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Digital Libraries to Knowledge Portals : Towards a Global Knowledge Portal for Secondary Schools in Singapore

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ABSTRACT

For digital libraries to remain relevant in the new millennium where the ability to manage knowledge is critical, this paper explores how digital libraries could strategically be evolved into knowledge portals to encapsulate knowledge creation, management, sharing and reusability, features evidently lacking in most conventional digital libraries. Two digital library scenarios of use in education are described and implemented as knowledge portals using G-Portal and the Greenstone software. We hope that the initial work carried out on these two portal-like DLs will eventually form part of a Global Knowledge Portal for Secondary Schools in Singapore.

Keywords

Digital libraries, information portals, knowledge portals, knowledge organisations, knowledge management.

1. INTRODUCTION

One reason for the Web becoming popular almost overnight was the introduction of Mosaic, a graphical user interface which made it "very easy" for anyone to explore information. In contrast, because the majority of current digital libraries (DLs) are mainly repositories of conventional-media information, users' experience in DLs is passive and less engaging compared to the Web. Furthermore, many DLs remove social exchange and interaction, focusing narrowly on the technical mechanisms of information access (e.g. Ackerman, 1994; Crabtree et. al., 1997; etc.).

For DLs to remain relevant in the new millennium where the ability to manage knowledge is critical, there is a need to strengthen the information organisation within DLs. Perhaps, DLs could play a more important role in facilitating the transformation of static information into active, value-added knowledge. It is in the light of this underlying motivation that we venture to explore Knowledge Management (KM), an emergent discipline, to gain useful insights to build DLs that would help users create, manage and share knowledge more effectively, something evidently lacking in most conventional DLs.

KM is defined as a "synergistic combination of data and information processing capacity of information technologies, and the creative and innovative capacity of human beings" (Malhotra, 1997). Mack, Ravin and Byre (2001) see KM as methods and tools for capturing, storing, organising, and making accessible knowledge and expertise within and across communities, which may be scientific, academic, business-oriented, or government-based.

What spurred us to explore KM is her emphasis on the interplay between people and information resulting in basically two types of knowledge: *tacit* knowledge and *explicit* knowledge. It is generally accepted to consider tacit knowledge as residing in people, while explicit knowledge or documented knowledge as existing in books, paper documents and electronic computer records (Loh and Al-Hawamdeh, 2001).

Tacit knowledge is knowledge that resists articulation or introspection (Forsythe et. al., 2000). It is subconsciously understood and applied, and possessors of this knowledge do not need to know what they know to use it. Polanyi (1966, p. 4-5) explain tacit knowledge as "*we can know more than we can tell"* (his italics) is often quoted. He goes on to add that "this fact seems obvious enough; but it is not easy to say exactly what it means. Take an example. We know a person's face, and can recognize it among a thousand, indeed among a million. Yet we usually cannot tell how we recognize a face we know. Therefore, most of this knowledge cannot be put into words." Due to the nature of tacit knowledge, it is usually shared through highly interactive conversation, story-telling and shared experience.

Explicit knowledge, on the other hand, is information and skills that have been codified and expressed as information in databases, documents, and other artifacts. As it has been codified (knowledge that can be, but has not been articulated, is known as implicit knowledge), it is easily communicated to others.

To be an effective knowledge workspace, KPs must address both forms of knowledge. The sharing of tacit knowledge can be facilitated by providing pointers to experts, for example, through a directory of expertise, and providing a forum for sharing and collaborating, for example, through easily customizable collaboration spaces. In essence, the KP should create the "location and occasion" for the sharing of tacit knowledge. In the case of explicit knowledge through repositories like DLs, and providing features for sophisticated searching, clustering, categorization, navigation, and visualisation of documents.

Snowden (1998) described KM as "the identification, optimisation and active management of intellectual assets, either in the form of explicit knowledge held in artefacts and tacit knowledge possessed by individuals and communities".

Knowledge creation as explained by Nonaka and Konno (1998) is about interactions between explicit and tacit knowledge in continuous, spiral manner resulting in four different areas: (1) socialisation in creating opportunities to share experiences; (2) externalisation by articulating tacit knowledge in some form; (3) internalisation in facilitating staff to absorb ideas and putting them into practice; and (4) combination by creating ways to integrate different types of knowledge and re-package them into different forms.

Prusak (1997) divides KM into two levels. At the macro-level, KM refers to all the tools, technologies, practices, and incentives deployed by an organisation to "know what it knows" and to make this knowledge available to people who need to know what they need to know it.

But at the micro-level, the KM flow is a cycle (see Figure 1). Solving a problem leads to new knowledge, initially tacit, and then made explicit when experiences are documented. The documented (explicit) knowledge is made reusable through transference from one party to another (Lee and Al-Hawamdeh, 2002). Documented knowledge used by others to solve new problems creates tacit new knowledge, with the potential of initiating a new KM cycle.

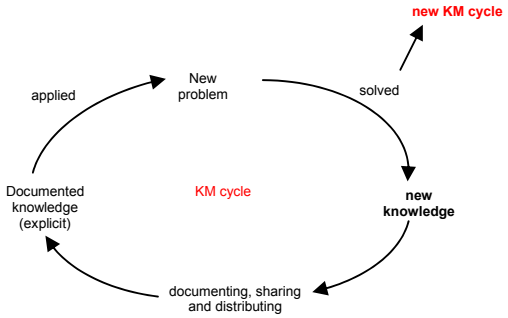

Figure 1. Knowledge Management Flow

DLs are radically reforming how information is disseminated and acquired in communities and institutions in the fields of education, science and culture around the world, and particularly in developing countries (Witten et. al, 2000). Many hope that the DL technology would initiate effective deployment and sharing of information in the public domain. However, most DLs are no more than *information portals* (Loh and Al-Hawamdeh, 2001) storing explicit knowledge with little or no mechanism to capture the richness of human experience and expertise embraced in tacit knowledge. For DLs to be more than information portals, the KM cycle needs to be incorporated to capture the evolution of tacit knowledge into explicit knowledge and vice versa.

Section 2 describes enabling technologies: G-Portal and Greenstone software we have used to build our two conventional DLs, namely, the Geography Examination Resources DL and the Children's DL of short stories. These two DLs

initially contained only static repositories of information.

In Section 3, we briefly revisit our previous work in building these two DLs so that the methods and findings can provide a background for the body of this paper and the issues explored within it. The theoretical motivations, commitments and assumptions that have shaped transformation of the design of these two DLs to knowledge portals (KPs), are described.

Compared to DLs, KPs are generally single-point-access software systems intended to provide easy and timely access to information and to support communities of knowledge workers who share common goals (Mack, Ravin and Byre, 2001).

We hope our two portal-like DLs would eventually form part of a Global Knowledge Portal for secondary schools (13 – 16 year olds) in Singapore.

2. ENABLING TECHNOLOGIES FOR IMPLEMENTATION OF OUR DIGITAL LIBRARIES

2.1 G-Portal

G-Portal is used to build our first DL on Geography Examination Resources (Chua et. al., 2002). The G-Portal software infrastructure encompasses tools to identify, classify and organise geospatial content on the Web, and to provide digital services such as searching and visualization (Lim et al, 2002). Using G-Portal, geospatial resources are primarily accessed through a map-based interface, allowing users to locate information spatially within regions of interest. This is contrasted with the approach taken by traditional Web portals (such as Yahoo) in which resources are organised into a hierarchy of categories even if they contain spatial attributes.

G-Portal projects are user-defined collections of related resources and are the means to create applications and/or communities within a geospatial DL. Content within a project is dependent on the project administrator or owner and is typically task-based or topic-based.

Resources may be further organized into *layers* that allow finer grained organization of content. In G-Portal, layers are collections of resources whose contents depend once again, on the project administrator. Projects may contain one or more layers, and a resource may reside in more than one layer.

A major part of G-Portal involves the development of a reusable framework for creating geospatial DL applications that offer not only searching and indexing facilities but also an environment for knowledge creation and sharing through user-contributed resources. This is achieved in two ways. Firstly, users are provided with tools to contribute metadata for distributed geospatial resources. Secondly, users are able to collaborate through *projects* that allow groups of users to create *communities of practice* (Wenger & Snyder 2000). Here, users can contribute and share resources within a specific area of interest.

G-Portal resources are defined as Web content, annotations and metadata. User may also add annotations to other resources to provide commentary and context for the benefit of others, if desired. By providing a platform in which users may interact with a customised set of resources and with each other, knowledge sharing becomes possible over G-Portal.

2.2 The Greenstone Software

The Greenstone software is used to build the second DL of short stories written by and for 11 – 14 years old, in partnership with St. Albans School in the United Kingdom (Theng et. al., 2001). The Greenstone DL software is an open source system that contains a suite of software for building and distributing DL collections (Witten et. al, 2000). It provides a way of organizing information and publishing it on the Internet or on CD-ROM. Greenstone is produced by the New Zealand Digital Library Project at the University of Waikato.

The aim of Greenstone is to empower users, particularly in universities, libraries, and other public service institutions, to build their own DLs (see http://nzdl.org). This software is developed and distributed as an international cooperative effort established in August 2000 among three parties: the University of Waikato (New Zealand); United Nations Educational, Scientific and Cultural Organisation; and the Human Info NGO (Antwerp, Belgium).

The Greenstone software provides effective full-text searching and metadata-based browsing facilities. Because special features are required in the Children's DL, customised plug-ins have been developed on top of the Greenstone software.

3. TOWARDS A GLOBAL KNOWLEDGE PORTAL FOR SECONDARY SCHOOLS

Benjamin Disraeli's famous remark (1874) that "upon the education of the people of this country,

the fate of this country depends" is especially true for Singapore, a small nation with no natural resources apart from her people. Since her independence in 1965, Singapore has undergone many periods of changes in the education system. 'Survival-driven' education was first introduced in the 1960s following Singapore's independence to meet the need for national survival and nation-building. In the 1980s and 1990s, efficiency-driven curriculum was introduced to address the growing manpower needs of Singapore's expanding economy. Today, we are witnessing the dawn of a knowledge-based economy, where information, rather than material resources, drives the economic growth and prosperity. As such, an ability-driven agenda for the education system is proposed as encapsulated in the government-funded initiative to promote "Thinking Schools, Learning Nation".

The "Thinking School", a concept posited by the Ministry of Education in Singapore in 1999, is in fact a learning organisation where staff and students are encouraged to constantly challenge ideas, survey professional development, share and adapt effective practices, and generate creative ideas to continually improve against the best. We have to manage change, and learning to learn becomes an imperative.

Another initiative "The National Singapore Masterplan for Information Technology (IT) in Education" was launched on 28 April 1997 to provide the blueprint for the use of IT in schools in Singapore.

The Minister for Education and the Second Minister for Defence, RAdm Teo Chee Hean, in his speech on 19 March 1998 urged schools to consider reducing content in every subject so as to "free up time for more collaborative learning, more self-directed research, more independent investigations, to develop process skills, thinking skills, and communication skills in students". In another speech on 22 March 2000, RAdm Teo Chee Hean signalled schools to "prepare students for the challenge of a knowledge-based economy. Pedagogy has to move away from being predominantly teacher-directed to one that is learner-oriented". He also stressed that our educational institutions must be "learning organisations, not just merely teaching agencies, dispensing knowledge".

Education is a private matter between the person and the world of knowledge and experience, and has little to do with school or college (Smith, 2002). For educational DLs to be useful, a learning environment should be created where collective aspiration is set free, and where people are continually learning how to learn together. Kerr (1997) pointed out that knowledge is passive in nature and so is the process of managing knowledge. The implicit assumption is that there is active learning on the individual's part and the organisation has a self-correcting and self-sustaining mechanism as a result of active learning, and learning from mistakes.

Culturally, specific reticence is frequently observed, and particularly acute in many collectivist cultures (Dat, 2001). In the case of countries with strong Confucian beliefs, where authoritarianism was traditionally the principal instrument through which society was established and maintained, the notion of respect for the teacher is very much entrenched into students' attitudes, and translates into a tradition of keeping quiet and being attentive in class, passively receiving knowledge. This respect, which is sometimes intensified into a fear of authority, makes the hierarchical implications in the teacher-student relationship more pronounced. Although slowly eroding, this phenomenon is still prevalent in Singapore.

For the above reasons and the fact that there is a strong mandate given by the government, our project aims to build a Global Knowledge Portal for secondary schools in Singapore. The idea here is firstly that the "layer of technology" provided by the KP can create pointers to expertise to support the case of codifiable knowledge. Secondly, pointers to experts for the case of tacit knowledge will act as a veil, creating the "information democracy" that Hamel (2000, p. 25) talks about. This makes the boundary separating the teacher and the student more permeable, hopefully enabling active participation in debates and making volunteering less rare.

4. OUR TWO DIGITAL LIBRARIES

To begin to build this Global Knowledge Portal, we are exploring the integration of our existing Geography Examination Resources DL and the Children's DL. Of course, these two DLs in education described in Sections 4.1 and 4.2 are two of the many examples of portal-like DLs that could be implemented into this Global Knowledge Portal.

We have worked with teachers and students as design partners and testers to ensure that the scenarios as described in Sections 4.1 and 4.2 are grounded in the work activities of the prospective users, as proposed by Carroll (2000). Scenarios are useful in helping designers to identify all possible situations of use for a particular system.

Scenarios seek to be concrete; they focus on describing particular instances of use, and on a user's view of what happens, how it happens and why (Carroll, 2000).

These two DL scenarios of use are implemented using G-Portal and the Greenstone software to illustrate how DLs could strategically be evolved into KPs to encapsulate knowledge creation, management, sharing and reusability, thus making information within DLs *active*, *dynamic* and *useful*.

4.1 The Geography Examination Resources Digital Library

Description

The Geography Examination Resources DL is built to assist secondary school students in revising for the Singapore-Cambridge General Certificate of Education 'Ordinary' (GCE 'O') level geography examination (Chua et. al., 2002). The GCE 'O' level examination is an annual national examination covering a variety of subjects such as mathematics, the sciences, literature, geography, etc. Depending on the results obtained, students are then admitted to various higher-level educational institutions such as junior colleges and polytechnics.

The instruction of geography is predominantly textbook-based supplemented with electronic resources covering various topics. In addition, students often work on past-year GCE 'O' level examination questions and peruse their solutions to help them revise for the examination. These examination solutions are sold as books organized by year and/or topics, and are used by students to see examples of the types of questions typically covered in the geography examination and to judge the relative importance of topics.

The Geography Examination Resources DL aims to adopt and extend this approach to geography examination revision by promoting learning through a "bottom-up" approach in which we first assist students with revision, and then provide related concepts for them to explore. In the process, we expect students to be able to draw associations between various geographical issues and develop their reasoning skills.

To accomplish this, past-year examination questions and their solutions are created as separate G-Portal projects with the help of experienced geography teachers.

Each project consists of resources, at least one of which contains the solution to the question. Other resources containing information to related topics are located on the Web and used as supplementary material for further investigation by students. Resources may be further organized into layers depending on the needs of the teacher who is authoring the project. For example, the solution to a desert region question could appear as a resource in a layer while a separate layer might contain vegetation resources found in desert climates.

Making the Geography Examination Resources DL Portal-like

In a typical usage scenario, solutions are first accessed by students through G-Portal's *classification interface* (Lim et al., 2002) which provides a topical listing of available examination questions. Upon selection of a question, G-Portal loads the associated project and displays the resources either on the map (see Figure 2) or on the classification interface. Since G-Portal's two interfaces are synchronized, the selection of a resource may trigger the other interface to display additional information related to the current resource. For example, selecting a desert region on the map might cause the classification interface to display related resources on temperature and rainfall, or even related examination questions.

Since G-Portal provides built-in facilities for collaboration and knowledge sharing, project resources within the examination DL are not just static and explicit. For example, experts such as teachers are available for students to tap on their *tacit* knowledge. We envision an environment in which content constantly evolves through the contribution of new resources into projects by students and teachers, thereby activating the KM cycle.

Figure 2. Map Interface for Resources with Spatial Attributes

Consider another example where a teacher first creates projects for several examinations questions and populates them with solutions and a few related resources. After indexing the

projects in G-Portal, the teacher creates accounts for his students to access the DL as well as assigns them access rights to add new resources to projects.

Once informed, students then use the DL as an aid to revise for the geography examination: they may load projects containing questions they wish to view, peruse the solutions and explore related topics. As they navigate the DL, they may annotate existing resources for the benefit of others. For example, a student might find that part of the solution would be better if an example was provided. The student could then author the example using an annotation tool, associate it with the relevant section of the solution and submit it to the project.

Students may also contribute new resources if they feel that these resources are related to the project. Returning to the scenario, a student surfing the Web finds a page that is relevant to a project. She then selects a region on the map and associates it the web page by creating a metadata resource for it. The student also annotates the resource to explain why the web page is relevant. Note however that to maintain the quality of the collection, students' contributions may be subject to review to ensure that certain standards are met. These review criteria will of course depend on the policies put in place by the project administrators. In our scenario, students' contributions are not automatically added into their respective projects and indexed into G-Portal. Instead, they are stored in a holding area pending the teacher's review. If a resource is deemed acceptable, the teacher publishes it, after which it becomes available to all other users. Resources that are not accepted will be discarded and the contributors will be informed accordingly.

Used in this way, the DL becomes dynamic, with each new contribution adding to knowledge about the geography examination. The DL also becomes a community, attracting geography students and providing an environment for them to share knowledge about the subject.

4.2 The Children's Digital Library of Short Stories

Description

The Children's DL collection provides effective full-text searching and metadata-based browsing facilities, as offered by Greenstone (Theng et. al., 2001).

A distinctive feature in the Children's DL is to allow children to create and submit their own stories and poems to a workspace permitting others such as their teachers and peers to read and give feedback by sending their comments via email to the children authors (see Figure 3). Thus, in contrast to other work (e.g., Koenemann, et. al., 1999; Nichols et. al., 2000; etc.), the Children's DL provides the children opportunity for *creation* of their own stories/poems and uploading them into the bulletin board for reviews from their teachers and peers, before submitting to the permanent DL. Only materials approved by the teachers can be submitted to the 'core' DL, thus ensuring the quality of the documents.

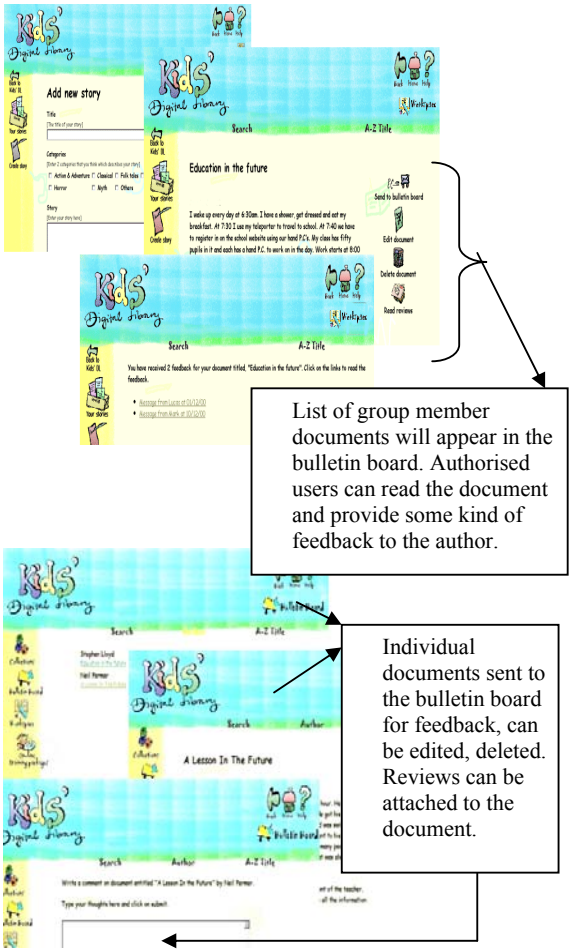

Figure 3. Interface Showing Personal Workspace

To encourage *collaboration*, children can query and browse stories and poems written by other children. They can read stories, give reviews, read other children's reviews on stories and email authors for other comments.

The DL environment also provides a display of the top ten stories/poems; information about the

authors, and a message board to post and discuss ideas.

Making the Children's DL Portal-like

Feedback from our design partners and testers at St. Albans (London, UK) highlighted the limitation of the Children's DL in providing them with the more flexibility to manage their personal workspaces and share resources. Therefore, we look into G-Portal to explore if more flexibility could be built into the Children's DL.

In G-Portal, for example, a teacher could create a project for students to populate with resources in order to complete a particular class assignment. Students then search the Web to locate relevant resources and subsequently "publish" them into the project. Students may also comment on existing resources, for example, to indicate how well a particular resource meets the objectives of the assignment. As the collection evolves through students' contributions, the project eventually becomes a useful DL of resources for students to access and interact with.

The teacher might create layers using G-Portal, one for each student to contribute the Web resources that they find, acting as a personal workspace. Used in this way, the teacher will be able to determine each student's contribution to the project. On the other hand, the teacher might also divide the project into subsections each represented by a layer. Students then add to the relevant layer depending on the type of resource found. Here, layers are used to organize the content of the class assignment. The environment is encouraging students and teachers alike to share and document their *tacit* knowledge, another example of how the KM cycle can be incorporated into DLs to make them more portal-like.

5. RELATED WORK

Our work on extending DLs with KP features shares similar goals with existing DL projects albeit with different approaches and in different domains.

For example, the Global Digital Museum (GDM) (Takahashi et. al., 1998) is a federated museum and classroom that allows users to search and access multimedia information from various museums through a single user interface. Within a museum, multimedia resources may be shared and reused through two textbook types. Textbooks for teachers are created by museum experts for teachers to explain the museum resources available for educational purposes. Textbooks for students are created by teachers as instructional resources for their students. In addition, users have access to personal books that allow them to maintain personal collections of museum materials as well as annotations.

Similarly, Synchrony (Goh and Leggett, 2000) is a DL system providing a spatial hypertext workspace to a collection of digitized videos of speeches given by President George Bush (Senior) and their corresponding textual transcripts. Like our work, the DL supports reusability and sharing of resources. Using their personal workspaces, patrons to the DL are able to retrieve desired speeches and transcripts, author annotations, and use these to create multimedia presentations. These annotations and presentations may also be published back into the DL for the benefit of other patrons.

The Digital Library for Earth System Education (DLESE) (Sumner & Dawe, 2001) also contains elements of KP features through the sharing of geography resources for various educational levels in earth system science education. A novel feature of the DL is that its contents rely entirely on users' contribution of resources, which may include maps, simulations, lesson plans, data sets, etc. Other users may then incorporate these resources into their lesson plans.

Finally, the goal of the SMETE (Science, Mathematics, Engineering and Technology Education) DL is to provide educational content as well as services over them. Besides searching and/or browsing for educational resources, the DL provides facilities for users to create reviews and comments that are shared with other users. Registered users may also create communities that represent various areas of interest. The DL will then automatically recommend related resources and other users with similar interests.

While our work has similarities with these projects, a major difference is that these DLs do not provide all the necessary features offered by a knowledge portal. A notable example is that all the DLs reviewed – GDM, Synchrony, DLESE and SMETE, support reusability but they do not provide a collaborative environment for a community of users to share knowledge. Both GDM and Synchrony offer personal workspaces but not community workspaces. Likewise, SMETE provides a community-building facility, but this facility does not serve as a workspace for knowledge sharing by groups of users.

6. CONCLUSION AND ON-GOING WORK

This paper discusses two DL projects in education, and we envisage that these two DLs would be more beneficial if we could convert them to KPs, serving schools in Singapore with a strong emphasis on creating a learning and sharing culture. Building a user-centred Global Knowledge Portal is difficult enough, but there are also constraining factors that may undermine the success of a KP as highlighted in a survey conducted by KPMG (1998): (1) the lack of familiarity with knowledge management techniques; (2) the lack of understanding of the knowledge management concept and benefits; (3) the lack of management commitment; and (4) the absence of a knowledge sharing culture.

This is on-going work for us. The initial work has created useful DLs in education, which have novel features *with a rationale for those features*. What we hope to address in the initial investigation with our two DLs are the design and usability issues that are vitally important in order for user-centred portal-like DLs to be built. We hope to that our work marrying the DL and KP technologies would forge new directions for design guidelines in the development of usable and useful portal-like DLs.

Certainly, more can be done: involvement with users; careful analysis of data. The pilot work suggests many exciting avenues to research in greater depth. We will be carrying out longer-term observational studies to study the impact portal-like DLs have learning and teaching.

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REFERENCES

Ackerman, M. (1994), *Providing Social Interaction in the Digital Library*, in Proceedings of Digital Libraries'94: First Annual Conference on the Theory and Practice of Digital Libraries, pp198–200, ACM Press.

Carroll, J. (2000), *Making Use: Scenario-based Design of Human-Computer Interaction*, MIT Press.

Chua, L.H., Goh, D., Lim, E.P., Liu, Z., Ang, R., *A Digital Library For Geography Examination Resources*, accepted for Second ACM+IEEE Joint Conference on Digital Libraries (JCDL 2002), Portland, Oregon, USA, July 14-18, 2002.

Crabtree, A., Twidale, M., O'Brien, J. and Nichols, D. (1997), *Talking in the Library: Implications for the Design of Digital Libraries*, in Proceedings of Proceedings of Digital Libraries' 97, pp221–228, ACM Press.

Dat, B. (2001). Communication reluctance in the EFL classroom: The case of Vietnamnese students. The English Teacher, 4(3), 232-242.

Disraeli, B. (1874), Great Quotes, Retrieved on 10 April 2002, http://www.cyber-nation.com/victory/quotations/authors/quotes_disraeli_benjamin.html.

Dong, A., and Agogino, A. (2001), *Design principles for the information architecture of a SMET education digital library*. In Proceedings of the First ACM+IEEE Joint Conference on Digital Libraries (JCDL 2001), pages 314-321, Roanoke, VA, USA, June 2001.

Goh, D., and Leggett, J. (2000), *Patron augmented digital libraries*. In Proceedings of the Fifth ACM Conference on Digital Libraries DL'00, pp. 153-163, ACM Press.

Forsythe, G.B., Hedlund, J., Snook, S., Horvath, J.A., Williams, W.M., Bullis, R.C., Dennis, M., & Sternberg, R.. (2000). *Construct validation of explicit knowledge for military leadership*. Retrieved on 10 April 2002, http://www.aera.net/divisions/i/home/ForsythePaper.pdf

KPMG Consulting (1998), *Knowledge Management Research Report* [Online]. Retrieved on 10 April 2002, http://www.brint.com/members/online/120205/kpmg.html.

Kerr, S. (1997), The Role of the chief Learning Officer. In Cortada, J. W. and Woods, J.A. (Eds.), The Knowledge Management Yearbook 1999-2000 (pp. 314 -318), Boston: Butterworth Heinemann.

Koenemann, J., Carroll, J., Shaffer, C., Rosson, M. and Abrams, M. (1999), *Designing collaborative applications for classroom use: The*

LiNC Project. In Druin, A. (ed.), The Design of Children's Technology. Morgan Kaufman. Pp 99-122.

Lee, C.K. and Al-Hawamdeh, S. (2002), Factors Impacting Knowledge Sharing, Journal of Information and Knowledge Management, 1(1), pp. 49-56.

Lim, E.P., Goh, D., Liu, Z.H., Ng, W.K., Khoo, S.K., Higgins, S.E. (2002), *A Map-based Digital Library for Distributed Geospatial and Georeferenced Resources*, accepted for Second ACM+IEEE Joint Conference on Digital Libraries (JCDL 2002), Portland, Oregon, USA, July 14-18, 2002.

Hamel, G. (2000). Leading the revolution. Boston: Harvard Business School Press.

Loh, S.Y. and Al-Hawamdeh, S. (2001), *The Importance of Knowledge Management in Today's Organisations*, In Singapore Journal of Library and Information Management, 30.

Mack, R., Ravin, Y. and Byre, R. (2001), *Knowledge Portals and the Emerging Digital Knowledge Workplace*, In IBM Systems Journal, 40(4).

Malhotra, Y. (1998), *Knowledge Management, Knowledge Organisations and Knowledge Workers: A View From The Front Lines* [Online]. Retrieved on 10 April 2002, http://www.brint.com/interview/maeil.html.

Nichols, D., Pemberton, D., Dalhoumi, S., Larouk, O., Belisle, C. and Twidale, M. (2000), *Developing an Interface to Support Collaboration in a Digital Library*. In Borbinha, B. and Baker, T. (Eds.), proceedings of Fourth European Conference ECDL'00, pp. 239–248, Springer.

Nonaka, I. and Konno, N. (1998), *The Concept of "ba" : Building a Foundation for Knowledge Creation*. In Cortada, J. W. and Woods, J.A. (Eds.), The Knowledge Management Yearbook 1999 – 2000 (pp. 37 -51). Boston: Butterworth Heinemann.

Polanyi M. (1966), *The Tacit Dimension*. Garden City, New York: Doubleday & Co.

Prusak, L. (1997), *Introduction to Knowledge in Organisations*. In Prusak (Ed.), Knowledge in Organisations. Butterworth-Heinemann, Boston.

Smith, L. (2002), Quotations, Retreiveed on 10 April 2002, http://www.tcnj.org/support/quotes/education.htm

Snowden, D. (1998), A Framework For Creating A Sustainsable Knowledge Management Program. In Cortada, J. W. and Woods, J.A. (Eds.), The Knowledge Management Yearbook 1999 – 2000 (pp. 52 - 64). Boston: Butterworth Heinemann.

Sumner, T. and Dawe, M (2001), *Looking at digital library usability from a reuse perspectiv*e. In Proceedings of the First ACM+IEEE Joint Conference on Digital Libraries 2001, pp. 416-425. ACM Press.

Takahashi, J., Kushida, T., Hong, J., Sugita, S., Kurita, Y., Rieger, R., Martin, W., Gay, G., Reeve, J., and Loverance, R. (1998), *Global digital museum: Multimedia information access and creation on the Internet*. In Proceedings of the Third ACM Conference on Digital Libraries, pp. 244-253, ACM Press.

Teo, C. H, (2000), Ministerial Statement by the Minister for Education, the Signing Ceremony of the IBM Reinventing Grant at Outram Park, 22 March 2000, Retrieved on 10 April 2002, http://www1.moe.edu.sg/speeches/2000/sp22032000.htm.

Teo, C. H, (1998), Ministerial Statement by the Minister for Education, The Budget Debate, 19 March 1998, Retrieved on 10 April 2002, http://www1.moe.edu.sg/speeches/1998/190398.htm

Theng, Y.L., Mohd-Nasir, N., Buchanan, G., Fields, B. and Thimbleby, H. (2001), *Dynamic Digital Libraries for Children*. In proceedings of the First ACM and IEEE Joint Conference in Digital Libraries, pp. 406-415, ACM Press.

Wenger, E. and Snyder, W.M. (2000). *Communities of Practice: The Organizational Frontier*. Harvard Business Review, Jan-Feb, pp 139-145.

Witten, I., McNab, R., Boddie, S. and Bainbridge, D. (2000), *Greenstone: A Comprehensive Open-Source Digital Software System*. In proceedings of Digital Libraries'00, pp. 113–121, ACM Press.