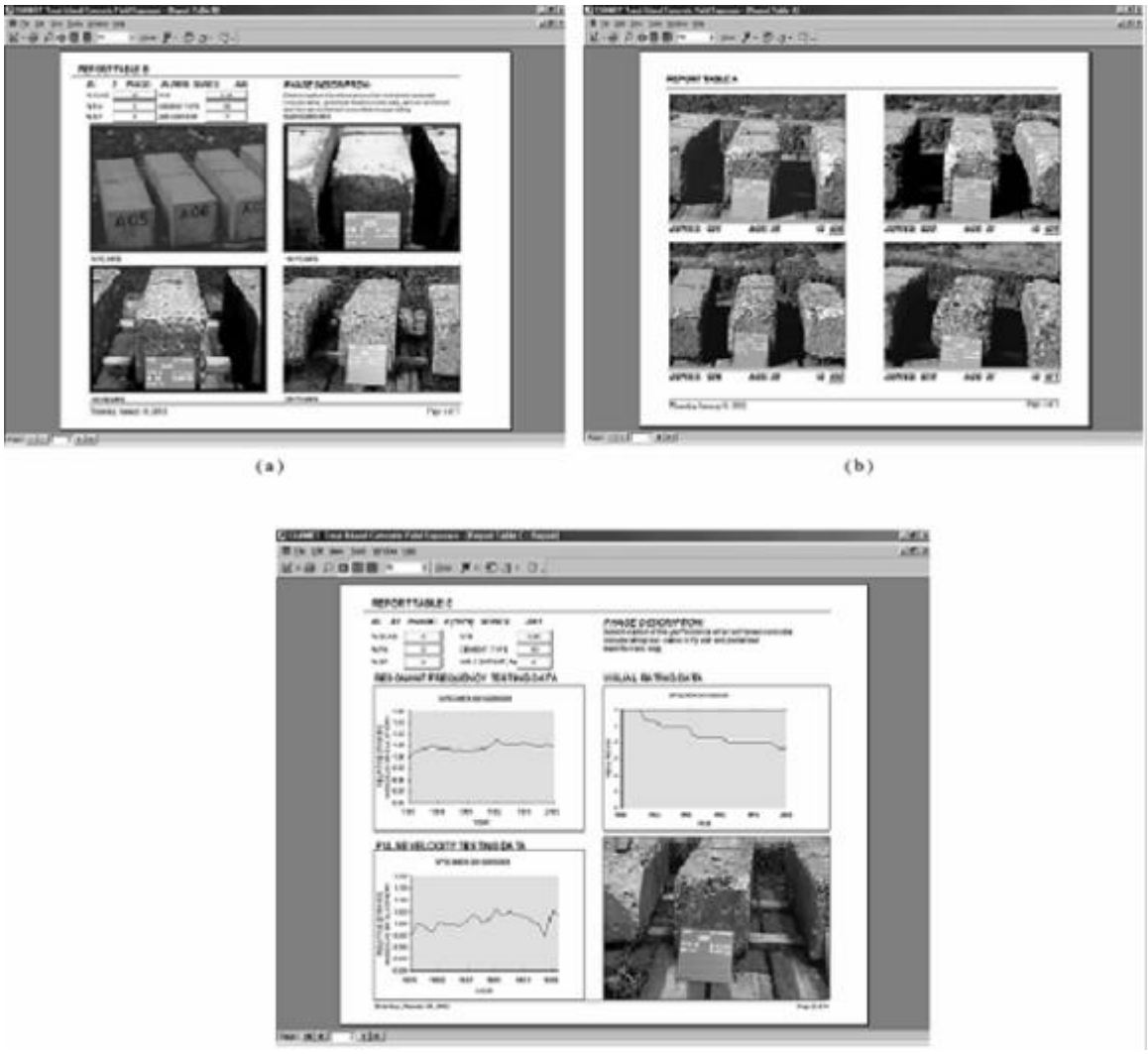
3.2.1 Multimedia database

The first step in developing a new knowledge dissemination mechanism was taken in 1994 with the development of a multimedia database incorporating the results of over two decades of research for CANMET's concrete durability studies at Treat Island (Kondratova et al, 1998). Multimedia data in the CANMET database comprises of static media, like text and historical photographs of specimens, and of dynamically linked Excel charts that graphically represent annual results of non-destructive testing (NDT) and visual evaluations. The CANMET database was initially developed as a stand-alone relational database that was updated annually following the summer testing and inspection, with a copy on CD forwarded to CANMET for research and archival purposes.

The database design allows side-by side comparison of historical photographs and testing results for different concrete mixtures and supports decision-making on the choice of environmentally friendly and durable concrete (Fig. 4). The visualization of research results, enabled by the multimedia database, enables a convenient and consistent method of comparing the performance of different concrete mixtures in severe environmental conditions. Unfortunately, the database, in contrast to the online Research Related Information repository presented in Fig. 2, is not accessible via the Internet. This makes this valuable, civil engineering, research resource virtually inaccessible for a broader community of concrete researchers and practitioners.

3.2.2 Web-based information system for knowledge dissemination

In 1999 the US Army Corps of Engineers were searching for better ways to disseminate the results of Treat Island research on concrete durability and decided to exploit the Internet as a knowledge dissemination tool. The decision was based on the understanding that an online research data repository would provide worldwide access to research findings on concrete durability at the Treat Island exposure site and would also be easier to use and maintain.



(a)

(b)

(c)

FIG. 4: CANMET research database: a) Specimens comparison Report; b) Historical Report; c) NDT and Visual Evaluation Report

Currently the Treat Island Web-based durability information system is posted on the Website of the Waterways Experiment Station (WES) for the U.S. Army Engineer Research and Development Centre (ERDC) http://www.wes.army.mil/SL/TREAT_ISL/index.html. It contains information on about 40 long-term research projects at the exposure site. These projects include studies on the use of supplementary cementing materials and lightweight aggregates for marine concrete (CANMET, Canada); high strength and high performance concrete, supplementary cementing materials to lower cement consumption, and high-performance repair materials for concrete structures (US Army Corps of Engineers, USA); concrete corrosion inhibitors and epoxy coatings (University of New Brunswick, Canada and Master Builders, USA); and high performance semi-lightweight concrete (Exxon Mobil, USA).

Each research program is presented using a general description and a photograph, with a link to a data page, which includes thumbnail photographs of the individual specimens involved in the program. The links on this page lead to the third and forth design layers that provide information on the concrete mixture design, non-destructive testing data, and a historical photographic record of test specimens (Fig. 5). The design of the site allows easy information navigation through links to the individual research programs. The user can find information using a keywords option; experienced users can visually locate specific specimens using maps of the exposure rack and the beach area. However more accessible, the knowledge dissemination mechanism in this case did not go far beyond delivering the Research Related Information Repository in a digital format, as per Fig. 2.

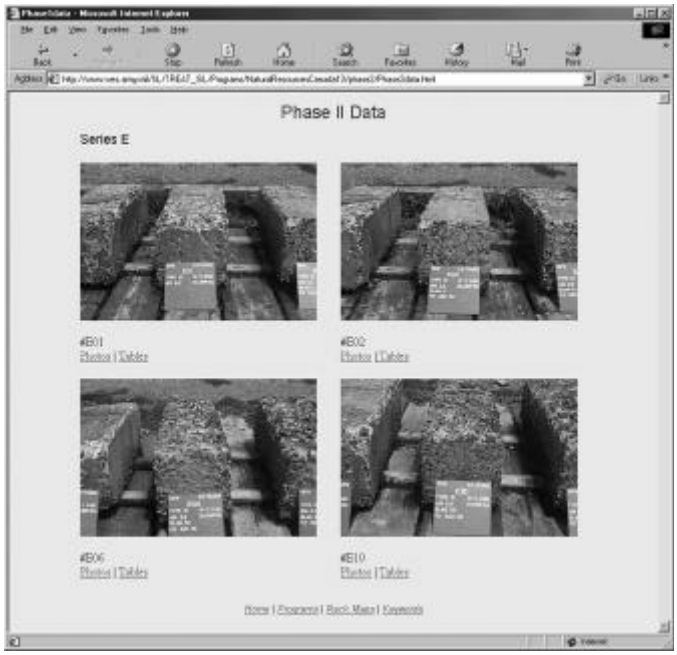


FIG. 5: US Army Corps of Engineers Web-based research repository

The US Corps of Engineers web-based information system on concrete durability research at Treat Island could potentially serve as a valuable source of information about the environmentally friendly concrete, but it is not, by any means, a comprehensive source of information on environmentally friendly concrete. In addition, this Web-based system only supports the "information spread" option, without the opportunity for commenting on data, asking questions, or contributing data from other similar research studies, etc. - knowledge building.

3.3 Other online resources on "sustainable" concrete

To evaluate the overall state of information dissemination and, possibly, knowledge sharing and exchange, in the area of environmentally friendly concrete and, in particular, of lightweight concrete, the authors of this paper thoroughly researched online resources on lightweight concrete and found only a few available. The most comprehensive source of information on lightweight concrete and, in particular, on structural lightweight concrete found was a Website of the Expanded Shale, Clay & Slate Institute – ESCSI, http://www.escsi.org/ . This international industry association Website provides detailed information on structural lightweight concrete, lightweight concrete aggregates, national and international companies-members, and has links to some comprehensive state-of-the-art reports and publications on the long-term performance of lightweight concrete.

The Solite Corporation web site, http://www.solitecorp.com/, also provides information on structural lightweight concrete, but does not cover the durability aspect, which is quite important to ensure wide spread acceptance and use of lightweight concrete. Concrete Network, http://www.concretenetwork.com / claims to be the number one source of information on residential concrete, but does not provide any substantial information on lightweight concrete usage and production. In addition, this Website mostly provides information on commercial products and services and contains no collaboration, knowledge sharing and exchange capabilities for a community of users. The American Concrete Institute (ACI) Website, http://www.aci-int.org/, provides paid (and in some cases free) access to the comprehensive database of research reports, standards and ACI publications on lightweight concrete, but is set up more like a large digital library than a site of a professional organization that has a mandate to promote concrete knowledge and support a virtual community of practitioners. The American Portland Cement Association, http://www.portcement.org, maintains a comprehensive Web site related to cement materials and concrete. However, all materials on the Website are distributed to the users in the "information spread" mode, some information is free and some is available to members only, but there is no opportunity provided to share and exchange knowledge. The Lightconcrete.com Website, , by Concrete Services http://www.lightconcrete.com/ LLC in Tuolumne, California promotes the usage of high-strength lightweight cellular concrete, and gives detailed information on its use. However, this site does not have any venues for the community of users to exchange information. In addition, the site does not provide names and credentials of professionals involved in posting the information, thus, in our opinion, lacks credibility (Fogg, 2002).

The Concrete Centre, http://www.concretecentre.com, is the new organisation for UK's concrete and cement sector. The Centre's aim is to provide a new focus for excellence in concrete design and construction that will enable all those who design and construct in concrete to realise the full potential of concrete, to become knowledgeable about the products and design options available, all with the minimum of effort. However, the organizational Website only contains "information spread" mechanisms for knowledge dissemination, has no discussion forum and no knowledge exchange and collaborative work opportunities for the intended community of practice.

US Army Corps of Engineers Engineering Research and Development Centre, http://www.erdc.usace.army.mil/, offers free online access to an excellent Digital Archive of full text ERDC publications and reports. This is a valuable source of information for civil engineering materials and concrete. In addition, as mentioned earlier, the US Army Corps of Engineers Web site maintains another valuable resource on concrete, and in particular, on lightweight concrete - a complete Web based information system on the concrete durability research at Treat Island, http://www.wes.army.mil/SL/TREAT_ISL/index.html. However, the knowledge dissemination is limited to the "information spread" mode, and there is no real opportunity for knowledge sharing or discussions by a broad community of users.

As a result of our investigation we found that even the most comprehensive of the above-mentioned online resources, on lightweight concrete, lack the depth and breadth of coverage of the topic. The knowledge dissemination options for all aforementioned Websites is limited to the "information spread" mode where there is no opportunity provided for knowledge sharing, discussions, or joint work on new knowledge creation by virtual teams of researchers and practitioners. For a person seeking information on concrete, be it a homeowner, a concrete researchers, a graduate student or a representative from the industry, we believe, it would be beneficial to have a "one stop" complete information source on production, properties, use, and environmental advantages of lightweight concrete and other types of environmentally friendly concrete – a Concrete Knowledge Portal. This Knowledge Portal will serve a virtual community of concrete researchers, design engineers, practitioners, and industrial companies. Preliminary work on the development of architecture and design guidelines for the Portal is being carried out in collaboration with Expanded Shale, Clay & Slate Institute, USA, and with consultation with CANMET, Canada and US Corps of Engineers, USA.

4. THE CONCRETE KNOWLEDGE PORTAL

In order to promote knowledge dissemination, creation and technology transfer, the proposed Concrete Knowledge Portal, as per the generic Knowledge Portal Model in Fig. 3, will include a Discussion Forum with a comprehensive search and retrieval capability and a supporting Repository of scientific information in the form of technical reports, publications, product specifications, etc. with advanced indexing, categorization, search and retrieval tools. Some existing technological solutions under consideration, that are currently implemented by virtual teams and virtual communities of practice for maintaining corporate knowledge portals and scientific publishing and knowledge exchange spaces are described below.

4.1 Existing technological portal solutions

This part of the paper expands on the existing design and technological solutions adapted by two types of portals in designing collaborative spaces for the virtual communities of interests. These communities are the corporate users for the IBM Global services corporate Portal and the academic and industrial community of users for the SciX scientific publishing and information exchange Portal.

4.1.1 The corporate Knowledge Portal

Corporate knowledge portals are single point access software systems that are designed to provide timely access to information and to support communities of corporate knowledge workers. All documents produced by the portal users are deposited into a repository. These documents undergo a variety of knowledge and content management processes.

For example, there are two types of knowledge management processes adapted by IBM's Global services knowledge portal (Mack et al, 2001). Firstly, there are higher-level knowledge management processes that involve dedicated teams of content experts that evaluate the quality of materials submitted into the repository. This might include review, classification and even certification of the documents submitted into the repository by teams of experts.

As a second level of content management, documents submitted into the repository are automatically gathered, registered, managed and even analyzed. A “crawler” technology, supported by the content analyzer that extracts text and meta-data from each document, is used to aggregate electronic information.

The extracted component is presented in a standard XML format that allows text analysis and indexing processes to cluster and categorize the document in the repository. This also helps to create a centralized search index for a collection of documents in the repository. Moreover, in order to facilitate better use of the documents in the repository, a subsequent analysis is used to analyze the content using linguistic analysis and extract the domain-specific features of the documents that help in clustering of the documents. The analysis process is performed semi-automatically, under the supervision and control of the portal administrator that has the power to exclude certain types of documents from the automatic clustering process. At the end of the clustering process, taxonomy for the Knowledge Portal is developed. A document categorization operation is performed when new documents are added to the portal. The document categorization system assigns documents to the categories that represent nodes in the portal taxonomy.

The quality control, by a team of experts, of documents submitted into the repository, similar to what is described for the OneFish community in part 2 of this paper, increases the value of the portal assets but could be a “bottle-neck” in getting the information into the repository in a timely manner. Thus, there have to be some compromises made in maintaining the quality of documents by automated means. For example, to automatically evaluate the “usefulness” of the documents, click logs can be used to find out how many times the document was accessed and machine learning can be used to detect useless documents.

4.1.2 Scientific publishing and information exchange Portal

A similar approach to knowledge dissemination involving a comprehensive Digital Repository of scientific information is taken by the IST Fifth Framework funded SciX (Open, Self Organizing Repository for Scientific Information Exchange) Project (Gudnason et al, 2002). The SciX project demonstrates new business models for scientific publishing and develops Web services for scientific publishing and information exchange.

The service provided by SciX has three main components such as the repository, the virtual community and the e-Journal. Similar to IBM Global Services, SciX is using machine learning and clustering techniques to manage the repository with minimum human intervention, to provide for an economical and sustainable system. The virtual community is designed to enable the users to exchange scientific information, knowledge, educate themselves and find people with similar interests. eJournals permit publication of submitted and reviewed papers.

By far the most important feature of the SciX system is its ability to provide so-called value-added “wrapper services” to the users. These “for fee” services allow wrapping content in the digital repository in a way that is more appealing for industrial companies and maintains sustainability of the service. The value-added services fulfil a very important need for the industrial companies, especially for SMEs. These services present research information in an easy to understand and easy to use format for companies that normally have no time and resources to go through conference proceedings and journal papers, even if these papers are easily accessible via e-Journals.

The processing of knowledge in the repository into value-added products for the industry is done by “knowledge workers”. They are the new actors in the value chain of the electronic publishing process. The concept of value added services is quite important; it brings up a new model of electronic publishing, which is totally different from the old paper-based publishing model depicted in Fig. 1 and from the “Model for 2020” in Fig. 2, by virtue of facilitating new knowledge creation and aiding in technology transfer to the industry. To achieve this, the virtual community needs to attract highly skilled content experts as “knowledge workers” that are able to extract information contained in different research studies and aggregate it into new knowledge. Value adding could also be achieved by involving virtual community members into joint creation of new knowledge by participating in the creation of a common document, knowledgebase, or in general a “knowledge artefact”. This process, as mentioned before, also brings a stimulating quality into the life of the virtual community of practice.

4.2 Design considerations for the Knowledge Portal

The Concrete Knowledge Portal should help to maintain an online environment of a “live” and dynamic scientific forum for concrete researchers, where scientists will exchange information about new projects and research directions, get peer reviews of their research data and publications, and get valuable feedback from the

industry. On the other hand, users from the industry would be able to follow the “cutting edge” research directions, and to receive answers to their questions from worldwide experts in the field.

According to research studies (Newell, 1998, Turk et al, 2002), professional associations have great potential to play a mediating role in the diffusion of knowledge. They provide a forum for the creation of inter-organizational networks that, in turn, create the necessary channels for diffusion of information, knowledge and ideas that enable companies and organizations to bring technological innovation. Thus, it would be beneficial to build the Knowledge Portal based on an existing industry association Website. General design considerations for the Concrete Knowledge Portal as well as potential user and player interactions are described in detail below.

4.2.1 Design for knowledge sharing and creation

Following the architecture of the existing corporate and academic portals described above and the generic Knowledge Portal model in Fig. 3, the Concrete Knowledge Portal will contain a comprehensive digital Repository similar to one described previously in this paper. Data within the repository should be represented in XML format, as the XML format allows automated tools to extract the context of the data and to present it independently from the diverse formatting in documents or databases. Advanced search and retrieval tools for the repository, ideally, should be based on both content and metadata as well as on the value-added services, such as document summarization.

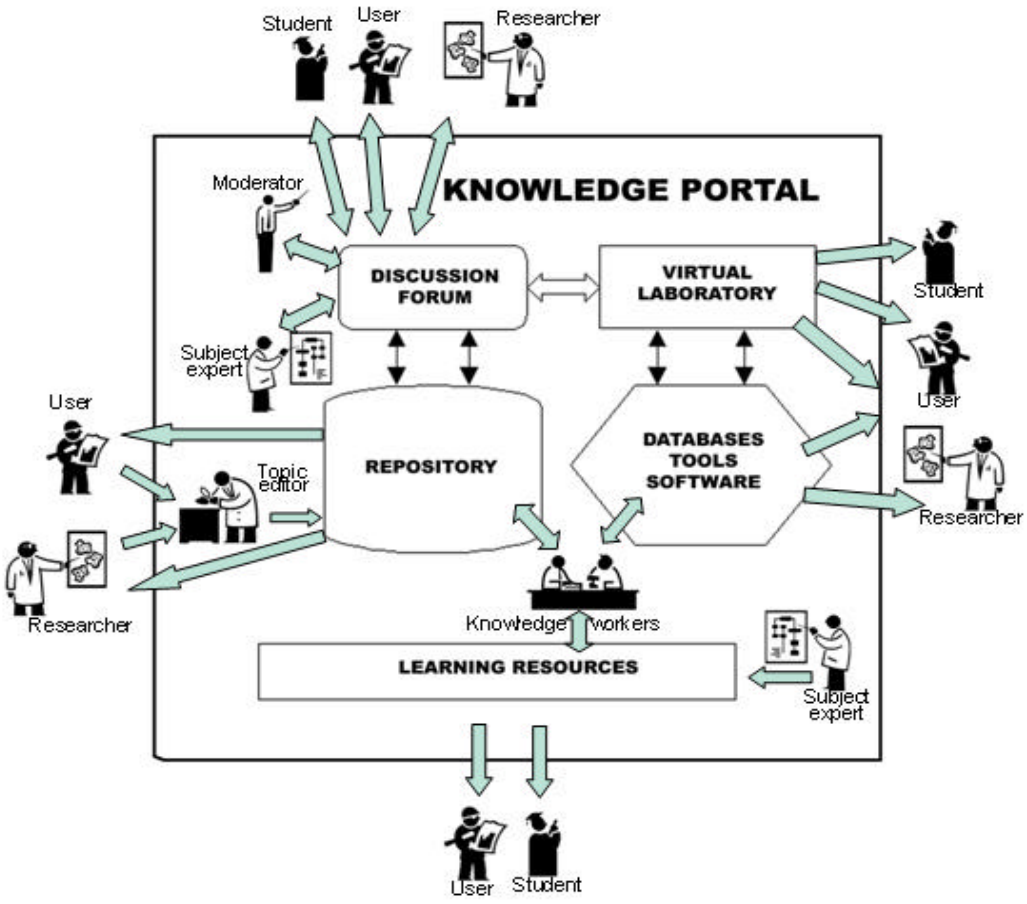


FIG. 6: Users and Players of the Knowledge Portal

However, the Repository by itself will not be able to support Forum discussions without the value-added services (as per the academic publishing portal model mentioned previously) provided by the Virtual Laboratory. We believe that the concept of value-added services, introduced by the previously described SciX portal, could be extended to the creation of services not only for industrial partners, but also to the scientific community. This could be done by aggregating research data and creating new scientific knowledge based on research results submitted to the digital Repository by members of the virtual community of practice. This newly aggregated and structured data should become a part of the Virtual Laboratory of the Knowledge Portal and is instrumental in

the knowledge creation process. This data will also contribute to the development of the Learning Resources component of the Knowledge Portal.

The state of the art reports, document summaries, and industry databases maintained by the knowledge workers in the Virtual Laboratory should provide the necessary support and structured materials for the Forum discussion participants to quickly retrieve information related to a particular discussion topic, in order to support effective participation in the discussion. The model for user and player interactions within the proposed Knowledge Portal is presented in Fig. 6.

Some information on the Concrete Knowledge Portal could be provided free of charge and some value-added services will be for members and subscribers only, similar to the model adapted by the highly successful CorrosionSource.com the Corrosion Community Portal, http://www.corrosionsource.com . This community of practice portal contains a Knowledgebase of corrosion protection resources and a popular Discussion Forum for the corrosion community. The same model is adapted by the SciX Digital Library, http://itc.scix.net/ . The existing research repositories, such as the CANMET database and the Natural Weathering Exposure Station Web site for the US Army Corps of Engineers should become an essential part of the Virtual Laboratory (Databases, Tools, Software in Fig. 6) for the Concrete Knowledge Portal.

In choosing design features for the Knowledge Portal it is important to differentiate between the enterprise knowledge portal functionality and the functionality for the online community of practice portal. The purpose of the enterprise knowledge portal is to "…enable companies to unlock internally and externally stored information, and provide users a single gateway to personalised information needed to make informed business decisions" (Firestone, 2003). On the other hand, community portals serve needs of the community of practice. "Virtual communities of practice are physically distributed groups of individuals who participate in activities, share knowledge and expertise, and function as an independent network over an extended period of time, using various technological means to communicate with one another, with the shared goal of furthering their "practice or doing their work better" (Allen et al, 2003). Thus, a virtual community of practice, as a rule, has some central features such as members' shared background and expertise, common language, common purpose and, most importantly, creation of new knowledge. Other features of communities of practice are dynamism, constant evolution, and social interactions. Social interactions represent an important feature of the virtual community of practice, in contrast with the corporate enterprise information portal, and require special attention when designing virtual community spaces.

4.2.2 Design for social interaction and collaborative work

There are certain design principles that should be addressed when building virtual communities of practice, like research collaboration communities, online. Some of these principles are general principles of social computing and interaction that should be taken into account when designing online collaborative spaces and other principles are specific to the design of online research communities (Kondratova and Goldfarb, 2003).

Kollock (Kollock, 1998) emphasizes the following three general design principles for online community building, based on the principles of social interaction and collaboration. These principles are derived from the so-called "Prisoner's Dilemma" situation and its study by Axelrod (Axelrod, 1984). These three principles of cooperation are: 1) arrange that individuals meet each other again; 2) individuals must be able to recognize each other; 3) individuals must have information about how the other has behaved in the past.

When designing online spaces for virtual communities of practice, the first principle translates into the design requirement that it must be possible for the individuals participating in virtual collaboration to be able to meet in the same place in the future. This means that in order to be successful, online communities should promote ongoing interaction of community members by designing forums to be used as discussion spaces for community members. Thus, the proposed Concrete Knowledge Portal will have a well-designed community Forum that will allow discussions, knowledge sharing and creation.

The recognizeability principle requires that the individuals participating in the collaboration should be able to get some information about each other. The recognizability principle supports group sociability that is influenced by knowing who is participating in the activity (Turoff et al, 1993). This design principle is also instrumental in combating online interaction resistance issues by promoting trust in the virtual community (Andrews et al, 2002). This principle is often in direct conflict with the ease of anonymity on the Web. This will translate into having a comprehensive directory of members for the Concrete Portal with some means to recognize the value of member's participation in Forum discussions or in the work of the Portal.

The third principle is that the history of the individual's behaviour in the past should be known. When information about the individual and his/her actions is collected within the online community a reputation is developed. This process encourages accumulation of social information and trust within the group. Godwin (Godwin, 1994) emphasizes the importance of accumulating knowledge about the individual members in the virtual community. He suggests that online communities should be designed to provide "institutional memory" that tracks group history and events. This "institutional memory" helps to promote continuity, keeping the "same faces", knowing personalities and reputations and having ongoing relationships – in turn, supporting the first principle of collaboration in virtual communities. The proposed comprehensive Portal member directory will support the above third principle of social interaction.

Kollock (Kollock, 1998) further extended the above general human collaboration principles to online communities of practice, involved in cooperative work and collective action. His extension is based on Ostrom's work (Ostrom, 1990) on the communities acting together and on some general requirements of this collaborative work. The most prominent principle is that the rules governing the use of collective goods (common spaces, research artefacts, etc.) should be matched to local needs and conditions and that most individuals affected by the rules should have a role in modifying these rules. This translates into a requirement for flexibility in the design of the virtual collaborative spaces, where the interface should be easily customized based on the member's needs or preferences. Research shows that this is also true for online collaborative environments that are used by distributed project participants (O'Reilly et al, 2003).

In the resent study on the communities of practice in a distributed environment and on the use of a document as a shared artefact for communicating and sharing knowledge between the members of the virtual community (Kimble et al, 2001), it was found that joint work on the shared document within the virtual collaboration group brings a significant stimulating quality into the collaboration process. This shared document not only stimulates discussions between the members of the group, but also acts as a catalyst for collaboration, thus creating a supportive environment for continuity of the virtual community. Based on this, we believe that the most important design consideration for the Knowledge Portal would be to have a common "artefact" or a set of artefacts that the community is collaborating on. These artefacts could be research and industry databases, collaborative documents or collaborative reports. For the Concrete Knowledge Portal it would be of great value to have such shared artefacts to work on and contribute to as, for example, the US Army Corps of Engineers or CANMET databases or other similar artefacts.

5. CONCLUSIONS

The proposed model, of the scientific Knowledge Portal, as an online collaborative space that provides means for knowledge sharing and collaboration within the virtual professional community of practice, could potentially serve as a generic model for the design of virtual research collaborative environments that play an important role in the new scientific publishing paradigm. The proposed Portal model contains several features necessary for creating and sharing knowledge within the online community of practice, such as the Repository of research resources, a Virtual laboratory that allows collaborative work by virtual teams, an e-Learning resource module that can empower and educate community members, and, most importantly, the Discussion Forum that allows information exchange within the community.

In this paper we emphasize the importance of certain design considerations for virtual collaborative and knowledge sharing environments serving a community of practice. These essential design requirements include providing a Discussion Forum and a Virtual Laboratory supported by a comprehensive range of value-added services, supplied by content experts. In order for a Knowledge Portal to become a valuable tool for researchers and industry practitioners, which allows better utilization of existing knowledge and new knowledge creation, the Portal Repository, Discussion Forum and the Virtual Laboratory should be equipped with advanced search and information retrieval capabilities that are needed to support fruitful discussions. It is also important to follow the interface design guidelines that facilitate social interaction and improve collaboration and knowledge transfer within the virtual community of practice. The proposed model of an online collaborative environment that includes an e-Learning module would also provide new opportunities for distance education of graduate students and young researchers (NRC 2001), and create indispensable knowledge dissemination and collaboration channel between researchers and the industry (Wenger et al 2002, Allen et al 2003). Currently the authors conduct research work on the analyses of design features for several existing community of practice portals and the results will reveal the applicability of the generic design model for building collaborative portals to the practice of virtual communities.

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