Information Science in System Dynamics: A Review of the System Dynamics Society Bibliography

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Abstract

The Information Science and Information Special Interest Group (iSIG) wishes to understand its domain within the context of System Dynamics and how to advance its chosen field. To this end, the System Dynamics Society's (SDS) bibliographic database is examined for titles and keywords relating to information science within SD. The Web of Science, a popular online publication database is also examined for references to encourage future SD works. The majority of articles in the SDS database come from two sources: The System Dynamics Review and the ISDC conference programs. There is little overlap between the SDS database and the Web of Science, as the latter does not generally index conference materials. This lack of overlap may limit the visibility of the Society's database to those individuals who already know of its existence rather than persons new to the field. There are also gaps within the Society's current database that limit its effectiveness when searching for items in the iSIG domain, as well as other areas of interest to the SD community. Changes to the submission system process are recommended to capture more meta-data and abstracts to increase the value of the database to the public.

Keywords: Information Science, System Dynamics, Bibliometrics, Information Systems.

1. Introduction

A reboot of the Information Science and Information Systems Special Interest Group of the System Dynamics Society (iSIG) began at the 2013 Cambridge ISDC meetings. Identifying the operating domain and interests of the iSIG members is a key step in this rejuvenation. The current iSIG vision is based on an assertion:

> "*The iSIG can be a locus for discussions on the technologies used to support our work, such as model integration and data interchange, standards (such as those under the emerging XMILE open standard), and other tools. We can also capture and disseminate best practices and guidelines for development of efficient and effective models.*" (iSIG Mission Statement, http://www.systemdynamics.org)

In this paper we employ a historical lens to the Society's reference database (REF) for guidance and insight into the past role of information systems and information science within the SD community. We report on our cursory review of iSIG-related topics within the Society's bibliographic file as well as a search within the Web of Science (apps.webofknowledge.com), an online resource used by academic researchers. Afterwards we make some tentative recommendations on how to improve the quality and visibility of SD works to those inside and outside the field.

2. Background Information

Information technology is at the core of System Dynamics modeling. In his seminal article on Industrial Dynamics, Forrester noted the importance of data-processing and information feedback systems to the improvement of management actions (Forrester, 1958). Specialized computer simulation languages and extensions to general purpose and mathematical languages are employed throughout the field to capture and express the nuances of dynamic analysis. Information Systems and their management have been the subject of dozens of SD studies, including fundamental analysis of software project dynamics (Abdel-Hamid & Madnick, 1991; Madachy, 2008), and unforeseen outcomes in technology projects (Abdel-Hamid & Madnick, 1990).

Information Science is more than information technology. The roots of information science are arguably based in the retrieval and storage of information in the form of books and the collection of artifacts, all predating computer technology by centuries. Information science is linked deeply to automation, where loom controllers and Hollerith cards serve as analog exemplars of the technological response to increased demand for faster and replicable processes. (ASIS&T, 2014)

In the Internet age, information science connotes the computational and mathematical forms needed to understand information capture, transmission, analysis and storage. Recent activities to develop XMILE, a universal standard for model exchange (Diker & Allen, 2005) standards for documentation (Martinez-Moyano, 2012) and the on-line delivery of systems training and modeling (e.g., www.forio.com). Others concentrate on the effective application of information through decision analysis, economics, and statistics. Quite recently the XMILE standards activities advanced towards an open XML protocol for interoperability and the integration of large scale datasets through the OASIS XML Interchange Language (www.oasis-open.org).

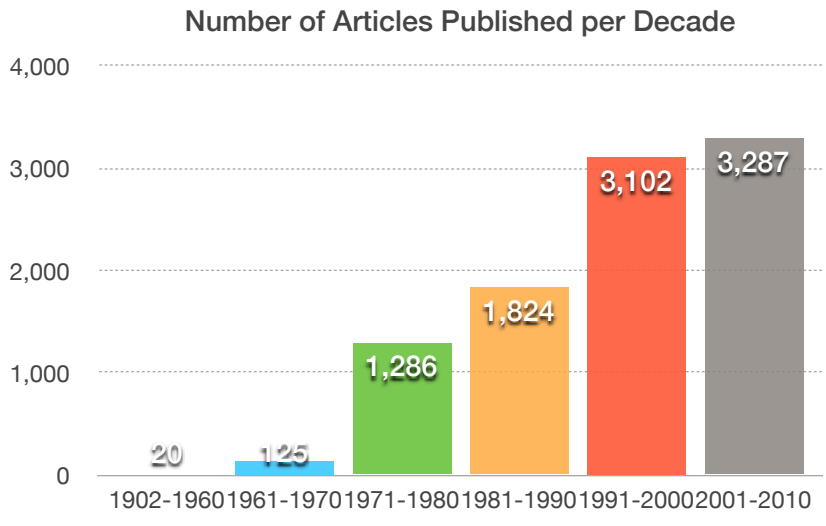
3. ISDC Database Analysis

What is the history of Information Science within our literature base? We begin our analysis by examining the contents of the latest System Dynamics Bibliography Database (2014a), provided by the System Dynamics Society as an open source resource. The database itself, as a creditable resource for research, is actively maintained by a number of professionals at the System Dynamics Society. It currently has more than 10,000 entries including journal articles, conference papers, conference proceedings, books, and many other types of publications in the field of System Dynamics. Precisely as of March 2014, it has a total collection of 10,577 articles published from 1902 to 2013 by 8,632 different authors in 892 various journals.

[Chart 1] shows the total number of articles published in every ten years. Due to a limited number of publication between 1902 to 1960, articles with a publish date prior to 1960 have been categorized into one column of twenty. Besides, articles published between 2011 and 2013 are not included for column graph. Starting 1961, a positive growth pattern was recognized over the following 50 years. And especially, the number of articles collected to the System Dynamics Society's Database in the most current twenty years is significantly higher than before, thanks to the continuous maintenance.

Chart 1

YEAR	ARTICLES
1902-1960	20
1961-1970	125
1971-1980	1,286
1981-1990	1,824
1991-2000	3,102
2001-2010	3,287
2011-2013	898
Undefined	35



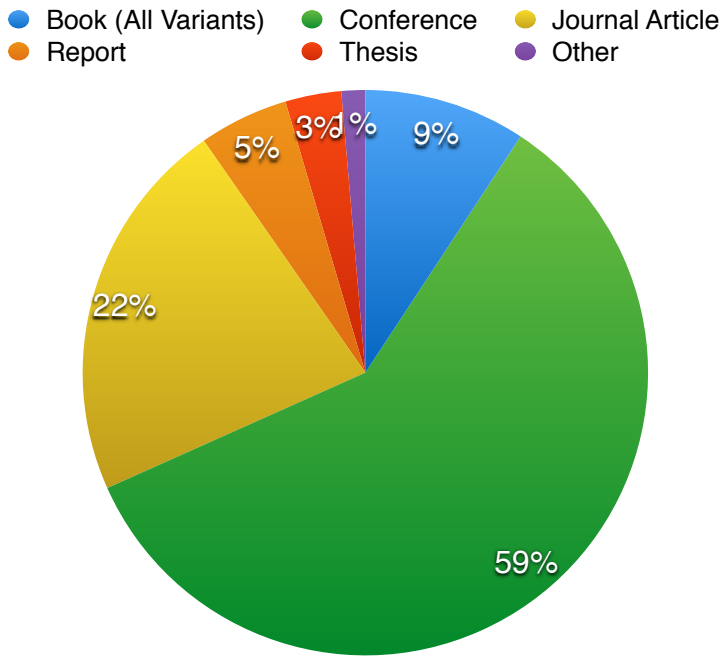
As an interdisciplinary field, system dynamicists come from a great variety of backgrounds with differentiated sub-domains and research groups. And these variations lead to a

good number of publication types. [Chart 2] demonstrates the total number of articles published in different types. As most publications were presented in forms of conference paper, journal article, and book, a pie chart was generated under more clustered categorization to ensure higher readability. The major sources for publication, as indicated above, contributes 59%, 22%, and 9% respectively for a total number of 9,553 out of 10,577.

Chart 2 - Reference Type

Number of Articles Published by Reference Type

REFERENCE TYPE	ARTICLES
Audiovisual Material	20
Blog	1
Book	403
Book Section	455
Computer Program	17
Conference Paper	6212
Conference Proceeding	34
Edited Book	121
Electronic Article	3
Electronic Book Section	1
Generic	16
Journal Article	2328
Magazine Article	31
Manuscript	30
Newspaper Article	10
Patent	3
Report	541
Thesis	339
Unpublished Work	1
Web Page	11
TOTAL	10577

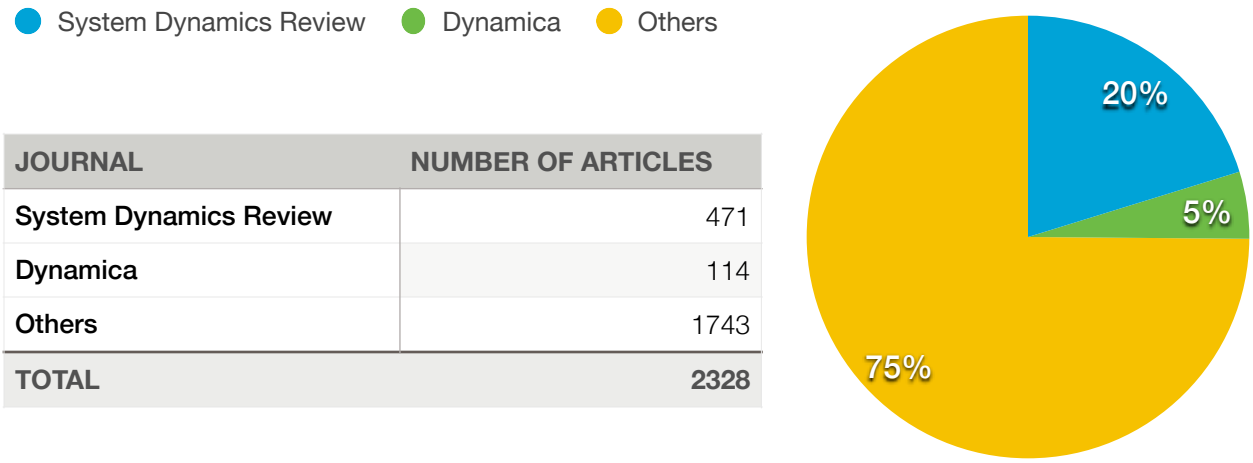


Clustered Categorization

REFERENCE TYPE	ARTICLES
Book (All Variants)	979
Conference	6246
Journal Article	2328
Report	541
Thesis	339
Other	144
TOTAL	10577

Within the entire collection of 6,246 conference papers, 5,678 (91%) articles were presented at the System Dynamics Conferences, ranging from 1976 to 2013. As for 2,328 journal articles, 471 were published in "System Dynamics Review" while 114 were published in its predecessor "Dynamica". A detailed percentage distribution shows below as [Chart 3].

Chart 3 - Major Journals



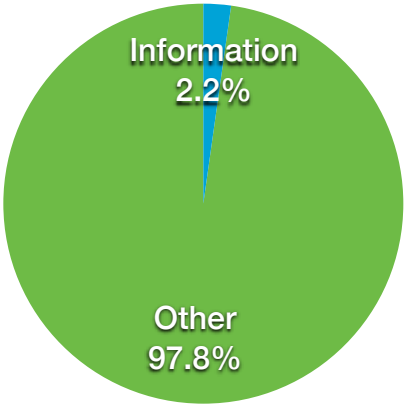
JOURNAL	NUMBER OF ARTICLES
System Dynamics Review	471
Dynamica	114
Others	1743
TOTAL	2328

System Dynamics Modeling was used in many domains, simulating different situations. In order to locate articles having general interest in Information Science, several search terms[1] were experimented. Eventually 235 articles were differentiated from the total population by having a detailed focus in the field of Information Science (use of information, information science, and information system), but using System Dynamics as a research method as well. These selected articles represent 2.2% of the total entries in System Dynamics Society Database as a simple pie [Chart 4] shows below.

[1] Several search terms were experimented in differentiated research parameters from anywhere in the database to title and keywords containing research term "Information". All research results were manually evaluated and compared. Eventually based on the best information retrieval precision, articles mentioning key term "Information" in title and keywords were selected for further analysis.

Chart 4 - Info. Science in System Dynamics

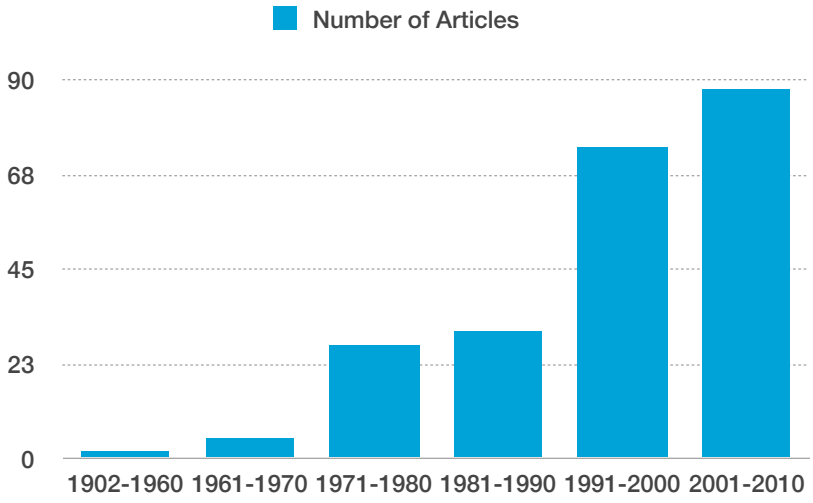
Topic	Articles
Information	235
Other	10342
TOTAL	**10577**



Instead of the entire ISDC database, a subsequent study was conducted for selected articles featuring Information Science from all reference types in ISDC database. Almost indistinguishable growth pattern was found in the column chart for number of articles published every ten years (dated from 1902 to 2010) with focus on Information Science (see [Chart 5]).

Chart 5 - Number of Articles Published per Decade - Information Science

YEAR	ARTICLES
1902-1960	2
1961-1970	5
1971-1980	27
1981-1990	30
1991-2000	74
2001-2010	88
2011-2013	9
Total	235

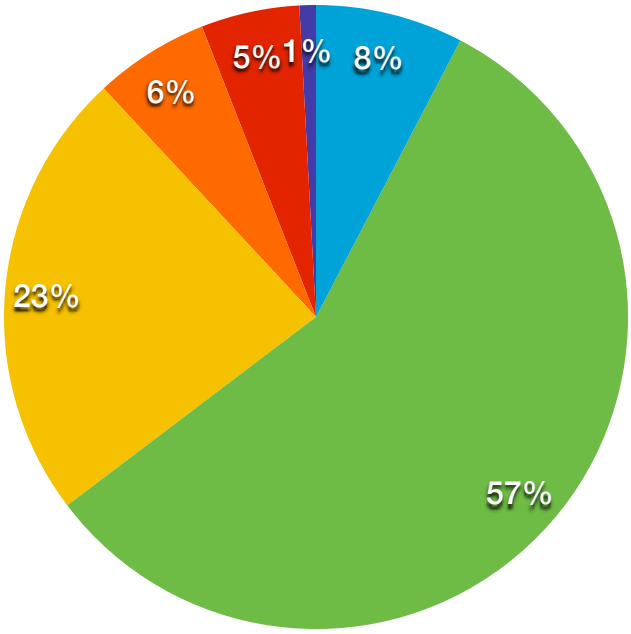


[Chart 6] shows an almost identical article distribution by publication sources, as compared to the distribution pattern of all entries in System Dynamics Society Database. Among

235 articles featuring Information Science, 57% were conference papers, 23% were journal articles, and 8% were book variants.

Chart 6 Distribution by Reference Type (Information Science)

SOURCE	ARTICLES
Book (All Variants)	18
Conference Paper	134
Journal	55
Report	14
Thesis	12
Other	2
Total	235



Citation History for Selected Articles in Web of Science

In order to locate some popular topics in System Dynamics Society's Database with Information Science focus, we attempted to find the citation history for selected articles mentioned above using Thomson Reuters' Web of Science search engine. Web of Science (WoS) is an online scientific citation indexing service that provides a comprehensive citation search from multiple database that reference cross-disciplinary research (Drake, 2004). Due to its limitation for conference papers and dated documents, only journal articles published after 1993 were searchable with full reference history.

[Table 1] in the appendix shows a detailed list of available citation history from selected articles, and many of them provide important ideas and insights for researchers in the field of both System Dynamics and Information Science, in association to their future publications. For example, the journal article "A Feedback Model to Understand Information System Usage", which published in Information & Management, has been cited 74 times. It examines the driving forces for widely accepted and constantly used information systems. With the help of system

dynamics feedback-loop modeling, it draws implications for information science theory as well as provides guidelines for industry on the implementation of new information systems (Bajaj & Nidumolu, 1998). Also, there is a similar article regarding information system design and development published in European Journal of Information Systems in 2005. In this article, author answered the question about social and organizational factors' impact on a successful information system design, using system dynamics modeling with information collected from CTG (Center for Technology in Government) (Luna-Reyes et al., 2005).

Another popular area is cognitive modeling, one typical paper is cited 39 times from the journal of Information and Software Technology. Titled as "The Use of Fuzzy Cognitive Maps to Simulate the Information System Strategic Planning Process", it paves new ways for directions in information system strategic planning and simulation (Kardaras, 1999). Another highly cited article (972 times in total) regarding cognitive modeling and information processing is from Mischel and Shoda, titled as "A Cognitive-Affective System Theory of Personality" (Mischel & Shoda, 1995).

The combination of System Dynamics and Information Science can also be highly technical. Barbeau & Dececchi presented their paper, "A Framework for the Object-Oriented Design and Simulation of Information System Dynamics", in Simulation and Gaming. It utilizes system dynamics in computer programming for object-oriented analysis and design (Barbeau & Dececchi, 1997).

In addition to journal publications, some other articles are still noticeable even their citation history is untraceable in WoS. Many works presented to the conference are very practical for solving real-world problems. Berard et al. presented their paper "Performance Evaluation of Management Information Systems in Clinical Trials: a System Dynamics Approach" at the 23rd International Conference of the System Dynamics Society in Boston. They developed a detailed influence diagram of information management process to illustrate economic and business impacts of the management information systems in clinical trials, with deep focus on automation (Berard et al., 2005). Another example is that Baugh and Walters submitted their work regarding hospital information systems to the 1994 International System Dynamics Conference in

Scotland. In addition to system dynamics simulation, they used soft systems methodology, a systemic approach for tackling real-world problematic situations, to improve the development of decision support systems for hospital managers and medical staff (Baugh & Walters, 1994).

5. Observation and Conclusions

The researchers who devote their efforts for the creation and maintenance of System Dynamics Society Database are deeply appreciated as their work positively supports the sustainable development for the field of System Dynamics. Their continuous commitment facilitates the composition of this paper and opens a wide window for future discussions. While we recognize the full worth of this database, however, some drawbacks are also noticeable. As one of the most important objectives of this article, the following suggestions for database optimization, aimed at creating and promoting a better and wider community of system dynamists, are presented after detailed observations.

First, the bibliographical entries maintained by the System Dynamics Society are clustered with limited publication sources. As we concluded above, 59% entries from the database are conference papers or proceedings. Furthermore, a majority of those are from the System Dynamics Conference. And authors may have submitted their work to certain journals without referencing their SD conference paper. While all conference materials are neatly archived in the society, the lack of diversification really concerns us. To better promote System Dynamics, Information Science, and encourage more members to join our community, a reciprocal connection between System Dynamics Society and other reputable research institutes and publication media is highly recommended. Since the bibliography database is free for public download, therefore a more diversified collection is positive to broadcast the field of System Dynamics to broader audiences. The society has a “call for bibliography update” page with contact information and submission requirements, however, it is recommended for the society to actively seek and reach potential scholars in the field of System Dynamics via mailing list servers, conferences, and major publication agencies.

After taking a closer look, many entries in System Dynamics Society Database were unorganized with large amount of missing information, which challenged our analysis from the

very beginning. Our goal was to demographically analyze the entire database provided by the System Dynamics Society and locate articles with an Information Science focus. However the missing metadata, including abstracts and keywords, will compromise the overall accuracy of our analysis. Therefore, it is highly recommended for the society to retrieve and specify the missing metadata, especially when most information are available directly from the archived documents. In addition, a notable number of duplicated, unrecognized, or irrelevant articles were found in the database. This issue can be fully fixed for only few hours using Endnote.

As a publicly available research database, it is critical for users to retrieve their intended citation information. The easiest way to achieve that is through organized keywords. However, many articles in the database don't have pre-assigned keywords even when they are clearly listed on abstract page, which will compromise their exposure to external research media and potential opportunity for future references. Furthermore, keywords from the database, when available, were disbanded in 4,941 variants. As highly diversified set of keywords will cause further confusion and reduce information retrieval precision, it is suggested to reduce keyword variation to a limited number. One possible solution here is to generate a list of pre-defined keywords in the field of System Dynamics only. And during submission process, researchers can select their keywords from pre-defined list, plus a limited number of customized keywords they would prefer based on their area of interest.

After our analysis for the ISDC bibliography database and focused review in the field of Information Science, some growth patterns are emerged as well as clustered reference distributions and missing metadata sets. Due to the consideration that ISDC database is still actively under maintenance, therefore, our recommendations are mainly aimed at improving the overall quality and diversification of data collection and the visibility of the database itself.

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Appendix

Table 1 - Available History of Citation

ARTICLE	NUMBER OF CITATION
1	18
2	N/A
3	N/A
4	0
5	972
6	N/A
7	6
8	N/A
9	0
10	74
11	39
12	10
13	N/A
14	5
15	9
16	6
17	1
18	19
19	22
20	10
21	N/A
22	1
23	3
24	1
25	3
26	4
27	17

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