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Quantitative Literacy on the Web of Science, 1: The Bibliography and its Role in the History of this Journal

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Quantitative Literacy on the Web of Science, 1: The Bibliography and its Role in the History of this Journal

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Abstract

Prior to deciding to propose in 2006 that the National Numeracy Network (NNN) publish a new journal for quantitative literacy with their support, the University of South Florida Libraries investigated the publication environment of the field on the Web of Science. Reproducing part of that study in this paper, we present findings from topic searches (March 2008) for “numeracy,” “quantitative literacy,” and “statistical literacy.” These updated results include a combined bibliography of 338 peer-reviewed articles amongst 210 different journals, by 748 authors from 321 institutions in 25 countries, in a total of 87 subjects (34% of the subject classes in Web of Science). Publication dates indicate exponential growth since 1974, with a doubling time of 4.8 years. Citation patterns argue that the field would benefit from the development of a hub journal. With the exception of citation-connected papers in medicine, health science and public health (21% of the collection), the papers of the bibliography are either completely isolated (54%) on a citation graph or in relatively small, weakly connected clusters. Very few are cited in prominent edited volumes associated with the NNN. In keeping with the concept that this journal will become a hub journal for the field as envisioned by the proposal from the USF Libraries, this paper presents the bibliography as well as a link and guide to an online version of the Histcite citation graph where readers can browse the abstracts.

KEYWORDS: bibliography

Introduction

The Board of Directors of the National Numeracy Network decided at its second annual meeting (August 2006) to develop a new online journal (Madison and Steen 2008a) – a decision which came to fruition when *Numeracy* was launched in January of this year. The board’s decision was in response to a proposal submitted by the University of South Florida Libraries, who volunteered to support the project as part of its alignment with the Association of Research Libraries’ 2005-2009 strategic plan.¹

Before the USF Libraries could make such a proposal and commit to such support, its Director of Collection Analysis & Technical Services (TC) needed to prepare an internal business plan, of course. That business plan included an investigation of the publication environment of quantitative literacy (QL). A compelling part of that investigation consisted of a quick look at what “quantitative literacy” and “numeracy” turn up in a topic search on *Web of Science* (*WoS*). The search revealed a bibliography consisting of hundreds of papers unfamiliar to the first author. That finding was disconcerting because he thought he was reasonably well read on the subject.

The disconnect between that bibliography and the familiar references outside the impact journals indexed by *WoS* – not to mention the largely disconnected, fragmented nature of the network of papers within that bibliography – argue for the potential benefits to QL education that would derive from an across-the-curriculum QL journal that could serve as a hub for scholarly activities in QL. With that concept in mind, this paper aims to acquaint readers of *Numeracy* with the vast network of papers published in the so-called impact journals. We present here the bibliography from a topic search of “numeracy”, “quantitative literacy”, and “statistical literacy” and a view of its citation graph. We also provide separately an online interactive version that provides access to the abstracts of many of the papers plotted on the graph. And we recount some observations that helped make the case for the USF Libraries to support the initiation of *Numeracy* with the objective of developing an open-access hub journal for QL.

¹ “ARL will be a leader in the development of effective, extensible, sustainable, and economically viable models of scholarly communication that provide barrier-free access to quality information in support of teaching, learning, research, and service to the community” (Association of Research Libraries, 2005).

Web of Science and HistCite

Thomson Reuter's ISI² *Web of Science*® (*WoS*) is an online citation index available at many academic libraries. As of June 20, 2008, it provides access to some 10,200 journals through the Science Citation Index (SCI, 1900-present, 67.6% of the journals), the Social Citation Index (SSCI, 1956-present, 19.9%), and the Arts & Humanities Citation Index (A&HCI, 1975-present, >12.5%) (Thomson Scientific, n.d.). The database can be searched by topic, title, author, journal, date, and Boolean combinations of these. *WoS* provides a variety of tools to analyze the results of the search and to explore the network of publications connected by the references and citations within the indexed journals. It is common practice now for researchers to try to keep up with their field by searching and analyzing this database.

Researchers familiar with *WoS* are well aware that this library resource has limitations. It is common knowledge that *WoS* does not routinely index books, edited volumes, symposium proceedings, government publications, gray literature, and Web sites, for example.³ Also, it does not come close to indexing all journals.⁴ Although 10,200 may seem like a huge number of journals, the number is small compared to the total volume of periodicals (300,000⁵ in Ulrich's Periodical Directory⁶). More specifically, many peer-review journals where one might seek papers on numeracy are not included (e.g., *The College Mathematics Journal* [Mathematics Association of America], *Teaching Mathematics* [National

² Developed following Eugene Garfield's 1955 conceptualization of citation indexing and searching (see http://isiwebofknowledge.com/currentuser_wokhome/cu_wokhistory/ for additional information and a history).

³ However, according to the current product specifications, the resource covers 5,000 books, 192,000 conference proceedings, and 5,000 Websites, as well as 23-million patents and 2- million chemical structures (Thompson Scientific, n.d.).

⁴ The rationale for selection is a "bang for your buck" argument. Articles are not uniformly distributed amongst journals. Librarians are well aware of the Bradford distribution (a Pareto-like, inverse power law) that says the overwhelming preponderance of articles is in disproportionately few journals, and they use the concept in selecting subscriptions with a limited budget. Garfield (1972) found a similar distribution for citations: back when SCI indexed 2200 journals (1969), "only 25 journals (a little more than 1% of SCI coverage) are cited in 24% of all references; only 152 journals are cited in 50% of all references; only 767 journals are cited in 75% of all references" and so on. He concluded: "Going beyond Bradford's studies, I can say that a combination of the literature of individual disciplines and specialties produces a multidisciplinary core for all of science comprising no more than 1000 journals."

⁵ This number refers to *all* periodicals, including newspapers and trade magazines. We do not have a figure for the total number of peer-review journals. Garfield (1972) noted the "contention" ("highly debatable" he said) of 50,000-100,000 for the number of scientific and technical journals. That, of course, was many years ago.

⁶ <http://ulrichsweb.com/ulrichsweb/>

Council of Teachers of Mathematics], *Journal of College Science Teaching* [National Science Teachers Association], *The Physics Teacher* [American Association of Physics Teachers], *Journal of Geoscience Education* [National Association of Geoscience Education], *Journal of Education for Business*, *Journal of Statistics Education*, *Chance*).

On the other hand, the subset of journals indexed by *WoS* is crucially important to the dissemination of research. They are also vitally important to academic researchers interested in professional advancement. These journals, which are all peer-review journals and are selected on the basis of proactive application, are, by sort of self-fulfilling definition, the infamous *impact journals* defined by the “impact factor” measure (Garfield 1972, 2005; Monastersky 2005; Lawrence 2007) and a new measure by which research faculty are increasingly evaluated, the H-index (Hirsch 2005). Indeed when we team-taught a project-oriented seminar course *Geologic Information* to USF geology graduate students during spring 2008, two key messages to students preparing for careers with a healthy portion of geological research were: “It doesn’t count as research unless it’s published,” and “It’s not published unless it’s published in an impact journal.”

One reason for the enormous impact of *WoS* on scientific research is the ease with which researchers can use it to find the core peer-reviewed literature of their field, and then browse the key papers identified by the network of citations. This great facility has been increased substantially with the development of *HistCite*,⁷ a software application that enables users to chart and explore the citation graphs of bibliographies that they create on *WoS*. The vertices (nodes) in *HistCite* citation graphs are the papers of the selected bibliography; the edges (links) show the citations; the vertices can be shown as circles with areas proportional to the number of citations; and the vertices are arranged vertically by date. Because of the last feature, the citation graphs are called “historiographs” in the language of *HistCite*. With a historiograph, users can quickly visualize the development of the literature of interest and easily pick out influential papers and emerging research fronts. Moreover, by hovering the mouse over any given vertex, the researcher gains access to the bibliographic and citation information of the paper as well as its abstract, if the *WoS* includes one.

The Bibliography and Its Historiograph

Topic searches in *WoS* find the papers using the search terms in the title, keywords and abstract (if included) of papers in the database. For the purpose of

⁷ “HistCite® is a software implementation of algorithmic historiography, and has been developed by Dr. Eugene Garfield, founder of the Institute of Scientific Information and the inventor of the Science Citation Index®” (HistCite, n.d.).

this paper, we conducted three topic searches: for “numeracy” (8 March 2008), “quantitative literacy” (29 February), and “statistical literacy” (29 February). In all, we found 338 unique articles in the three searches.

The 338 articles are listed in the bibliography of the appendix together with an abbreviation (N, QL, SL) indicating the search term that found each of them. Thus the bibliography of the appendix is the union of three single-search term bibliographies: the N-Bibliography (290 articles), QL-Bibliography (29) and SL Bibliography (25).

The historiograph of the combined bibliography is shown in Figure 1. Obviously, it contains too much information for a page in a journal. Fortunately, *HistCite* includes an HTML-publishing feature that enables one to post an interactive presentation of the results of a *WoS* bibliographic search. We encourage interested readers to go to our “*HistCite* - Select Bibliography Concerning Numeracy, Quantitative Literacy and Statistical Literacy, 1926-2008”⁸ (hereinafter, “*HistCite* Bibliography”). This online *HistCite* Bibliography opens with a bibliographic listing of the 338 references, which can be sorted by date, alphabetically by author, and alphabetically by journal. Click on Historiographs. The first option “Citation patterns within the select bibliography” is a large-scale version of Figure 1. The other three options produce historiographs for the N-, QL- and SL-Bibliographies. One needs to scroll both vertically and horizontally to browse the graph. Allow time to peruse the abstracts.

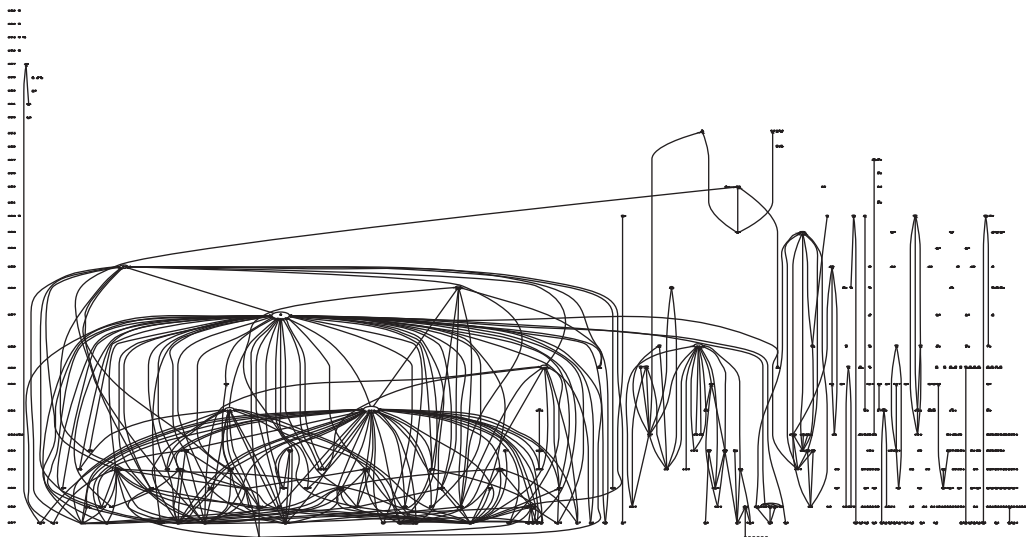


Figure 1. Historiograph for the Bibliography in the Appendix: 338 vertices, 312 edges; one large cluster; several small clusters; few cross-connections; many isolated vertices.

⁸ http://www.lib.usf.edu/Numeracy/V-C_2008-07/

One can access the abstracts either on the historiographs or on the “List of All Records” page. At either place, clicking on the record number of the paper retrieves the abstract as a popup in a separate window. For example, when the all-records page is sorted by author, Adamsprice (1993) is the first record in the sorted list. It is “record number 43”, meaning it is the 43rd record chronologically. (Abstracts start at record 28, in 1992.)

Information about each paper’s references and citations is available on the all-records page, the historiographs, and the abstract popups. The terminology is as follows. “Local” refers to the collection, in this case the 338 papers in the bibliography; thus LCS (Local Citation Score) is the total number of later papers in the collection that cite the paper in question, and LCR (Local Cited References) is the number of earlier papers in the collection that the paper in question cites. “Global” refers to all the other papers in the *WoS* database and is used in GCS, the Global Citation Score. CR, meaning Cited References, is the number of references both inside and outside of *WoS*. The papers can be sorted on the all-records page by any of these variables. Thus one can learn easily that Schwartz et al. (1997) is cited the most times (LCS=50) by other papers in this collection; that Williams et al. (1995) is cited the most times (GCS=341) by papers in impact journals; that Ancker and Kaufman (2007) cites the most number of papers (LCR=18) in this collection; and Thomas (1987) cites the most papers (CR=204).

Some Observations

The bibliographic listing and its citation graph contain a wealth of information. For the purpose of this paper, we focus here on some observations that the USF Libraries found compelling when they decided to propose that NNN publish a scholarly journal in numeracy.

- The number of new papers using the terms “numeracy,” “quantitative literacy,” and “statistical literacy” is growing at an increasing rate. In fact, the growth of the bibliography has been exponential. Ignoring the two early references (Henschen 1926; Kaiser 1936), and starting with $t_0 = 1974$ when the impact-journal papers began appearing regularly, the size of the bibliography can be described by $2.535 \exp[0.1444(t - t_0)]$ ($r^2 = 0.99$), where t is the publication year. The implied doubling time is 4.8 years.⁹

⁹ For comparison, the well-known doubling time for scientific literature (de Solla Price 1965) is about 15 years (It was derived from Garfield’s SCI data for 1961; for interesting discussion see Griffith 1988). The value for geological literature indexed by the American Geological Institute’s GeoRef data base is about the same (Fratesi and Vacher 2008). For the literature of climate change, it is 11 years (Stanhill 2001).

- The reach of the three terms is broad; they represent an emerging multi-disciplinary field. *WoS* uses a detailed classification scheme of 256 subjects to tag the articles. The 338 articles of the bibliography are classified into 87 (34%) of those classes (with numerous double-counting, such as “education” in combination with some other subject). That means about a third of the subjects covered by the *WoS* database is touched by the papers on the subject of this journal.
- The authors using the terms are large in number and widely distributed; the interest in numeracy is global. The 338 papers have a total of 748 authors, associated with 321 institutions in 25 countries (less than half from the US).
- Bibliographically, the literature is widely scattered and disjointly distributed. The field is wanting of a hub journal. The fragmented nature of the literature is seen in a variety of ways:
 - The 338 papers are distributed amongst 210 journals. Only three journals have 10 or more of the papers: *British Educational Research Journal* (12), *American Statistician* (11), *Medical Decision Making* (11). Nearly three-quarters of the journals (155/210) have but a single article.
 - The journals of the three bibliographies (N, QL, and SL) do not overlap much; broadly speaking, users of the three terms use different journals. For example 70% (12/17) of the journals of the QL-Bibliography contain most (52%; 15/29) of the papers of that bibliography, and they have none of the papers included in either of the other bibliographies. Similarly, 54% (7/13) of the journals of the SL-Bibliography have 29% (7/25) of the statistical literacy papers and none of the papers in either of the other bibliographies.
 - The overall view of the historiograph (Fig. 1) is that there is one large cluster; a few weakly connected, small clusters; and many disconnected individuals. Regarding the latter, 251 (74%) of the papers are not cited by any other paper in the bibliography, 220 (65%) do not reference any other paper in the bibliography, and 182 (54%) neither cite nor are cited by another paper in the bibliography. The eye-catching tangle is a network of interconnected references with waves of evident benchmarks (Williams et al., 1995; Adelsward and Sachs 1996; Baker et al. 1999; Wolsohin et al. 2001; Lipkus et al. 2001) (Fig. 2). This cluster in the field of medicine, health sciences and public health contains 70 references (21% of the bibliography; 45% of the references that have any connection with others in the

bibliography). Other clusters evident in the historiograph include cascades from Brown et al. (1998) on the National Numeracy Strategy (UK), from Wallman (1993) on statistical literacy, from Riverabitiz (1992) on employment, and from Bialystok (1992) on cognitive development. These clusters are nearly to completely disjoint from each other and the large medicine-health cluster.

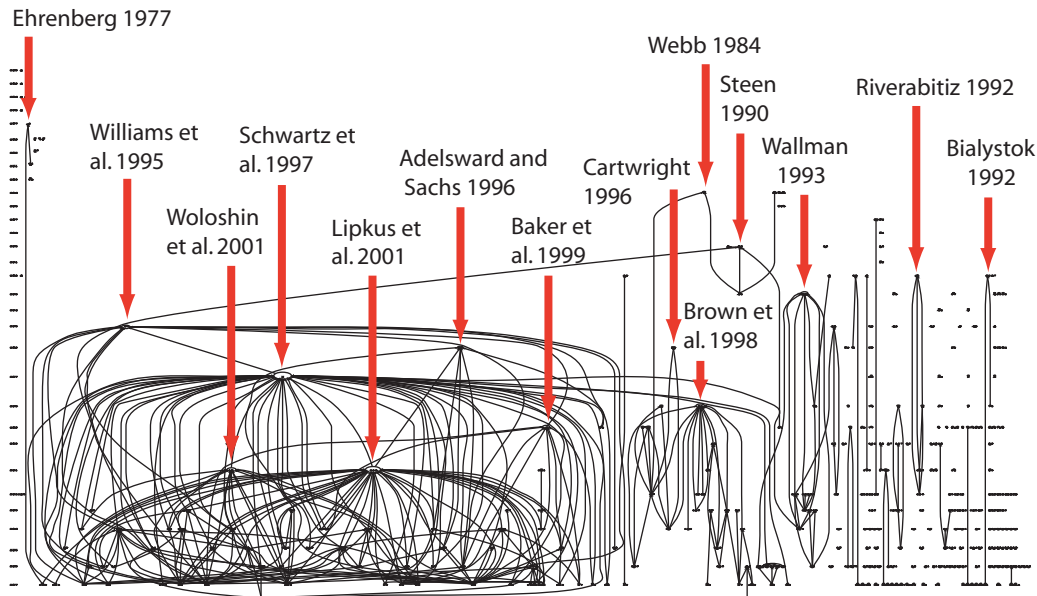


Figure 2. Benchmark Papers in the Bibliography

- The literature of the *HistCite* bibliography (Figures 1 and 2) is largely disjoint from the “familiar literature of QL outside the impact journals,” as we asserted in the Introduction. The disjunction can be substantiated in various ways – most easily by a quick look at the community of authors. We take as hallmarks of “the familiar literature” the prominent edited volumes by Steen (2001), Madison and Steen (2003), Gillman (2006) and Madison and Steen (2008b). All told, there are 90 papers in these collections and 100 different authors and members of advisory groups (design team for Steen 2001; steering committee for Madison and Steen 2008b). This community overlaps hardly at all with the 748 authors in the *HistCite* bibliography. Only four individuals are in both groups: Joel Best, Richard Scheaffer, Lynn Steen and Jessica Utts, accounting for a total of seven of the 338 papers in the *HistCite* bibliography. More laborious would be a compilation of the cited references in those 90 papers. We leave it

to interested readers to browse the classic edited volumes; we are convinced from our scan that those papers tend to cite books, edited volumes, symposium proceedings and official documents and very few papers in journals indexed by *WoS*. In fact, the only papers in the *HistCite* bibliography that we recognized in the references of the familiar QL edited volumes are Steen (1990) (by Steen 2003); Steen (1999) (by Design Team 2001 and Steen 2003) and Nolan and Speed (1999) (by Lutsky 2008). In other words, the *HistCite* bibliography provides a window to a numeracy literature that differs dramatically from the familiar QL literature of the monographs and edited volumes.

Concluding Remarks

This paper is a case example of how topic searches in *Web of Science* contributed to a university library's decision: Should the USF Libraries support the initiation of a new journal in QL? From the Libraries' perspective, the motivating reality is that subscriptions to academic journals continue to increase in cost, even to the extent that researchers and readers are becoming unable to afford them and libraries are becoming unable to provide them. Thus a priority drive for USF Libraries is to contribute to global dissemination of important information by making it openly accessible to users regardless of their economic level or affiliation with an academic or commercial entity. The questions that needed to be answered, therefore, had to do with the field of QL – its importance, viability and level of interest – and whether a new journal would make a difference. For “importance,” the question was, is it multidisciplinary? For viability, the question was, is it an emerging, growing field? For level of interest, the question was, is there a global constituency with lots of potential authors? The evidence from *WoS* supported an affirmative answer to all of these questions. Regarding making a difference, it is more than evident in the *HistCite* graphs that this emerging field wants a hub journal.

Acknowledgments

We thank the former and current deans of the USF Libraries who have made the USF support of the *Numeracy* project possible. Dean Derrie Perez, who was a driving force in adopting open-access journal publishing as a part of the Libraries' strategic plan, had the vision to encourage – and fund – the initiation of the journal. Dean William Garrison is similarly committed to the project, and to expanding the Libraries' support to additional globally relevant, multidisciplinary areas of research. We also thank the three anonymous reviewers for their helpful feedback.

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Appendix: The Bibliography

The abbreviations, N, QL, and SL indicate the terms used to conduct the search in which the reference was found: numeracy, quantitative literacy, and statistical literacy, respectively.

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