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Revisiting h measured on UK LIS and IR academics

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Revisiting h measured on UK LIS academics

A brief communication appearing in this journal ranked UK LIS and (some) IR academics by their h -index using data derived from Web of Science. In this brief communication, the same academics were re-ranked, using other popular citation databases. It was found that for academics who publish more in computer science forums, their h was significantly different due to highly cited papers missed by Web of Science; consequently their rank changed substantially. The study was widened to a broader set of UK LIS and IR academics where results showed similar statistically significant differences. A variant of h , h_{mv} , was introduced that allowed a ranking of the academics using all citation databases together.

Introduction

How best to judge the impact of academics is a topic that has long been discussed and it is unlikely that a single solution satisfactory to all will ever be determined. The h -index is a ranking method currently in vogue. An academic's h is the number of their papers that have $\geq h$ citations. The index was introduced by Hirsch (2005). Perhaps due to its simplicity and relative ease of measuring, it was used in a number of studies ranking academics within a particular field, including LIS: Cronin and Meho (2006) produced a ranking of US-based LIS academics and shortly after, Oppenheim ranked UK-based LIS and a selection of Information Retrieval (IR) academics also in the UK (2007). In both studies, the Thomson ISI Web of Science® database (WoS) was used to determine h (referred to here as h_{WoS}).

An alternative database for computing h is *Google Scholar* (GS): the free and presumably¹ fully automated scholarly publication search engine that tallies a citation count for each publication stored. Because Oppenheim did not use GS, it was decided to re-rank the academics in his study by h_{GS} to examine changes. Before describing this work, we review and briefly discuss past papers that use and/or criticize GS. The methodology used in this paper is described next. This is followed by details of the re-ranking and discussions and further work that arose from it, before the paper closes with conclusions and future work.

¹ To the best of our knowledge there are no public details on how Google Scholar works or what publications it holds. Its modus operandi is similar to CiteSeer: a fully automated scholarly article search engine with citation counting facilities, which uses a combination of structured database and web crawl sources (Giles, Bollacker, Lawrence, 1998).

Past work with Google Scholar

The introduction of Google Scholar produced divergent views on its utility and accuracy, with generally positive views from Zhao (2005) and Bauer and Bakkalbasi (2005); while Jacsó (2005, 2006) and Meho and Yang (2007), by and large, emphasised problems with the scholarly publications search engine. In this Section, we address the problems identified in past work and explain why such issues have a minimal impact on the study conducted for this paper. The key criticisms were: the longer time required to process GS output compared to WoS; and GS's inflation of citation counts.

Processing GS data is time consuming?

Meho and Yang (2007) used overall citation counts to rank US-based LIS academics from three sources: WoS, GS, and Elsevier's Scopus. The core findings were that:

1. Use of WoS and Scopus resulted in different rankings of academics; and
2. although GS found many more citations to publications than Scopus or WoS, ranks of academics by GS were similar to those derived from Scopus and from WoS. When citation data from WoS and Scopus were combined, the ranking compared to that from GS was very similar.

The authors of the paper stated that processing GS output took at least an order of magnitude longer than processing data from WoS or Scopus as the output of GS was relatively unstructured and often contained a number of duplicate entries to the same publication and that the facilities to filter results were limited. However, this greater processing overhead may not be an obstacle when calculating h as a much smaller number of publications are examined (the first h for each academic) thus reducing examination time.

Google Scholar inflates citation counts

The second major criticism of GS is the claim that citation counts are inflated with citations from poor quality publications (see Jacsó, 2006). Meho and Yang provided substantial evidence relevant to such concerns. In their study of LIS publications, of the 5,968 total citations they located in GS, around 8% (475) were from sources that most would agree should not be included in citation studies: "*bachelor's theses, presentations, grant and research proposals, doctoral qualifying examinations, submitted manuscripts, syllabi, term papers, working papers, web documents, preprints, and student portfolios*". A further 22% (1,312) of the citations were found to come from "*Master's theses, doctoral dissertations,*

technical/research reports and books”, which Meho and Yang chose to exclude from their study. It was not claimed that these sources were of lesser quality than those found in WoS just that the sources were different. In fact, as detailed in the extensive tables at the back of the Meho and Yang paper, the majority of citations unique to GS came from highly reputable refereed sources. It is of course prudent to be concerned about inflation, but it would appear from Meho and Yang’s work that although GS adds citations that were undesirable and more that were different, the majority of the additional citations found by GS were from valid sources simply missed by other citation databases.

Re-ranking LIS academics with Google Scholar

In order to calculate h_{GS} correctly, it was necessary to search extensively for a range of variations of an academic’s name and then carefully examine the resulting matches, removing papers not by the academic and merging duplicate entries. This was a time consuming process. In this study, the aim was to rank academics relative to each other, it was hypothesised, therefore, that a swifter strategy would allow the calculation of a good approximation of h_{GS} that would ensure good relative ranking. After some experimentation, the following methodology for calculating h_{GS} was chosen.

1. For each academic, a single search string was determined that most accurately found works by that academic and no one else. This was found to be the forename and surname of the academic (taken from Oppenheim’s tables²) or if the academic’s name had several initials (e.g. S.E. Robertson), the query string was composed of the initials and surname. There was one exception to this: Van Rijnsbergen’s forename is sometime published as “Keith” and other times “C.J.”, in his case, only his surname was searched.
2. The list of publications (both first and n-authored papers) was scanned for duplicate entries of the same paper. If any were found, the duplicate was removed and its citation count was added to the remaining paper. As with Oppenheim, the papers counted were those relevant to LIS although, it should be noted that judging what is and isn’t a relevant paper is very much in the eye of the beholder; we can only assume our interpretation was the same as Oppenheim’s.

² A couple of spelling errors in the table were corrected before searching.

3. The ranking from GS was almost entirely sorted in descending citation count order, therefore, scanning of the remaining ranking started at the top and stopped when a publication with a citation count below the academic's h_{GS} was encountered³.

This swift methodology was checked by examining 3 academics in detail to determine the level of error. It was found that by adopting such a strategy, h_{GS} was underestimated by between 5-10%. It was assumed that such an underestimation would equally affect all academics in the study and so would not affect their relative ranking. Using such an approach, h_{GS} took between 10 and 20 minutes to calculate per academic.

Application of methodology

Our interest in re-ranking was focussed on Table 2 of Oppenheim's paper showing the ranking of 26 "Active UK academics ranked by h -index". It was also noticed that 2 senior academics were missing from the data: Dr. Val Gillet and Dr. Peter Bath were both senior lecturers at the time the original study was conducted and so were added to the table. As in Oppenheim's paper we chose to ignore Harnad's cognitive science publications⁴. Care was needed when counting Van Rijbergen's h_{GS} due to GS incorrectly listing him as author of three books on which he was series editor.

Table 1 shows the results: as might be expected from Meho and Yang's work, h_{GS} was almost always higher than h_{WoS} , with an increase for 20 of the 28 academics, the same for 4, lower for 4. The average increase over all 28 researchers was 3.4 (43%). However, little can be definitively concluded about the increase, as h_{GS} was based on publications from the full range of years GS has, whereas the h_{WoS} study from Oppenheim was restricted to 1992-2005. The h_{GS} was computed in early March, 2007, just over a year later than Oppenheim, consequently, one is likely to see an increase in h with an additional year of "citation time". According to Meho and Yang's studies (see Table 8 in their paper), GS's coverage of pre-1992 publications was poor (approximately 1% of the citations were from pre '92 publications). However, the

³ Self-citations were included. Schreiber (2007) showed that such citations inflate h substantially, however, Kendall τ rank correlation between the h and h_s (h without self citations) columns of Table 1 of Schreiber's paper was 0.88, showing that removal of self-citations had little impact on rank.

⁴ Presumably Oppenheim eliminated the publications as his focus was on an academic's LIS-related impact.

collection GS uses continually changes and presumably expands, therefore, an examination of pre-1992 publications was conducted on a randomly selected sample of 25% of the 28 academics considered. It was found that fewer than 10% of the publications that contributed to an academic's h were from pre-1992 publications, more than reported by Meho and Yang. Over the sampled academics, the average increase in h from pre-1992 publications was 1.1 (12%). Therefore, of the 43% increase observed, some was due to earlier publications being considered, some due to h measured just over a year later than Oppenheim's study and some due to Google Scholar (presumably) searching over a wider range of publications. However, apportioning the exact levels of increase to the different factors was not focus of the study.

Name	h_{wos}^5	h_{GS}	$\Delta(h_{GS}, h_{wos})$		Name	h_{wos}	h_{GS}	$\Delta(h_{GS}, h_{wos})$	
Peter Willett	31	28	-3	-10%	Cliff McKnight	7	12	5	71%
Stephen Robertson	18	25	7	39%	Steven Whittaker	7	29	22	314%
Val Gillet	15	12	-3	-20%	Anne Morris	6	5	-1	-17%
Mike Thelwall	14	24	10	71%	Julian Warner	6	7	1	17%
David Ellis	13	17	4	31%	Peter Brophy	5	8	3	60%
Nigel Ford	13	16	3	23%	Paul Burton	5	5	0	0%
Keith van Rijsbergen	13	21	8	62%	Leela Damodaran	5	5	0	0%
Stevan Harnad	11	21	10	91%	Peter Enser	5	5	0	0%
Peter Bath	10	11	1	10%	Forbes Gibb	5	5	0	0%
David Bawden	9	11	2	22%	Rita Marcella	5	6	1	20%
David Nicholas	9	10	1	11%	Jonathan Raper	5	8	3	60%
Charles Oppenheim	9	13	4	44%	Fytton Rowland	5	8	3	60%
John Feather	8	7	-1	-13%	Ian Rowlands	5	6	1	20%
Elisabeth Davenport	7	10	3	43%	Jennifer Rowley	5	15	10	200%

Table 1: the Δ in h for a set of UK-based IR academics, sorted by h_{wos} .

Five researchers (Robertson, Thelwall, Van Rijsbergen, McKnight and Whittaker, highlighted) were identified as those who publish more in computer science (CS) forums than the others in the list and their h_{GS} was compared to the remaining 23. As can be seen in Table 2, there was a small difference in h_{wos} for the 5 compared to the rest. However, the difference in h_{GS} between the more and less CS focussed academics was larger and was significant (using a 2-sample unequal variance t-test⁶: $p < 0.05$). The Δ between h_{GS} and h_{wos} for the less CS focussed academics was 1.8 compared to 10.4 for more CS focussed; the difference was also significant. Beyond the general increase in h , found to exist on average across all academics, for those with a CS focus, there was a substantial difference in h , which couldn't easily be

⁵ Values taken from Oppenheim's paper with Bath and Gillet's h_{wos} added calculated in the same manner.

⁶ The significance test used throughout this paper.

explained by the difference in date ranges between Oppenheim's h_{WoS} and the h_{GS} presented here. It would appear that WoS did not represent the citations to such academics' publications as well as GS.

Research focus	h_{WoS}	h_{GS}	$\Delta(h_{GS}, h_{WoS})$
Less CS (23)	8.6	10.4	1.8
More CS (5)	11.8	22.2*	10.4*

Table 2: Comparison of the h and Δh of the academics when grouped by their research focus

The citations of the 5 academics were studied in more detail. The Δ in h for Whittaker was largest: it would appear that the change was due to WoS's lack of conference publications. In one of Whittaker's research areas, Human Computer Interaction (HCI), the premier forum for dissemination of research is the ACM CHI conference; generally viewed as more important than any journal in the field, with an acceptance rate of typically 1 in 5. None of Whittaker's 5 CHI conference papers (that contributed to his h_{GS}) were listed in WoS whereas GS cumulatively listed over 450 citations to these papers.

Of the other 4 researchers, 3 showed increases in citations to publications already listed in WoS, however, Robertson's citations showed some notable differences. In GS, many of Robertson's most cited papers appeared in the well known though un-refereed Text REtrieval Conference (TREC). Of particular note was the paper Robertson co-wrote for TREC-3 (Robertson, et al, 1994) where the widely used ranking formula, BM25 was first described. WoS records 23 citations to this important paper; GS records over 500. A further 3 un-refereed TREC papers (with a total in excess of 100 citations) and one un-refereed tech report (cited 94 times in GS, 12 times in WoS) from Robertson contributed substantially to his h_{GS} . A sample of the papers citing these papers were examined and were found to be from reputable refereed conferences.

Conferences with a 100% acceptance rate and self-published tech. reports would normally be dismissed as poor sources. However, it would appear (at least for Robertson) that the strategy of GS to search widely in all possible sources of scholarly works, found a number of additional papers, which through extensive citation added an important contribution to measuring the worth of a well respected academic.

The finding of more citations by GS for CS oriented academics than for the others is in agreement with the findings of Meho and Yang, who in Table 13 of their paper detailed publications that they found were unique to GS, this table was dominated by CS-related publications.

Rank of academics

Although large changes in h were observed, such changes overall only marginally affected the ranking of academics although for 5 of the 28 (Gillet, Feather, Whittaker, Morris and Rowley) their rank was changed substantially. Meho and Yang also reported little change when authors were ranked by data from different citation databases, though they did report occasional large changes. However, the number of CS oriented academics in their study was relatively small.

Are the five identified academics outliers?

Given the strong increase in h observed for the 5 more CS focussed academics, it was judged important to understand if the 5 were outliers or indicators of a broader trend. Assuming that more CS focussed researchers would show the greatest increase in h calculated on GS relative to WoS, the index was calculated for those senior UK-based academics who, like Van Rijsbergen, have a research focus in IR but were not included in Oppenheim's study. They were⁷ Prof. Mounia Lalmas (Queen Mary, U. of London), Dr. Mark Sanderson (U. of Sheffield), Dr. Ian Ruthven (Strathclyde U.), Prof. Stefan R uger⁸ (Open U.), Dr. Joemon Jose (U. Glasgow), Dr. Iadh Ounis (U. Glasgow), Prof. John Tait (U. Sunderland) and Dr. Ayse Goker (City U.). The h_{WoS} was calculated for each, in the same manner that Oppenheim described: using Cited Reference Search (CRS) for citations to publications in the date range, 1992-2005.

Name	h_{WoS}	h_{GS}	$\Delta(h_{GS}, h_{WoS})$	Name	h_{WoS}	h_{GS}	$\Delta(h_{GS}, h_{WoS})$		
Mounia Lalmas	7	17	10	143%	Iadh Ounis	3	9	6	900%
Mark Sanderson	5	15	10	200%	Ayse Goker	3	5	2	200%
Ian Ruthven	6	12	6	100%	Joemon Jose	1	10	9	700%
Stefan R�uger	4	10	6	150%	John Tait	1	8	7	67%

Table 3: differences in h for the additional senior UK-based IR academics.

As can be seen for all the academics (Table 3), their h_{GS} was substantially higher than their h_{WoS} . An examination of the papers contributing to these academics' h_{GS} revealed that conference papers constituted the majority of publications. Consequently, the large increase in h found for the 5 academics identified earlier was judged not to be an outlier but instead indicative of a broader problem caused by the lack of coverage of conferences in WoS. Note, although recent work by Kousha and Thelwall (2007) might appear

⁷ Two of the academics were not listed here as their h_{GS} and h_{WoS} was <5 .

⁸ On WoS, R uger's publications were searched using the string "Ruger".

to contradict the work described here, where significant correlations between the citation counts of GS and WoS were found; in Kousha and Thelwall, only the citation patterns of open access journals, not conferences, were considered.

Measuring h using other databases

The ranking used in Oppenheim's paper was on WoS citation index searches covering publications from 1992 up to (presumably) the time the paper's research was conducted, late in 2005. Given that a number of the academics listed in the rankings have many publications dating back to before 1992, it was decided to examine a wider spread of years in WoS. Another change that occurred since Oppenheim's study was the introduction of WoS "Author Finder" (Fingerman, 2006), which calculates the h of a particular academic automatically. Therefore, it was decided to calculate h using this service (h_{WoSAF}) as well as the mirror service from Scopus, "Author Identifier" (h_{Scopus}). The results are shown in Table 4. All the academics from Oppenheim's study were listed along with the additional grouping shown in Table 3. Since it appeared that the focus on CS related research seemed to affect differences in h particularly when GS was involved, the academics were grouped by their CS focus and then ranked by h_{GS} .

Both services, though easier to use than dealing with the raw data of the CRS from WoS (now identified as h_{WoSCRS}) have their limitations. The h_{WoSAF} includes citations for publications stored within WoS, whereas h_{WoSCRS} also lists publications cited by the papers held by WoS. Scopus has poorer coverage of publications dating to before the 1990s. Such limitations were seen in the variations in h for the academics measured across the two additional databases: Van Risjbergen's h_{WoSAF} dropped substantially showing that most of his citations in WoS were to papers not listed in the database. In contrast, Willett and Bawden's h_{WoSAF} increased noticeably, showing the importance of examining publications before 1992 in WoS.

An analysis of the two grouping was conducted, results were presented in Table 5. The average h measured in each group was examined: h_{Scopus} , h_{WoSAF} , and h_{WoSCRS} were similar across the groups, h_{GS} was larger for the more CS focussed academics compared to the others. No significant differences were observed. The Δ measured between h_{GS} and each other citation database (h_{Scopus} , h_{WoSAF} , h_{WoSCRS}) was large and significant ($p < 0.01$). There was a concern that the drop in h_{GS} observed for Willett, Gillet, Bawden, Feather, Morris and Gibb, might have caused the Δ to be significant. Therefore, the h scores of these 6 academics were

eliminated from the comparisons. Despite this, all the differences between the three Δh scores remained significant.

1	2	3	4	5	6	7	8	9	10	11
Name	h_{Scopus}	h_{WoSAF}	h_{WoSCRS}	h_{GS}	$\Delta(h_{GS}, h_{Scopus})$	$\Delta(h_{GS}, h_{WoSAF})$	$\Delta(h_{GS}, h_{WoSCRS})$			
Peter Willett	35	38	31	28	-7	-20%	-10	-26%	-3	-10%
Stevan Harnad	8	5	11	21	13	163%	16	320%	10	91%
David Ellis	11	14	13	17	6	55%	3	21%	4	31%
Nigel Ford	13	14	13	16	3	23%	2	14%	3	23%
Jennifer Rowley	8	5	5	15	7	88%	10	200%	10	200%
Charles Oppenheim	11	10	9	13	2	18%	3	30%	4	44%
Val Gillet	14	16	15	12	-2	-14%	-4	-25%	-3	-20%
Peter Bath	11	10	10	11	0	0%	1	10%	1	10%
David Bawden	7	14	9	11	4	57%	-3	-21%	2	22%
David Nicholas	10	10	9	10	0	0%	0	0%	1	11%
Elisabeth Davenport	5	7	7	10	5	100%	3	43%	3	43%
Peter Brophy	4	3	5	8	4	100%	5	167%	3	60%
Jonathan Raper	6	4	5	8	2	33%	4	100%	3	60%
Fytton Rowland	4	4	5	8	4	100%	4	100%	3	60%
John Feather	2	4	8	7	5	250%	3	75%	-1	-13%
Julian Warner	5	6	6	7	2	40%	1	17%	1	17%
Rita Marcella	4	4	5	6	2	50%	2	50%	1	20%
Ian Rowlands	6	5	5	6	0	0%	1	20%	1	20%
Anne Morris	4	5	6	5	1	25%	0	0%	-1	-17%
Paul Burton	3	5	5	5	2	67%	0	0%	0	0%
Leela Damodaran	3	4	5	5	2	67%	1	25%	0	0%
Peter Enser	2	4	5	5	3	150%	1	25%	0	0%
Forbes Gibb	6	5	5	5	-1	-17%	0	0%	0	0%
Steven Whittaker	10	6	7	29	19	190%	23	383%	22	314%
Stephen Robertson	13	18	18	25	12	92%	7	39%	7	39%
Mike Thelwall	17	14	14	24	7	41%	10	71%	10	71%
Keith van Rijsbergen	13	5	13	21	8	62%	16	320%	8	62%
Mounia Lalmas	10	6	7	17	7	70%	11	183%	10	143%
Mark Sanderson	6	2	5	15	9	150%	13	650%	10	200%
Cliff McKnight	6	7	7	12	6	100%	5	71%	5	71%
Ian Ruthven	7	4	6	12	5	71%	8	200%	6	100%
Stefan Ruger	4	4	4	10	6	150%	6	150%	6	150%
Joemon Jose	6	0	1	10	4	67%	10	∞%	9	900%
Iadh Ounis	4	2	3	9	5	125%	7	350%	6	200%
John Tait	5	1	1	8	3	60%	7	700%	7	700%
Ayse Goker	2	2	3	5	3	150%	3	150%	2	67%

Table 4: a range of h measures; academics grouped by CS focus: less CS above the line, more below

Average	h_{Scopus}	h_{WoSAF}	h_{WoSCRS}	h_{GS}	$\Delta(h_{GS}, h_{Scopus})$	$\Delta(h_{GS}, h_{WoSAF})$	$\Delta(h_{GS}, h_{WoSCRS})$
Less CS (23)	7.9	8.5	8.6	10.4	2.5	1.9	1.8
More CS (13)	7.9	5.5	6.8	15.2	7.2**	9.7**	8.3**

Table 5: Comparison of h and Δh of academics when grouped by their CS research focus

From such results it was concluded that h_{GS} for academics with a more CS research focus was significantly increased compared to the other academics measured in the study and this increase was consistent across the citation databases considered in the study. That such a difference was observed between two sets of academics grouped by their research focus suggested that the increase in h_{GS} was not due to erroneous inflated counts, but rather a significant difference in coverage of CS publications between GS and

Scopus/WoS. The creators of the later two databases might argue that they focus their contents on quality sources, such as journals, as opposed to GS's much more liberal inclusion approach. However from this citation based study, it appeared that there were papers appearing in the wider range of sources (e.g. referred conferences, un-refereed conferences or even self-published tech reports) that through heavy citation have shown their worth, and therefore, should be included when measuring an academic's contribution.

Comparing databases

In terms of database coverage, from the analysis in this paper, it is clear that all three databases are missing content. For the more CS focussed academics, WoS, to a lesser extent Scopus, missed citations. However, h_{GS} for 6 of the 36 academics was lower due to missing citations. In addition, Scopus, with its focus on more recent publications, also missed citations. Such differences were confirmed through a pair-wise examination using the Kendall τ rank correlation measured between the h rankings of all academics (considered in this study). As can be seen in Table 6, the correlations between each of the citations databases were never particularly strong, the highest τ was between the two WoS databases, though they correlated least strongly with the ranking derived from GS. The ranking from GS was best correlated with that from Scopus. When attempting to rank the two groups of academics listed here, no citation database appears to be best.

	h_{GS}	h_{WoSCRS}	h_{WoSAF}	h_{Scopus}
h_{GS}	-	0.51	0.38	0.69
h_{WoSCRS}	0.51	-	0.79	0.64
h_{WoSAF}	0.38	0.79	-	0.59
h_{Scopus}	0.69	0.64	0.59	-

Table 6: Kendall τ rank correlation of the academics in Table 4 ranked by h from each database

Name	h_{mx}	Name	h_{mx}	Name	h_{mx}	Name	h_{mx}
Peter Willett	38	Nigel Ford	16	Elisabeth Davenport	10	Julian Warner	7
Steven Whittaker	29	Jennifer Rowley	15	Stefan Ruger	10	Anne Morris	6
Stephen Robertson	25	Mark Sanderson	15	Joemon Jose	10	Forbes Gibb	6
Mike Thelwall	24	David Bawden	14	Iadh Ounis	9	Rita Marcella	6
Keith van Rijsbergen	21	Charles Oppenheim	13	John Feather	8	Ian Rowlands	6
Stevan Harnad	21	Cliff McKnight	12	Peter Brophy	8	Paul Burton	5
David Ellis	17	Ian Ruthven	12	Jonathan Raper	8	Leela Damodaran	5
Mounia Lalmas	17	Peter Bath	11	Fytton Rowland	8	Peter Enser	5
Val Gillet	16	David Nicholas	10	John Tait	8	Ayse Goker	5

Table 7: ranking the 36 UK LIS and IR academics by h_{mx}

If one assumes that the differences in h across the databases were due to false negative errors and that the false positive errors in the databases were negligible, one could rank academics by their maximum h (h_{mx}) measured across the citation databases. Although each h is no more than an estimate, h_{mx} provides a better estimate by mitigating the problems of false negative errors. Table 7, shows such a ranking of the senior UK LIS and IR academics.

As with the previous brief communications h studies published recently, what was not shown was if any of the h rankings correlated well with other means of ranking academics, such as a survey of peers. In addition, although we contend that h_{mx} provides a better estimate of h than using any single database, a closer examination of the overlaps of citations and publications between the databases is likely to provide a better estimate still. Such ideas are left for future work.

Conclusions

In this brief communication, a previous study that ranked UK-based LIS and (some) IR academics was re-examined on different citation databases and the range of academics was expanded. It was found that scholars who published in more Computer Science related forums had a significantly higher h_{GS} than their h_{WoS} or h_{Scopus} . Examination of the citations in GS confirmed previous research showing the citations to be from predominantly legitimate publications. False positive errors, though present in Google Scholar, were not found to be as important as the substantial number of false negative citation errors in WoS and (to a lesser extent) in Scopus. The differences in h across the databases led to noticeable differences when academics were ranked by each database. No single citation database was ideal, which led to a re-ranking by h_{mx} .

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