© Nottingham University Press
Proceedings of the International Conference on
Computing in Civil and Building Engineering
W Tizani (Editor)

An operational model for locating and sharing online learning resources – using construction safety as an example

Ken-Yu Lin
University of Washington, USA

Abstract

With the new opportunities presented by social bookmarking technologies, initiatives for sharing online learning resources in higher education are flourishing. Although these initiatives provide a nice technological remedy, little has been discussed on their operational effectiveness in discipline-specific contexts. This paper presents an operational model to support students in locating and sharing useful learning resources for a given subject. The model is enabled by the integration of a robust search method, social bookmarking technology, and the learning principle from the National Research Council, NRC. The robust search method acts as the main driver that incorporates subject knowledge into the model. It does this through the preparation of a discipline repository and by handling the resource searching requests made by students. Pedagogical exercises, guided by the NRC's learning principle, are built on top of the social bookmarking technology to provide the contexts of learning and opportunities for resource sharing. The paper illustrates the model design, explains how the model can be integrated into pedagogical exercises, discusses the preliminary model testing, and provides lessons learned on the feasibility and operability of the proposed model. Although the model is tested in the contexts of construction safety and health, its general form can be adopted in other disciplines of interests.

Keywords: mind mapping, construction safety, social bookmarking, search engine, resource sharing

1 Introduction

Drown in data, thirst for information – a challenge for undergraduate students to find useful online resources for their learning and researching adventures. Although a majority of undergraduate students utilize the Internet for academic research work (Jones, 2002; Griffiths and Brophy, 2005; Van Scoyoc, 2006), they also often find the search engine results useless and turn to aggregated research resources (Head, 2007). On one hand, students might not know what keywords to use or in what combinations these keywords should be used in the search queries. This very likely is resulted from that students, especially at the beginning of their learning or researching tasks, have little knowledge of their targeted topics and hence little context for the generation of keywords (Eckel, 2006). On the other hand, general search engines are not designed to support discipline-specific search queries and benefits of using domain-specific searches are vivid (Sellen et al. 2002; Tang et al. 2006). For the former, it is essential to include information literacy as a part of the undergraduate curriculum in any discipline. For the later, it is necessary to have a robust search method, which can be tailored to access and capture discipline-specific online resources in order to support students' learning and researching activities.

Knowing is not power, sharing is - how can one student share the captured online resources with other students who have similar learning or researching interests? Capturing and sharing useful online learning and researching resources among students can be potentially beneficial at many levels. At the very least, students who have similar learning interests or research needs can reuse the resources found by others without reinventing the wheel. Resources captured by individual students can contribute to the clarification of discipline knowledge and shape the students' collective learning in synergy. Interactions among students for sharing resources might even highlight concepts, from the learner's point of view, where help is most needed.

The captured resources can be classified according to Nonaka and Takeuchi (1995) as a form of explicit knowledge and transformed from individual knowledge into collective knowledge through "socialization". Indeed, with the new opportunities presented by social bookmarking technologies, initiatives for sharing learning and researching resources in higher education are flourishing. These include commercial systems such as "Scholar" by the Blackboard system, freely-accessible online social bookmarking services such as "delicious" by Yahoo! Inc., and in-house developments such as "RISAL" created at the University of Hong Kong (Churchill et al. 2009). These projects provide a nice technological remedy but did not address the operational issues that need to be tied in with the day-to-day pedagogical exercises. Specific concerns are: (1) how to assist students in locating useful online resources for a specific topic? (2) being aware of the bias of folksonomy and, as a result, the importance of tag recommendation for organizing located resources (Jäschke et al. 2008), how can discipline knowledge be used to assist resource tagging?, and (3) do students, through the pedagogical exercises, create overlapped resources or tags which can facilitate socialization overtime?

The author proposed an operational model, by integrating a robust search method (Lin and Soibelman, 2009) and social bookmarking technologies onto a set of pedagogical exercises, to address and test the aforementioned issues. The robust search method has the strength of utilizing a domain's knowledge for obtaining domain-specific online information and has been successfully applied in the context of "construction product procurement". The author would like to, through the operational model, verify the potential of the method in the civil and construction engineering education with the introduction of social bookmarking technologies. Although pedagogical exercises and student learning goals in specific civil and construction engineering subjects are not the main focus of the research, they provide the educational contexts. For this reason, learning principals from the US National Research Council (NRC) (Bransford et. al., 2000) will be consulted for developing specific pedagogical exercises in parallel to using the operational model.

2 The Model Design

The schematic model design is illustrated in Figure 1 and involves four main processes which are supported by "discipline knowledge", "resource repository", and "online resources".

Discipline knowledge helps set up the learning contexts, guides the robust search method as well as the preparation of the resource repository, and provides support to knowledge coding. Means and methods for enriching such knowledge include (1) the identification of concepts (e.g. "current", "voltage", "grounding") fundamental to a given subject (e.g. "electrical safety" in construction), (2) outlines of scenarios providing the contexts of learning for the subject (e.g. electrocution of crane operators due to contacts of high voltage power lines during construction), (3) verification of sources (e.g. OSHA and NIOSH) which provide relevant learning/researching resources, and (4) definition of subject keywords and thesaurus. In particular, subject thesaurus from (4) directly contributes to the ranking function of the robust search method, which then can be used to collect online learning resources into the repository or to look for resources that learners subscribed from the repository.

Resource repository acts as a sieved container which stores online resources relevant to the given learning subject (e.g. "electrical safety" in construction), easing a learner's search task. The repository also plays the role of a middle man and bridges learners who subscribe to common repository resources, increasing the chance of socialization. The repository will be prepared using three approaches. The first approach automatically downloads resources from verified sources (e.g. OSHA and NIOSH for "electrical safety" in construction) using a software agent such as GNU Wget. In the second approach, the robust search method is adapted with the support of a discipline thesaurus. In the third approach, online resources found by learners but are not available in the repository are added to the repository. Essentially, knowledge coding generated in process 3 can be used to expand the discipline thesaurus, which will trigger the robust search method to widen its search. This strategy together with the third approach will increase the repository volume continuously and maintains the openness of the repository.

In the model, besides searching the resource repository, learners also have the option to search the Internet (i.e. indicated by *online resources* in the operational model) directly. This is a critical design of the model which enables an incremental transition from using the Internet to using the repository before the repository reaches a satisfactory scale. This also enables learners to contribute to the repository collection, a mechanism that constitutes the third approach for repository development.

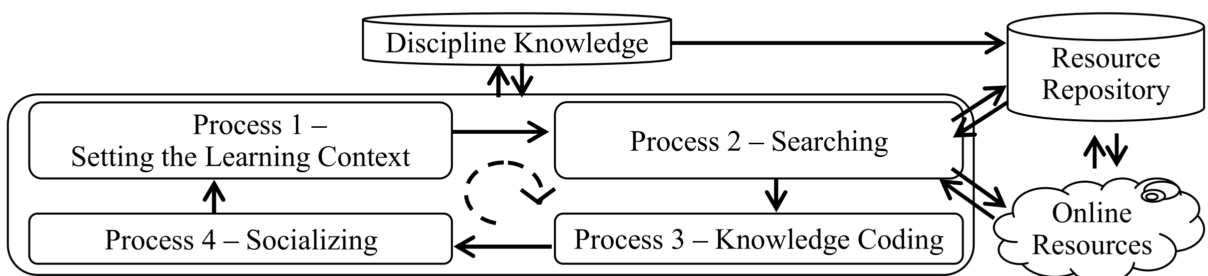

Figure 1, The schematic model design

Process 1 sets up the learning contexts by clarifying subject learning goals as its initial step. The goals will guide the design of pedagogical exercises, through which learning experiences occur. A learning instrument, mind mapping, is leveraged to support student learning as a part of the pedagogical exercises. Mind mapping can be thought of as a form of an outline with ideas and pictures radiating out from a central concept (Buzan and Buzan, 1996), or a creative pattern with connected ideas (Jensen, 1998). Based on what Jonassen et al. (1998), Willis and Miertschin (2006), and Juell (2007) have reported, mind mapping helps learners organize information intuitively while improving their learning experience simultaneously. Another notable advantage of mind mapping is that it lends a natural use of the operational model. The second step in Process 1 therefore is to design a set of pedagogical exercises which include mind mapping activities to address subject learning goals.

Process 2, the search mechanism, serves many purposes including preparation of the resource repository, real-time retrieval of both online and repository resources, and discovery of similar learning interests expressed by other learners. The mechanism is mainly supported by the robust search method that the author developed (Lin and Soibelman, 2009), which takes knowledge input in the form of a domain thesaurus and produces a ranked list of resources that are highly relevant to the search domain. The author, however, would like to clarify that a learner's real-time retrieval of online resources is still operated through the use of general search engines. It is expected that once the resource repository reaches a satisfactory scale, most search requests made by learners will transit from the Internet to the repository.

In Process 3, useful resources identified are considered as explicit knowledge according to Nonaka and Takeuchi (1995) and are codified through metadata tagging to obtain some degrees of structure for sharing and communication. Specifically, codification can guide the search mechanism and help connecting individual learners for socialization. The learning instrument, i.e. mind mapping, adopted in the pedagogical exercises facilitates knowledge coding as each concept mapped is described by some keywords from a predefined subject thesaurus.

Process 4 hosts socialization through similar learning interests or commonly subscribed resources. Similar learning interests are indicated by the common metadata tags that learners use to describe their mapped concepts. A learner can use the search mechanism to find peers who share similar learning interests. Commonly subscribed resources are indicated by subscriptions made by learners to the same repository resources. These resources can be automatically verified in the model for networking the social relationships between learners. It is assume that individual learners have smaller chances of subscribing to the same resources if the Internet is utilized directly for learning/researching materials. Alternatively, the resource repository will increase the chances of learners referencing the same resources and therefore promote socialization. Scuttle, an open-source software package will be used to build the social bookmarking platform.

3 Integrating the Model into the Pedagogical Exercises

Although the research scope is not positioned to improve specific student learning goals but the efficiency and feasibility of the model through which students identify and share learning and researching resources, *strategies* for successfully integrating the model into the pedagogical exercises are still crucial. This will ensure that the model will not hamper but enhance the pedagogical exercises and that the excises alone will still serve the educational needs, even without the use of the model.

To integrate the model into the pedagogical exercises, students are first introduced to the subject fundamentals (e.g. overview of electrical hazards for the subject "electrical safety in construction") as a part of the pedagogical exercise. Students are then exposed to a range of common subject scenarios (e.g. electrocution of construction workers due to direct worker contact with energized equipment) that need to be addressed. Up to this point, the exercise is entirely supported by Process 1 in the model.

Next in the exercise, students are asked to research available learning resources and analyze the given scenarios for identifying influential factors as well as exploring the causal relationships between the factors (e.g. "do not assume safety conditions" vs. "ensure that electricity is disconnected before working on an electrical source"). Students are expected to practice their information literacy skills during this part of the exercise, which is essentially supported by Process 2 in the model, and apply the learning resources to support their analyses.

To produce the learning deliverable at the end of the exercise, students are to compile their analyses in the forms of mind maps to express how the identified factors contribute to the scenarios. During mind map creation, students are required to (1) explain each the concept they select in a short paragraph (e.g. "do not assume safe conditions": follow lock-out/tag-out procedure for de-energized equipment before service or maintenance), (2) tag each concept using keywords from the supplied thesaurus (e.g. "lock-out", "tag-out", "safety procedures"), (3) specify what learning resources they have used to further their understanding and analysis of each concept (e.g. http://www.elec-toolbox.com/Safety/safety.htm#lockout), and (4) recommend effective plans to address the scenarios based on their mind maps. This part of the exercise is supported by Process 3 in the model.

With Processes 1, 2, and 3 in place, links between students can be established through common tags or subscriptions to the same resources on the social bookmarking platform in Process 4.

4 Preliminary Testing

A pilot activity that the author engaged in her CM333 Construction Safety class at the University of Washington offers some interesting observations on the model feasibility and operability, before the model is fully implemented. The author was eager to know (1) how mind mapping could be successfully adopted for student learning and at the same time facilitate the proposed model, and (2) to what level can socialization be initiated, if no resource repositories are available and students have to work with online resources directly using general search engines.

In 2008, students taking CM333 were asked to plot their own mind maps for "electric safety" and to furnish each mind map concept with at least three useful resources from the Internet. Students appreciated the learning opportunity through mind map creation and found it an easy task once they started. However, some students complained about the assignment and stated that they did not understand how the maps could come into play in real-world situations. In 2009, students taking CM333 were asked to go through a series of pedagogical exercises about "electrical safety" and to produce their mind maps as bi-products of the exercises. The 2009 students clearly demonstrated a higher level of learning interest and skills to take advantage of the mind map capability. This also highlights how the strategies discussed in section 3 influence the model feasibility and operability.

56 students turned in the mind mapping assignment in 2008 and submissions from 28 of them who volunteered to share the answers anonymously were further studied for data analysis. After the initial data cleaning, four assignments were excluded because they did not follow the assignment requirement. Among the 24 effective assignments, 717 web links were identified as having useful learning/researching resources on "electrical safety". Surprisingly, over 50% (i.e. 363) of the 717 links were cited by more than one student, projecting a high potential of socialization through subscriptions to common resources when students worked directly with the Internet without the availability of specialized resource repository.

However, a closer look on the 363 links revealed sequential patterns indicating that 120 out of the 363 links repetitively appeared across four particular submittals possibly due to student collaborations. There were also occasions when a link was reused by the same student numerous times, which accounted for 38 out of the 363 links. Therefore, the number of total web links reported was adjusted downwards to 599 to exclude these duplicated links.

75% (i.e. 454) of the reported web links were cited by only one student and 25% (i.e. 145) of the reported links were cited by more than one student. 74 of the links that were cited by more than one student were unique links, meaning that 71 out of the 145 links were simply duplicates. This marks 528 (88%) out of the 599 reported web links to be unique (after the adjustment), with OSHA, Wikipedia, YouTube, L&I WA (Washington State Dept. of Labor and Industries), and CDC/NIOSH being the top five sources that provide these resources. Students seemed to highly accept resources from non-authority websites. The 25% of link reuse will set the socialization baseline for next stage of the research. Table 1 summarizes the results of the data analysis.

Table 1. Results of data analysis for the 2008 mind mapping assignment.

Criteria	Number of Links
Effective (before adjustment)	717
Cited by more than one student (before adjustment)	363 (= 50% of 717)
Effective (after adjustment)	599
Cited by more than one student (after adjustment)	154 (= 25% of 599)
Unique	528

5 Conclusion

Although new opportunities presented by social bookmarking technologies can potentially support students' capturing and sharing of useful online learning and researching resources, the operational issues (e.g. how to assist students in locating these resources) that need to be tied in with the day-to-day pedagogical exercises are rarely addressed. The author therefore proposed an operational model which integrates a robust search method and social bookmarking technologies to work with subject-specific pedagogical exercises as a remedy. Because mind mapping as a learning instrument also helps lend the natural use of the model, strategies which ensure the smooth adoption of mind mapping in pedagogical exercises are crucial to the success of the model and are provided. Data from the pilot study that the author conducted in her safety class in both 2008 and 2009 reveal how the strategies influence the model feasibility and operability. Additionally, a 25% resource reuse rate was derived based on the 2008 data when students worked directly with online resources using general search engines. This rate can be used as the baseline for socialization assessment and is expected to grow once the model is fully implemented. As the research has a steady progression and more work has to be done, the challenge remains in how to balance both the educational and the researching requirements and how to benefit from the strength of both areas.

Acknowledgements

The author would like to thank Lana Lenz, Director of the Center for Instructional Development and Research at the University of Washington for her comments and advices on the reported work.

References

BRANSFORD, J.D., BROWN, A.L., and COCKING, R.R., 2000. *How People Learn: Brain, Mind, Experience, and School.* Washington DC: National Academy Press.

BUZAN, T., AND B. BUZAN., 1996. *The mind map book: How to use radiant thinking to maximize your brain's untapped potential*. New York: Plume.

CHURCHILL, D., WONG, W., LAW, N., SALTER, D., and TAI, B., 2009. Social Bookmarking–Repository–Networking: Possibilities for Support of Teaching and Learning in Higher Education. *Serials Review*, 35(3), pp. 142-148.

ECKEL, E., 2006. KwMap.net: A Keyword Generating Tool for Information Literacy Instruction. *College & Undergraduate Libraries*, 13(1), 33 - 39.

GRIFFITHS, J.R. and BROPHY, P., 2005. Student searching behavior and the Web: Use of academic resources and Google. *Library Trends*, 53(4), 539-554.

HEAD, A., 2007. Beyond Google: How do students conduct academic research. *First Monday*, 12(8). Available online: http://firstmonday.org/issues/issue12_8/head/index.html, Last accessed: September 2009.

JÄSCHKE, R., MARINHO, L., HOTHO, A., SCHMIDT-THIEME, L., and STUMME, G., 2008. Tag recommendations in social bookmarking systems. *AI Communications*, 21(4), 231-247.

JENSEN, E., 1998. *Teaching with the Brain in Mind*. Alexandria, VA: Association for Supervision and Curriculum Development.

JONASSEN, D.H., CARR, C., and YUEH, H.P., 1998. Computers as Mind tools for engaging learners in critical thinking. *Tech Trends*, 43 (2), pp. 24-32.

JONES, S., 2002. *The Internet goes to college: how students are living in the future with today's technology.* Pew Internet & American Life Project, Available on: http://www.pewinternet.org/PPF/r/71/report_display.asp, Last accessed: Sep. 2009.

JUELL, P., 2007. Using a Class to Build Ontology. In: *2007 Midwest Instruction and Computing Symposium (MICS)*, Grand Forks, North Dakota, USA.

LIN, K.Y. and SOIBELMAN, L., 2009. Incorporating Domain Knowledge and Information Retrieval Techniques to Develop an Architectural/Engineering/Construction (A/E/C) Online Product Search Engine. ASCE, *J. of Computing in Civil Engineering*, 23(4), 2009, 201 – 247.

NONAKA, I., and TAKEUCHI, H., 1995. *The Knowledge-creating Company: How Japanese Companies Create the Dynamics of Innovation.* Oxford University Press.

SELLEN, A.J., MURPHY, R. and SHAW, K.L., 2002. How knowledge workers use the web. In: *the SIGCHI Conference on Human Factors in Computing Systems*, ACM Press, 227 - 234.

TANG, T., CRASWELL, N., HAWKING, D., GRIFFITHS, K. and CHRISTENSEN, H., 2006. Quality and relevance of domain-specific search: A case study in mental health. *Information Retrieval*, (2006) 9, 207 - 225.

VAN SCOYOC, A.M., 2006. The electronic academic library: Undergraduate research behavior in a library without books. *Libraries and the Academy*, 6(1), 47–58.

WILLIS, C.L., and MIERTSCHIN, S.L., 2006. Mind Maps as Active Learning Tools, *J. of Computing Sciences in Colleges.* 21(4), pp. 266 – 272.