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An assessment of systems and software engineering scholars and institutions (1999–2003)

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Abstract

This paper presents the findings of a five-year study of the top scholars and institutions in the Systems and Software Engineering field, as measured by the quantity of papers published in the journals of the field. The top scholar is Khaled El Emam of the Canadian National Research Council, and the top institution is Carnegie Mellon University and its Software Engineering Institute.

This paper is part of an ongoing study, conducted annually, that identifies the top 15 scholars and institutions in the most recent five-year period.

Keywords: Top scholars; Top institutions; Research publications; Systems and software engineering

1. Introduction

Who are the most published scholars in the field of Systems and Software Engineering (SSE)? Which are the most published institutions?

This paper is the 11th in an annual series whose goal is to answer those questions. The first such paper was (Glass, 1994); subsequently such studies have been published each year, in a fall issue of this journal (when the journal was published 12 times per year, the study findings were published in the October issue; now that it is published 15 times per year, they are published in the 12th or 13th issue). This is the seventh year in which the study has included five years' worth of data (in the previous years, 1–4 years were covered). In future years, the study will continue to cover the most recent five year period. This paper reports on the top scholars and institutions for the five-year period 1999–2003.

The methodology of the study and its limitations will be discussed later in this article. It is important to note two things at the outset, however:

1. The study findings are based on frequency of publication in the leading journals in the SSE field.
2. The study focuses on the field of SSE, and not, for example, on computer science or information systems.

Here are the findings.

2. Leading scholars

The leading scholars in the field are shown in Table 1. These scholars have achieved a score of 4.2 or more during the years covered by this study. (The scoring scheme is discussed under the topic "Study Methodology" below, but a 4.2 roughly represents participation in four or somewhat more published papers during the study period.) The table lists the top 16 ranked scholars (there

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Table 1
Top scholars in the field of systems and software engineering

Rank	Scholar	Journals in which published[a]						Score	Previous rank
		IST	JSS	SPE	SW	TOSEM	TSE		
1	Khaled El Emam, Cnd. Nat. Res. Council	0	3.7	0	0.5	0	3.6	7.8	1
2	Barbara Kitchenham, Keele	1.7	1.7	0	1.5	0	1.4	6.3	3
3	Hyoung-Joo Kim, Seoul National University	2.4	2.8	0.7	0	0	0	5.9	6
4	Robert L. Glass, Computing Trends	0.5	4.1	0	1	0	0	5.6	4
5	Lionel C. Briand, Carleton University, Canada	0	1	0.5	0	0	4	5.5	9
6	Brian Henderson-Sellers, University of Tech., Syndney	2.2	1.2	0	1	0	1	5.4	11
7	Richard Lai, La Trobe	0.7	2.4	0.7	0	0	1.4	5.2	2
8	Kassem Saleh, American University, Sharjah	4.3	0.7	0	0	0	0	5.0	5
9	Mary Jean Harrold, Georgia Institute of Technology	0	1	0	0	1.5	2	4.5	–
10	Claes Wohlin, Blekinge Institute of Technology, Sweden	1	1.7	0	0.5	0	1.2	4.4	14
10	Myoung Ho Kim, Korea Advanced Institute of Science and Technology	1.7	2.7	0	0	0	0	4.4	–
12	T.Y. Chen, Swinburne University of Technology	1.2	2.1	0	0	0.5	0.5	4.3	7
13	Xudong He, Florida International University	3.7	0	0	0	0	0.5	4.2	–
13	Per Runeson, Lund University, Sweden	1.3	1.2	0	0.5	0	1.2	4.2	–
13	James A. Whittaker, Florida Institute of Technology	1	0	0	3.2	0	0	4.2	12
13	Hai Zhuge, Chinese Academy of Sciences	1	3.2	0	0	0	0	4.2	–

[a] Journal abbreviations are defined later in this paper.

Table 2
Top scholar keywords describing research focus

Rank	Scholar	Research focus
1	El Emam	Software quality, software measurement
2	Kitchenham	Software metrics, project management, quality management, technology evaluation, evidence-based software engineering
3	Kim	XML, semantic web, object-oriented system
4	Glass	Software problems/solutions, software practice, software as discipline, project failure
5	Briand	Software testing, empirical software engineering, object-oriented analysis and design
6	Henderson-sellers	Object-oriented methodologies, metamodeling and modeling languages
7	Lai	Web services, communication protocol engineering, component based software engineering, software metrics and testing
8	Saleh	Distributed systems, software mobility
9	Harrold	Scalable program analysis based software engineering, regression testing, analysis and testing of object-oriented software, software visualization, remote monitoring of deployed software
10	Wohlin	Empirical methods, software metrics, software quality, systematic improvement
10	Kim	Database systems, distributed information processing
12	Chen	Software testing, software quality, software maintenance
13	He	Formal methods, software architecture, software testing
13	Runeson	Empirical software engineering, verification and validation, software quality management
13	Whittaker	Computer security, penetration testing, software testing, software engineering
13	Zhuge	Internet-based software engineering, software process model, knowledge-based software engineering, team software development

are 16 and not 15 because four scholars tied for the final position in the list this year), with scores ranging from 4.2 to 7.8. Note that because of the sliding time period used, authors can actually have fewer papers (and a lower score) in one year's study than they had the year before—the range last year, for example, was 4.0–7.8.

The geographic spread of the top scholars is interesting—six are from the Americas, seven are from Asia-Pacific, and three are from Europe.

In Table 1, we list the top scholars in this year's study.

We asked the top scholars to indicate the key words that best describe their research focus. Here are the results, in Table 2.

As can be seen from Table 2, the research interests of the top scholar are quite diversified.

3. Leading institutions

The leading 15 institutions in the field are shown in Table 3. These institutions have achieved a score of 9.58 or more during the years covered by the study. The institutional scoring scheme is similar but not identical to that for authors; the scheme and its differences are discussed under the study methodology section below.

Table 3
Top institutions in the field of systems and software engineering

Rank	Institution	Journals	Score	Previous rank
1	Carnegie Mellon/SEI	All	24.17	1
2	Korea Advanced Institute of Science and Technology	All but TOSEM, TSE, SW	21.20	3
3	National Chiao Tung University	All but TOSEM, SW	17.50	2
4	Fraunhofer IESE	All but TOSEM	16.74	6
5	Bell Labs/Lucent	All	15.23	4
6	Seoul National University, Korea	All but TOSEM, SW	14.00	8
7	City University, Hong Kong	All but TOSEM	13.48	7
8	Iowa State University	All but TOSEM, SW	11.40	–
9	Microsoft	All but TOSEM, SW	11.28	–
10	National University of Singapore	All but TOSEM, SW	10.85	5
11	Georgia Institute of Technology	All but SW	10.73	14
12	Lund University, Sweden	All but TOSEM	10.25	15
13	National Cheng Kung University	All but TOSEM, SPE, SW	10.00	–
14	Osaka University	All but SW	9.98	–
15	Aristotle University of Thessaloniki, Greece	All but TOSEM, SW	9.58	–

Most of the top institutions are from academe, although two are from industry research centers. Geographically, five of the institutions are from the Americas, seven are from the Asia-Pacific region, and three are from Europe.

There are special circumstances associated with the top-ranked institutions. CMU's score includes that for the Software Engineering Institute, which is located at CMU (that is not new in the study this year, but it does account for higher scores over the years than would have been achieved by CMU alone).

Also, geographically separated branches of an institution are scored as unique institutions—for example, the campuses of the University of California are each scored separately, as are the various branches and laboratories of IBM (this rule is particularly harmful to the IBM score, since there are more than a dozen separate IBM locations that have achieved scores). Note also that scores are not normalized for the number of researchers; for example, an institution with 100 researchers and one with two will be scored identically. Although this may be an advantage to institutions with a large number of researchers, it does not give special advantage to very small institutions, as normalization would do.

4. Other rankings

Recall that this study is specific to the field of Systems and Software Engineering (SSE). (For an analysis of the characteristics of research in the SSE field, see (Glass et al., 2002).) There are similar studies for the related fields of Computer Science (CS) and Information Systems (IS). (Similar analyses of the research in these fields may be found in (for CS) (Ramesh et al., 2004), and (for IS) (Vessey et al., 2002).)

Regarding CS, the best and latest such study is (Geist et al., 1996). That study examines CS research institutions only (not individual authors), and restricts itself to academic institutions (none from industry) in the US (none from outside the US). (The authors of this study tell us, however, that there is a Web version of the study that includes industrial as well as academic institutions, and that is international in scope. This raises one of the interesting dilemmas of the electronic age, specifically regarding what constitutes scholarly published work. We have chosen to utilize the printed, stable, referenceable version of the study, and we mention the Web version only in passing.) For its methodology, Geist et al. (1996) examined published papers in the journals of the ACM and IEEE Computer Society (excluding Communications of the ACM). As will be seen later in this paper, the CS study covers more journals than this one (and in that sense is broader), but it does not examine journals from outside the professional societies that we cover here.

Nevertheless, the findings of the CS study are interesting. It lists and ranks the top 100 US academic CS programs. The top 10 are the University of Maryland, MIT, the University of Illinois, the University of Michigan, the University of Texas, Carnegie Mellon, Stanford, the University of Wisconsin, the University of Southern California, and Purdue. Given that SSE and CS are related fields, perhaps the biggest surprise here is the differences between the lists. Only one of the top 10 in the CS list are in the SSE list. However, it should be noted that the CS study includes neither foreign nor industry organizations, and nearly all of the top 10 in our list fall into those categories. It is difficult to decide whether the studies differ because of the population of institutions they examine, or because of innate differences between the CS and SSE fields.

There are four other rankings of CS programs of interest to our study. Three of them, those performed by US News and World Report (USNWR), the US National Research Council (NRC), and Business Week (BW) (Business Week, 1997), are basically academic opinion polls. (USNWR and NRC evaluated academic computing programs, and BW ranked the nation's top computing research labs.) Those three subjective studies present similar findings—the top five CS schools are (USNWR/NRC/BW ranking) Stanford (1/1/1), Cal-Berkeley (2/3/6), MIT (3/2/3), Carnegie Mellon (4/4/2), and Cornell (5/5/20). It is interesting that these studies have findings quite unlike either ours or the (Geist et al., 1996) study; of the top five schools in these opinion polls, two are not present in these lists. This would suggest that even the informed opinions of fellow academics simply do not relate well to the publication frequency of the schools in question.

The fourth ranking of CS (and other) programs may be found in the Gourman studies (e.g., Gourman, 1993). This is a ranking performed in terms of *quality* (a much more comprehensive concept than the scholarship we and the other CS studies cover, since it includes things of interest to, for example, potential students). The top five programs in that report are MIT, Stanford, Carnegie Mellon, Cal-Berkeley, and Cornell. Because of the similarity between these rankings and those of USNWR, NRC, and BW, it is clear that they are (once again) ranking something different from what we are attempting to rank here, scholarship (as measured by publication frequency).

Regarding the field of IS, there have been several studies of scholarship. The leading institutions, for example, were studied in (Shin Im et al., 1998; Segars and Simon, 1992). The top five in the first study were Arizona, Minnesota, MIT, Carnegie Mellon, and NYU (in the second they were very similar—Minnesota, Arizona, MIT, Texas, and NYU). Only one of these—CMU—is in the top five (or even 15!) of the SSE list. The leading IS institutions in "research performance" over the years 1986–1997, according to Trieschmann et al. (2000), were Minnesota, MIT, Texas, Georgia State, and Carnegie Mellon. These rankings, based on "pages published in leading [IS] journals", are quite similar to the other IS studies. (It is interesting to note, however, that the authors of the latter paper, studying a more recent time period (1998–2001), found a considerably different ranking: Maryland, Indiana, Georgia State, Minnesota, and Georgia. Apparently the IS rankings are somewhat unstable, and dependent on the performance of a few top scholars (Dennis, 2002).)

(The Gourman reports do not explicitly rank IS programs. They do rank a program called "Information Science", but that is a Library Science related field, different from IS).

5. Correlation of top institutions, scholars

The variance in findings of the IS paper and follow-on study by Trieschmann, noted above, raises an interesting issue—how strong is the linkage between top institution performance and the performance of their top scholars?

Table 4
Top institutions and top scholars

Rank	Institution	Top scholars
1	Carnegie Mellon/SEI	
2	Korea Advanced Institute of Science and Technology	Myoung Ho Kim
3	National Chiao Tung University	
4	Fraunhofer IESE	
5	Bell Labs/Lucent	
6	Seoul National University, Korea	Hyoung-Joo Kim
7	City University, Hong Kong	
8	Iowa State University	
9	Microsoft	
10	National University of Singapore	
11	Georgia Institute of Technology	Mary Jean Harrold
12	Lund University, Sweden	Per Runeson
13	National Cheng Kung University	
14	Osaka University	
15	Aristotle University of Thessaloniki, Greece	

We asked one of the authors of that paper, Alan R. Dennis, about the influence of top IS scholars on institutional performance. His response (Dennis, 2002) was "Most IS research performance rankings are driven by a small number of highly productive people..." He qualified that statement by noting that "IS... is a small discipline".

With that in mind, we examined our own data, looking to see which institutions were highly ranked because they were the home of one or more top scholars. Table 4 shows the result of that analysis.

We can see that only four of the top 15 institutions housed a top scholar during the study period, and further, that no institution housed more than one. Clearly, although top scholars undoubtedly are influential in driving up the scores of top SSE institutions, they are not critical to the scores the institutions achieve.

6. Study methodology

In this 11th year of our study findings, only papers published during the calendar years 1999–2003 were tallied. Next year we will add data from the year 2004, but drop that from 1999. There may be minor discontinuities each year, as the early year findings are discarded, but we anticipate that in general the future findings of this study will exhibit a satisfying stability. Initially, the assessment periods of the surveys varied from 1 to 4 years. Starting from 1998, the assessment periods have been standardized to five years. Since the standardization, there have only been three scholars leading the scholar list, and CMU has always been on the top of the institute list.

6.1. Journals

The study findings are heavily dependent, of course, on the journals we include in our survey. The following journals were selected for their relevance to the field of SSE:

- Information and Software Technology (IST), Elsevier Science
- Journal of Systems and Software (JSS), Elsevier Science
- Software Practice and Experience (SPE), John Wiley & Sons, UK
- Software (SW), IEEE
- Transactions on Software Engineering and Methodologies (TOSEM), ACM
- Transactions on Software Engineering (TSE), IEEE

These journals were chosen on the basis of a survey of the editorial board of the Journal of Systems and Software conducted in 1991, and there have been no changes in the list of journals since that time. We believe that the JSS board represents a knowledgeable, active, and unbiased source of judgment about the SSE field.

Other journals suggested by board members but not included in this study are the following:

- Communications of the ACM. This journal frequently publishes special issues on a single topic. These theme issues would tend to skew the findings of a study of this kind. A special issue that focused on the design of a chip of one particular vendor, for example, would have caused that vendor to be near the top of our rankings that year even though there were no other papers from that vendor in our data. It is interesting to note that CACM was excluded from the CS study discussed above, as well.
- MIS Quarterly. This is a leading journal of the IS field, but it was not thought sufficiently relevant to SSE.
- IEEE Computer. This is a leading journal of the computing field in general, but again, it was not thought specifically relevant to SSE.
- Cutter IT Journal. This journal presents important findings from the field of SSE practice, but was not thought sufficiently related to SSE scholarship to be included.

Several other journals have been suggested from time to time by others interested in this study. To keep the findings relatively stable, however, we have resisted those suggestions. We may reconsider, in the future, the list of journals examined. However, we will keep any such changes evolutionary in order to minimize turmoil in the ratings.

Table 5
Top scholars per journal

Journal	Number of top scholars
IST	13
JSS	14
SPE	3
SW	7
TOSEM	2
TSE	10

It may be interesting to note the frequency with which the top scholars publish in these six selected journals. For this 1999–2003 study period, those numbers are presented, by journal, in Table 5.

Of course, these journals publish with different frequencies. For example, TOSEM is a quarterly (publishing approximately 15 papers/year), whereas IST and JSS publish 15 issues (80 and 100 papers, respectively) per year at present. Thus the opportunities for publication vary rather significantly across journals.

6.2. Counting schemes

Regarding paper counting schemes, we used the following methods:

6.2.1. Scholars

- Single authors receive a score of one for each paper published.
- Authors of multiple-authored papers initially received a score equal to their fractional representation on the paper. For example, co-authors each receive 0.5; if there were five authors, each would receive 0.2.
- For author totals, the initial scores for multiple authors are then modified as follows:
  - 0.5 becomes 0.7
  - 0.33 becomes 0.5
  - $<=$ 0.25 becomes 0.3

The reason for this transformation is (a) the belief that the original fractional representation unfairly penalizes authors of multiple-author papers, and (b) the transformation was used in a previous similar study of authors in the IS field (Shim et al., 1991). Obviously, this kind of transformation can be misused by authors conniving to increase their scores, as a reviewer of this paper has suggested, but we see no reason to believe that is happening.

6.2.2. Institutions

Author raw scores (excluding the above transformation) are attributed to the institution named on the paper.

Two previous studies in the IS field (Segars and Simon, 1992; Trieschmann et al., 2000) included length in published pages as part of the score for a paper. We choose not to consider paper length in our scoring scheme. Some similar studies have ranked the participating journals, resulting in papers published in some journals being worth more than others. In our study, all journals included are ranked equally. Many of the journals examined contain regular columns that do not represent research papers and are not refereed. For example, JSS sometimes contains an Editor's Corner, and SW contains a number of regular columns. None of this material is included in the totals of our survey.

7. Study limitations

There are practical limitations to the number of journals that can be studied for such a survey. This study is limited to six journals (the CS study included 17 journals, but only examined institutions and not scholars).

The publishers of JSS, Elsevier, believed at the outset of this study that it was important to limit the number of journals included. That turns out to have been a wise consideration. The conduct of this survey is extremely time-consuming. The problem we have encountered is in counting institutions; to date, we have found no easy way to count institutions associated with particular papers (tabulating scholars, by contrast, can be automated through standard library techniques). We rejected the notion of assigning authors to institutions based on a current directory, on the grounds that the mobility of scholars would make such findings inaccurate. (In this study, we count a paper for the institution(s) for which the scholar worked at the time of publication.)

Because of the volume of data involved, this kind of study is also quite error-prone. We have received a number of challenges to our findings over the years; most such challenges result from misunderstandings and not errors, but two recent studies (published in 1998 and 1999) contained errors which were corrected in later issues of the Journal of Systems and Software. We will continue, of course, to attempt to eliminate all errors; but we also welcome input from those who believe they have found them. To aid with alleviating such errors, we have added a co-author, T.Y. Chen of Swinburne University of Technology, Australia.

Another limitation of our study lies in the difficulty of measuring quality. What we are trying to measure here is the top ***quality*** scholars and institutions in the SSE field; that is, those who (which) have made the greatest contribution to the field. But what we are really measuring is the top ***quantity*** scholars and institutions, those who or which have published the most papers in the field. In defense of what we have done, we offer these thoughts:

1. Other similar studies have used the same approach. Both the (objective) CS and IS studies named above and referenced below have counted the number of papers published, and have not been able to measure the quality of that work.
2. Quality does enter into our measurement, in the following ways:
   (a) The papers counted have all been through a peer referee process. Our expectation is that this review process guarantees that the papers are of sufficient quality to have met acceptance criteria.
   (b) The choice of journals was made by the JSS editorial board, whom we consider to be a panel of experts. We believe that we have included only high-quality journals in our study. (One reviewer of this paper, however, noted that there are "huge differences" between the journals chosen; certainly there is a wide spectrum, ranging from deep theory to deep practice). We also believe that quality journals tend to choose quality referees to make the selection of high-quality papers.

(Note that, in subject areas where quality measurement is difficult, the choice of quality is by a panel of expert judges (consider the fields of ice skating and diving, for example). We believe the same approach is valid here.)

3. Perhaps the best measure of quality would be the number of times papers under consideration were actually referenced in the literature of the field (that is, by citation counts). However, there are problems with that approach:
   (a) Such data is extremely laborious to obtain. We know of no standard library measurement of citations at the level of individual papers (there are, however, such studies for journals).
   (b) Even citation analysis has its opponents. For example, in (Barrett, 1997), some viewed academic citation analysis as "an uncomfortably silly fascination", "a little bit of fun to see, but... not a really good thing to do with your time," or (just because something has been cited presents) "no evidence... that anyone has read it".

It is our belief that citation analysis would be a better scheme for measuring what we are trying to measure, in spite of the opposition noted in b, above; but citation analysis is simply too hard to do.

One final limitation of this study has been noted by some who find its results surprising, particularly in the list of top scholars. It is important to say here that this study does not attempt to identify the most influential or visible people in the SSE field. Such a list would no doubt contain easily recognizable names, which this list often does not. However, any such list would need to be based on objective measures. There is a great danger, one we believe we have avoided here, of publishing a list resulting solely from a popularity contest. And it is often true—in fact, it is almost a truism of academe—that the most scholarly people are not necessarily the best known.

8. Conclusions

This study is one in an ongoing series whose goal is to identify the top scholars and institutions in the field of SSE. Similar studies in related fields (CS and IS) convince us that such a study is meaningful and worthwhile.

By now, at the end of 11 years of conducting the study, we believe we can identify with some confidence those top scholars and institutions:

Top Scholars:
1. Khaled El Emam of the Canadian National Research Council
2. Barbara Kitchenham of Keele University
3. Hyoung-Joo Kim of Seoul National University, Korea
4. Robert L. Glass, Computing Trends
5. Lionel Briand of Carleton University, Canada

Top Institutions:
1. Carnegie Mellon University and the Software Engineering Institute
2. Korea Advanced Institute of Science and Technology
3. National Chiao-Tung University of Taiwan
4. Fraunhofer Institute for Experimental Software Engineering
5. Bell Labs, Lucent

Regarding the relationship of the field with its collegial fields of CS and IS, we find:

- A few similarities with CS in the list of top institutions, but still enough differences to be able to say that SSE is a different field from CS.
- Enough differences with the field of IS to say that they are clearly quite different fields.

(A study of the curriculum and research differences between the fields may be found in (Glass, 1992) (curriculum), and (Glass et al., 2004) (research).)

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