

## Impact of commercial search engines and international databases on engineering teaching and research

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For the last three decades, the engineering higher education and professional environments have been completely transformed by the ‘electronic/digital information revolution’ that has included the introduction of personal computer, the development of email and world wide web, and broadband Internet connections at home. Herein the writer compares the performances of several digital tools with traditional library resources. While new specialised search engines and open access digital repositories may fill a gap between conventional search engines and traditional references, these should be not be confused with real libraries and international scientific databases that encompass textbooks and peer-reviewed scholarly works. An absence of listing in some Internet search listings, databases and repositories is not an indication of standing. Researchers, engineers and academics should remember these key differences in assessing the quality of bibliographic ‘research’ based solely upon Internet searches.

*Keywords:* Bibliographic search; Search engine; Library; Database; Digital repository; Engineering

### Introduction

Engineering is related to the application of science to real-world applications. Engineering graduates must be familiar with practical applications and relevant solutions, often based upon past experience and current state of the art. For the last three decades, the higher education and professional environments have been completely transformed by the ‘electronic/digital information’ revolution. That has included the introduction of personal computer, the development of email and world wide web, the introduction of search engines, and broadband Internet connections at home (table 1). This tendency has been associated with the development of digital resources, e-journals, but also computer-based courses and ‘virtual learning’, too often at the expenses of technical scholarship and practical studies in university studies. All these e-resources have had some impact on the access and retrieval of technical information used in engineering projects.

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Table 1. Summary of chronological development of electronic/digital resources.

Product	Chronological development	Personal experience of the writer
Personal computer	Mid 1970s 1977 : Apple II 1981 : IBM PC 1984 : Apple Macintosh	1980 : introduction to personal computer
World Wide Web/Internet	1969 : ARPANET 1983 : TCP/IP 1991 : World Wide Web project (CERN)	1990 : introduction to World Wide Web
ADSL/broadband Internet connection at home	2000 : introduction in Australia	2004 onwards
Email	1965 early 1980 growing usage	1992 : introduction
Google	1996 : Project "BackRub" 1997 : Registered 1998 : Incorporated	
Google scholar	Nov. 2004 : Registered	2005 onwards

In 2005, the engineering community saw the development of a new Internet resource called Google Scholar™ (e.g. Cozzolino and Di Pace 2005, Vaughan and Shaw 2005, Chanson 2006). The new Internet search engine aims to ‘*search specifically for scholarly literature*’ (Google Scholar Beta). It is a powerful tool for the university students and engineering professionals. But what is ‘*scholarly literature*’ as defined by Google Scholar™? The search engine documentation is very quiet. Could such a tool replace scientific libraries? Will we see: ‘Google as lecturer’ (Martin 2006)? For sometimes, universities have had access to another type of scientific resources: *i.e.*, the scientific databases like EI Compendex™ and Web of Science™. These databases are increasingly utilised by some university management and government education departments to quantify academic research outputs. Will the commercial search engines replace such commercial databases? Another source of information is the open access digital repositories such as the Eprints network and OAIster. These collections of digital, electronic resources regroup primarily academically-oriented digital resources that are easily searchable by anyone and open access.

In this note, the writer reviews the impact of commercial search engines, international databases, and related Internet based resources on engineering teaching and research, especially civil engineering. The study is based partly upon the experience of the writer as an university academic, a hydraulic researcher and an expert consultant for the hydraulic engineering industry.

### Information collection in engineering

The retrieval and use of technical documentations is an important component of engineering education including design projects and postgraduate research. It may be also a significant component of professional design projects undertaken by consulting engineers. Searching, finding and accessing the right information were traditionally undertaken in libraries: *i.e.*, university libraries, state libraries, professional libraries and personal collections. This approach has shifted towards Internet-based searches for the last decade. These include Internet library catalogues, international databases and specialised search engines.

## Definitions

A search engine is an Internet based tool designed to search, rank and present results in the form of links (URL) relevant to the searched terms. In 2006, the market is dominated by Google™ which started recently a specialised engine Google Scholar™ aimed to search the scholarly literature.

An international scientific database is a commercial database accessible by the Internet and listing international refereed publications. In engineering, some well-known examples include Web of Science™ and EI Compindex™. Other databases are managed by publishing companies and limited to the publisher's journals: *e.g.*, Science Direct™ and Scirus™ by Elsevier™, Kluwer Online™, Scitation™ regrouping several professional institutions like ASCE, ASME, AIP. However the access and usage of a commercial database is not free. It is relatively expensive, and hence it is limited only to large library institutions owned by government agencies, universities and large industrial groups.

An open-access digital repository is a service developed to support open-access (OA) research information. Open-access repositories (OAR) were developed by universities in reactions to high journal prices and licensing terms. The number of these repositories has blossomed over the last 5 years. The directory of open-access repositories (DOAR) operated by the University of Nottingham (UK) listed 371 open-access repositories (OAR) in April 2006.

A library is '*a place where books, recordings, films, etc are kept for reference or for borrowing by the public*' (The Penguin English Dictionary). Traditional libraries used to store and provide textbooks, handbooks, monographs periodical publications, theses and archive collections. Nowadays most libraries offer a broader range of services including printed materials, multimedia, on-line information resources, and in-person and on-line assistance.

## Applications in engineering

For engineering students, researchers and engineers, a project starts with some bibliographic research that involves (1) a search for relevant titles and listings, and (2) the retrieval of the most appropriate documents. These two phases may involve distinct specific techniques and they should not be mistaken. Further the two stages must be followed by a critical analysis of the retrieved information that is not discussed herein. For example, let us consider the design of a hydraulic jump energy dissipator at the downstream end of a spillway (figure 1). An engineer must first search for the relevant terms : *e.g.*, hydraulic jump, energy dissipation, spillway. Then he will select, retrieve and analyse the few, most relevant documents.

There is a basic difference between the search and retrieval stages. The search may be conducted in a library or on-line using library catalogues, scientific databases and Internet search engines. The search results provide a very broad listings of relevant materials and resources that must be critically ranked. For example, a search for "hydraulic jump, energy dissipation, spillway" in Google™ yields 12,400 results, while a search with Google Scholar™ gives 219 titles! (Of the 219 documents listed by Google Scholar™, more than 50% are not open access.) For comparison, a search in Web of Science™ yields 22 refereed journal publications.

The second stage, the "retrieval", is closely linked with (a) a selection of the most relevant results of the search, and (b) the rights and permission to access the resources. Engineering students and academic researchers may access a wide range of physical and electronic resources provided by their university library. These encompass the physical collections, the electronic periodical subscriptions and open access repositories. Professionals have usually some restricted access to these services. The cost of traditional libraries and international databases is often prohibitive. Many consulting engineers can only access commercial search



Figure 1. Photograph of a hydraulic jump energy dissipator in operation (Courtesy of John REMI) - Pine Coulee dam spillway during floods in South Alberta, Canada in June 2005 - Flood flow from left to right.

engine like Google Scholar™ and open-access digital repositories: *e.g.*, ‘*as a consultant, I don’t have access to journal indexes or databases (. . .) it’s just much too expensive*’ (J. Remi, Person. Comm., 9 March 2006). Individuals and small companies are simply limited exclusively to open access materials, including the open access repositories and the ‘grey literature’.

Although some ranking of the search results may be based upon the number of citations or cross-references (*e.g.* Web of Science™, Google Scholar™), the final selection of the relevant references derive often from an iterative process involving the search, retrieval and analysis of the documents by the engineers, which may lead to further relevant documents.

### **Comparison between commercial search engine and international databases**

Some recent studies compared the search outputs of Google Scholar™ and ISI Web of Science™ (Vaughan and Shaw 2005, Noruzi 2005), although they did not encompass engineering. Herein the writer tested and compared the outputs/performances of commercial Internet resources, international databases, digital repositories and traditional library resources. Table 2 lists some comparative search results from three international scientific databases, an electronic repository and Google Scholar™ for several hydraulic engineering topics including tidal bore and broad-crested weir.

First it is important to remember that the search engine Google Scholar™ is a commercial tool from a dominant market leader which is developing new Internet services. The search engine Google Scholar™ is not an independent scientific database like EI Compendex™ and ISI Web of Science™ which includes Science Citation Index™. Search results from Google Scholar sometimes include more non-refereed references than peer-reviewed publications (*e.g.* table 2). While differences were expected, it was noted that the quality of Google Scholar search outputs was closely linked with the appropriate selection of technical and scientific terminology. In

Table 2. Comparative search results in hydraulic engineering topics between a search engine, three scientific databases and an open-access digital repository

Search topic	Data	Google Scholar™	EI Compendex™ 1884–2006	ISI Web of Science™ 1945–2006	Scirus™ *	OAIster
‘Tidal bore’	Number of results	170	78	29	1036/81	13
	Percentage of peer-reviewed works	50	90	100	8/90	92
‘Broad-crested weir’	Number of results	85	58	28	1619/35	3
	Percentage of peer-reviewed works	45	95	100	2/100	100
‘Dropshaft’	Number of results	81	33	15	191/8	16
	Percentage of peer-reviewed works	79	94	100	4/100	94
‘Air entrainment’ in “hydraulic jump”	Number of results	164	37	8	301/28	5
	Percentage of peer-reviewed works	73	92	100	9/100	100
‘Dam break wave’	Number of results	71	30	17	389/14	12
	Percentage of peer-reviewed works	85	97	100	3.5/100	100
‘Thixotropic fluid flow’	Number of results	3	1	1	6/2	0
	Percentage of peer-reviewed works	100	100	100	33	–

Notes: Topic searches performed between August 2005 and March 2006.

(\*): total number of results/number of journal results (Scirus™).

other words, the output quality was related to the quality of the inputs. Interestingly the writer was surprised positively by the results from the open access digital repository OAIster developed by the University of Michigan (table 2, column 7). (OAIster accessed over 730 institutions and included over 10 millions of open access documents in January 2007.)

For comparison, the writer searched the University of Queensland Library catalogue associated with a search in the shelves for each term listed in table 2. He found several key references that were not listed in any search engines nor international databases, especially 12 books and 4 video documentaries. In fact, books, video documentaries, photographic records and side-shows are typical library resources that are often ignored by the Internet. Let us consider again the earlier example for the design of a hydraulic jump energy dissipator. A search for ‘hydraulic jump, energy dissipation, spillway’ at the University of Queensland Library yields nearly 25 books, monographs, theses and videos (figure 1). None is available on the Internet. Clearly these show that traditional libraries cannot be replaced simply by an Internet search.

## Comments

One advantage of search engines (e.g. Google Search™) is the ability to search for on-line/digital versions of older manuscripts. For example, the writer found at least six libraries that hold the classical hydraulic engineering reference ‘*Recherches Hydrauliques*’ by Darcy and Bazin (1865) and another twenty libraries that hold the textbook ‘*Essai sur la Théorie des Eaux Courantes*’ (Boussinesq 1877), while he found on-line the original paper of Shields

(1936) on the critical bed shear stress for sediment motion in rivers and open channels. Another aspect is the type of search outputs. Search engine results include both commercial journal databases and open-access repositories, although they rarely encompass textbooks and technical monographs.

## Discussion

In recent years, the writer has become increasingly concerned by the disinterest of young researchers, engineers and students for basic references that are not listed nor available in the Internet, like textbooks, handbooks, videos. This attitude covers also scientific publications published prior to 1997–2000 because these are too often not available on-line. This trend is true to most international scientific journals like *Journal of Fluid Mechanics*, *Journal of Fluids Engineering ASME*, *Journal of Hydraulic Research IAHR* or *Experiments in Fluids*. Many scientific journals should initiate some project to scan all earlier issues of their journal for digital access. Importantly the fact that an article or a book is not available in a digital format does not constitute a valid information on its standing. The number of citations by peers in refereed publications (*e.g.* using Science Citation Index) is a better indication of scholarship and quality.

We must understand that computer search engines and Internet databases cannot replace conventional libraries. They fail to convey well images, pictures, and graphical information. For example, they cannot express the beauty of turbulence in Nature (figures 1 and 2), the sorrows of an environmental catastrophe nor the extent of a human tragedy at world-scale (figure 3). Figure 2 shows a photograph of a tidal bore in France and the event was documented with some video materials. Figure 3 presents two photographs of the Sumatra tsunami impact on 26 December 2004 on the Aceh coastline. Traditional library resources may include a wide



Figure 2. Photograph of a tidal bore propagation in the Sélune river, France.



Figure 3. Photographs of a damaged cement plant in the Lhonga Area (South-west of Banda Aceh) after the 26 December 2004 tsunami disaster (Photographs Dr V. GUSIAKOV, Novosibirsk Tsunami Laboratory) (A) Looking South from a hill top at a tug boat and large barge moved inland by the tsunami waves, with the cement plant in the background left and a sunken ship in the harbour (background right) (B) Damaged cement plant.

range of support including audio-visual, hard copies of older books and 3D animation that are not on-line. Internet ‘surfing’ does not replace browsing the shelves of a good scientific library.

Further digital materials are biased towards the American and English literature, at the expense of other sources (*e.g.* Vaughan and Thelwall 2004). For example, in hydrodynamics, Hero, the Bernoulli family, Jean-Charles de Borda, Joseph LAGRANGE, Pierre-Simon LAPLACE did not publish in English.

Lastly civil engineering, including hydraulic engineering, is not a ‘virtual’ science! Engineers and researchers must gain first hand experience in real professional situations, and comprehend the complex interactions between engineering and non-engineering constraints. Computer and Internet aids cannot replace field experience and personal individual observations (*e.g.* Chanson 2004).

## Summary and conclusion

In summary, the writer believes that new search engines and open access digital repositories may fill a gap between traditional search engines, databases and libraries. But these new means should not be confused with traditional libraries and international scientific databases that encompass textbooks and key peer-reviewed publications. Similarly the standing of textbooks and handbooks should not be confused with a lack of listing in some databases and repositories. Researchers, engineers and academics should be aware of these key differences in assessing the quality of bibliographic ‘research’ that would derive solely from Internet searches. In addition, Internet ‘surfing’ cannot replace traditional resources and personal experience. This is particularly true in hydraulic engineering and fluid mechanics, and the future lies probably in a complementary use of all tools by expert, knowledgeable researchers, academics and engineers.

## References

- Boussinesq, J.V., Essai sur la Théorie des Eaux Courantes. (‘Essay on the Theory of Water Flow.’) *Mémoires présentés par divers savants à l’Académie des Sciences*, 1877, Paris, France, Vol. 23, Série 3, No. 1, supplément 24, pp. 1–680 (in French).
- Chanson, H., Enhancing Students’ motivation in the undergraduate teaching of hydraulic engineering: the role of field works *Jl of Prof. Issues in Engrg Educ. and Practice*, 2004, ASCE, **130**(4), 259–268.
- Chanson, H., Commercial search engines, international databases or traditional libraries? *Jl of Hyd. Res.*, 2005, IAHR, **43**(6), Supplement, pp. A85–87.
- Cozzolino, L. and Di Pace, P., Using google scholar. *Jl of Hyd. Res.*, 2005, IAHR, **43**(3), Supplement, pp. A44–45.
- Darcy, H.P.G. and Bazin, H., Recherches hydrauliques. (Hydraulic Research.) *Imprimerie Impériale*, 1865, Paris, France, Parties 1ère et 2ème (in French).
- Martin, P., Google as teacher. everything your students know they learned from searching google. *Colleges & Research Libraries News*, 2006, **67**(2), pp. 100–101.
- Noruzi, A., Google scholar: the new generation of citation indexes. *Libri*, 2005, **55**, 170–180.
- Shields, A., Anwendung der Aehnlichkeitsmechanik und der Turbulenz Forschung auf die Geschiebewegung. *Mitt. der Preussische Versuchanstalt für Wasserbau und Schiffbau*, 1936, Berlin, Germany, No. 26.
- Vaughan, L. and Shaw, D., Web citation data for impact assessment: a comparison for four science disciplines. *Jl Am. Soc. for Inform. Sc. and Tech.*, 2005, **56**(10), 1075–1087.
- Vaughan, L. and Thelwall, M., Search engine coverage bias: evidence and possible causes. *Information Processing & Manag.*, 2004, **40**, 693–703.



## Relevant bibliography

- Chanson, H. Coastal observations: the tidal bore of the sélune river, mont saint michel bay, france. *Shore & Beach*, 2004 **72**(4), 14–16.
- Chanson, H. Le Tsunami du 26 Décembre 2004: un Phénomène Hydraulique d'Ampleur Internationale. Premier Constats." *Jl La Houille Blanche*, 2005 No. 2, pp. 25–32.
- Directory of Open-Access Repositories DOAR, the University of Nottingham (UK) {<http://www.openoar.org/>}
- EI Compendex {<http://www.engineeringvillage2.org/>}
- Google Scholar {<http://scholar.google.com/>}
- ISI Web of Science {<http://portal.isiknowledge.com/>}
- OAIster {<http://oaiSTER.umdl.umich.edu/oaiSTER/>}

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*Hubert Chanson* is a Professor in Civil Engineering at the University of Queensland, Brisbane, Australia. His research interests encompass the design of hydraulic structures, experimental investigations of two-phase flows, coastal hydrodynamics, environmental hydraulics and natural resources. His publication record includes twelve books and over 350 international refereed papers. He authored the student textbook "The Hydraulics of Open Channel Flows: An Introduction" (1st edition 1999, 2nd edition 2004) currently used in 50 universities worldwide.

In 2003, the IAHR presented Hubert Chanson with the 13th Arthur Ippen Award for outstanding achievements in hydraulic engineering. The American Society of Civil Engineers, Environmental and Water Resources Institute (ASCE-EWRI) presented him with the 2004 award for the Best Practice paper in the Journal of Irrigation and Drainage Engineering. His Internet home page is <http://www.uq.edu.au/~e2hchans/>.