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S-Index: A Comprehensive Scholar Impact Index

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Abstract

Limitations of impact indices to compare scholars across disciplines and time based only the number of publications and citations are discussed. The S-index, based on more comprehensive scholar impact factors, is proposed.

Keywords: S-index, h-index, impact index.

1. Publications

"It is idle to measure a man's real value by the number of memoirs he writes, although that is very influential just now in academic appointments on both sides of the Atlantic – it is easier to count than to weigh."[1] So wrote Karl Pearson (1857 – 1936), the first champion of modern statistics, about 90 years ago. Scholar impact factors are hot again, and the prevalent indices are based on the number of publications and citations.

Perhaps the most well-known is Hirsch's[2] h-index. Currently, according to *Publish or Perish*[3] (*PoP*) software, my h-index is 19, which is based on 1,210 citations. This means I have 19 publications that have been cited at least 19 times each. The same value appears via the Google Scholar citations-gadget,[4] because both obtain their statistics by parsing the scholar.google.com search engine. The h-index Calculator,[5] an add-on for the Firefox (Mozilla) browser, has my h-index at 19 (1,261 citations) or 26 (2,255 citations) depending on using my first name or its initial in the search, respectively.

The h-index can be estimated[6] with $h' \approx a\frac{\sqrt{N_C}}{2}$, where N_c is the number of citations and a is a scaling factor obtained through solving a power function for empirical data obtained from similar scholar settings (e.g., discipline and sub-discipline, country, time period). For faculty in the College of Education at Wayne State University, setting $a = 1$ is a reasonable estimate

for most departments (r = .92), but it systematically under-estimates the h-index for faculty in the Kinesiology, Health, and Sport Studies department (r = .48). (Hirsch[2] recommended *a* be set from 3 to 5.)

PoP provided an overview of other indices, including the generalized h-index that discounts how long ago the article was published, and other age-weighted indices.[7-9] To boost the scholarly walrus, the individual h-index[10] divides the h-index by the number of co-authors. The multi-authored h-index[11] grants fractional credit to dilute multi-author impact. These are questionable adjustments, because the number and position of co-authors are too capricious to be meaningful, especially (1) in disciplines where it is not uncommon to have a half dozen or more authors to a publication, (2) at laboratories where the policy is to place the senior scholar as last author listed, (3) in research communities who begin authorship alphabetically and rotate with subsequent publications, or (4) for major professors who take the second position, or in some cases decline joint authorship, in order to support their doctoral students' emerging careers. Moreover, there is little value in discounting the impact of time when that is a key construct being measured.

Karl Pearson's h-index is 56. How did it get so high? "Pearson was a prodigious and compulsive worker. I remember asking him once how he had time to write so much… [H]e replied… 'I never answer a telephone or attend a committee meeting.'"[12] This may become the ultimate faculty end game if impact indices based on publications (and indirectly citations) are universally adopted as the sole barometer of a scholar's impact.

1.1. Compliments to the h-Index

1.1.1. Publications Weighted Index (PW-index)

The purposed PW-index is a weighted h-index to take into consideration the impact factor of the publication outlet,

$$\text{PW-index} = \frac{\sum_{i=1}^{h}\left(h_{A_i} \times h_{J_i}\right)}{\sum_{i=1}^{h} R_i} = \frac{2}{h(h+1)}\sum_{i=1}^{h}\left(h_{A_i} \times h_{J_i}\right) \quad , \qquad (1)$$

where h_A is the author's h-index (with the most cited publication assigned the value of h), h_J is the associated publication outlet's h-index, and R is the rank.

1.1.2. Excess Citations and Excess Publications Indices (P_{EC}-index & P_{EP}-index)

An obvious limitation is how to handle excess citations (EC). Based on expanding the e-index which was developed for this purpose,[13]

$$\mathrm{P_{EC}}\text{-index} = \sqrt{N_{C_h} - N_{C_{h_{MIN}}}} + \sqrt[3]{N_C - N_{C_h}} \qquad (2)$$

is proposed to handle excess citations, where N_{C_h} is the number of citations for articles used to compute the h-index and $N_{C_{h_{MIN}}}$ is the minimum number of publications to achieve that h-index. To handle excess publications (EP),

$$\mathrm{P_{EP}}\text{-index} = \sqrt[3]{N_P - h} \qquad (3)$$

is proposed, where N_P is the total number of publications. Although there has been development of statistical methods for estimating the existence of publications not found, this has become mooted somewhat due to Google Scholar Citations'[14] ability to input missing publications, correct references, merge duplicate entries, and delete self-citations.

1.2. Journalism

It would be silly to require publications to be empirical or data-based, because the scholarship of many disciplines is based on scholasticism, historiography, logos rhetoric, etc. Nevertheless, it does seem prudent to differentiate between essays published in scholarly outlets that cater to synthesis (i.e., non-numeric meta-analysis) or critical argument vs. journalistic outlets such as the *Chronicle of Higher Education* or *The New York Times*. Similarly, the self-described non-professional Wikipedia is based on a content policy (WP:NOR)[15] of rejecting original research; disdaining primary sources in favor of secondary or tertiary sources; and inclusion by consensus of unknown, volunteer editing cabals instead of content expertise and credentials. Therefore, contributions to those outlets, as well as popular or trade magazines, newspapers, newsletters, blogs, social media, and propaganda should be eschewed. However, contributions via academic associations, professional societies, discriminating publishing houses, etc., even if they are not disseminated in the classical journal, periodical, or even print format should be included.

1.3. Limitations

These impact indices suffer from common ailments. (1) Sometimes work is highly cited because it is wrong. (2) The number of publishing outlets is related to the number of scholars in the field, favoring certain disciplines. (3) There is no differentiation between exploration and explication. The same issue in *Psychological Bulletin* that I published a new knowledge article that has been cited 160 times also contains a statistics primer for dummies by Jacob Cohen (1923 – 1998, h-index = 62) that has been cited 8,547 times. (4) Credit is given in the index for a citation even if it supports a position contrary to the publication. (5) These indices can change extremely quickly. My Δ-h, defined[5] as the number of additional citations of specific publications that will change my h-index from 19 to 20, is only 3 additional citations

of the 20th most cited publication. (6) These indices can change extremely slowly. Some editors prefer authors to cite recent, secondary references to seminal work instead of the original, not only because it makes the literature review look fresher, but as time passes it becomes difficult to access seminal work. (These are different reasons from that invoked by Wikipedia, which relies on secondary sources to enable equal participation of editors who are completely devoid of any substantive knowledge in the field.) Also, well known methods are rarely referenced, such as Karl Pearson's Chi-Squared test, Student's t-Test, or Wilcoxon's Rank-Sum test. (7) Disciplines where the scholarly outcomes are lengthy treatises, qualitative, or juried exhibits or performances will never be equitably served by formulae based on numbers. Scholarship in the form of plenary or keynote addresses before scholarly societies and professional associations that are not abstracted or subject to proceedings, scholarship serving as the basis for legislative language, and expensive and extensive literature reviews found in technical reports from federally funded peer reviewed grants (e.g., the United States Department of Education, National Science Foundation, National Institutes of Health) will not be captured by these indices. Although the software programs listed above permit searching for patents and post non-peer law review publications that are eventually cited in judicial decisions, these forms of scholarship are generally not cited with the same frequency as found in other disciplines.

There are additional problems if the index is based on a quick and cheap Google Scholar search. (1) Google Scholar doesn't differentiate between peer and non-peer reviewed publications. It includes citations from self-published books and editorials. (2) Publications not on the internet cannot be found. Sometimes, even if they are on the internet they are inaccessible because they require membership login, don't use Google Scholar's required html <meta> commands, or exceed Google's five megabyte per document limitation. (3) Posthumous re-publication causes inflation. For example, Pearson's "Tables of the Incomplete Beta-Function" was republished 29 years after his death and has 615 citations, and "The life, letters, and labours of Francis Galton" was republished last year and already has 91 citations. Google Scholar treats these posthumous re-releases of his earlier work as new publications. (4) Searches are often not replicable, because results are based on a random set of 1,000 hits. Google will (at least temporarily) suspend privileges if too many searches are conducted within a short timeframe – exacerbated by not publically disclosing (a) the maximum number of searches that may be conducted (b) within what timeframe that will trigger a suspension and (c) for how long the suspension will remain in effect for a given ip address. (5) Searches for author last names that are common, transliterated, misspelled, contain diacritical marks, or changed when married may be problematic.

Some issues pertaining to Google Scholar's search engine may be ameliorated if it is replaced with the Thomson ISI Web of Science database[16] or other commercial resources. The obvious limitation, however, is the subscription costs to private scholars and independent researchers who do not have free access to those commercial sites.

2. Teaching

It is a misnomer to call the h-index a scholar index, because it is restricted to publications and citations. The contention that teaching has no scholar impact is preposterous. Louis Paul Émile Richard (1795 – 1849) never published anything. Yet, his students included Urbain Jean Joseph Le Verrier (1811 – 1877) who discovered Neptune through the mathematics of celestial mechanics, Évariste Galois (1811 – 1832) who sketched the tenets of Galois theory the evening before being killed in a duel at age 21, Joseph Alfred Serret (1818 – 1885) who published two of the most popular advanced graduate level mathematics textbooks of the last quarter of the 19th century, and Charles Hermite (1822 – 1901) who proved *e* (the base of natural logarithms) is transcendental.

As long as curricula were not ensconced in faculty hands teaching should not have been a part of impact formulae. The preeminent mathematical statistician Sir Ronald Fisher (1890 – 1962, his h-index is 118; by comparison Albert Einstein, 1879 – 1955, has an h-index of 95), stated, "Cambridge University should never appoint a professor who is older than 39. If they do, then by the time his proposal for his teaching program has been approved by the university, he will have reached retirement age."[17] Although modern curriculum development is conducted more expeditiously, teaching continues to have no role in determining scholar impact. This is presumably due to untrustworthiness in measuring teacher success: the anomaly that professors can grade any performance – cognitive, behavioral, affective, or psychomotor – and yet faculty union officials and their wards appear to believe teaching defies the laws of measurement theory.

2.1. Doctoral Students

Mentoring, however, is a form of teaching that lends itself to the metrics of scholar impact. It is gelastic to compare the h-index of Scholar A who has no teaching responsibilities with Scholar B who does, especially if B works in a graduate school and supervises doctoral students. What greater impact can a professor have apart from inspiring the next generation of scholars? Therefore,

$$S_1 = D, \qquad (4)$$

is proposed, where *D* is the number of doctoral (Ph. D., Ed. D., etc.) dissertations chaired as Major Professor. Because publications can appear with "in press" dating and are subsequently citable, it is analogous that an approved prospectus should be included in *D* even though the final dissertation has yet to be defended. They have publishable segments appropriate for journals that have a section catering to preliminary results or brief reports. This is especially relevant to time series and other longitudinal studies.

A Co-Advisor is sometimes employed when the dissertation is so broad as to require expertise beyond the Major Professor. A Second Advisor may be employed when the dissertation is fully within the expertise of the Major Professor, but becomes necessary due to the Major

Professor being absent for extended periods (e.g., health, Sabbatical), existence of two laboratories, or other such reasons. The impact factor

$$S_2 = \sqrt{D_{Co} + D_2}, \qquad (5)$$

is proposed, where D_{Co} and D_2 refer to the number of doctoral students Co-Advised and Second Advised, respectively.

A Minor Advisor (also known as a Cognate Advisor) supervises the doctoral minor area of study, which typically represents the core of a Master's program. Oftentimes this forms the context for the dissertation. The impact factor

$$S_3 = \sqrt[3]{D_M}, \qquad (6)$$

is proposed, where D_M refers to the number of students served as the Minor Advisor.

Ordinary doctoral committee members can be invaluable, but may vary based on their role on the committee and also may vary from committee to committee. For example, the methodologist is often both wedding planner and compere. The cumulative inverse (known as a divergent or harmonic series), which increases far more slowly than the square or cube root, is proposed to represent the impact factor

$$S_4 = \sum_{i=1}^{N} \frac{1}{D_{O_i}}, \qquad (7)$$

where D_O represents ordinary committee member. (Note that merely serving on a doctoral qualifying or examining committee is not considered sufficient as an impact factor.)

Post-doctorate students (known as "postdocs") are prevalent in some disciplines. The impact on postdocs is likely to be less than that for full-fledged doctoral students. Hence, the proposed impact factor is

$$S_5 = \sqrt[3]{D_P}, \qquad (8)$$

where D_P refers to postdocs.

2.2. Doctoral Students' Publications Index (DS-index)

Due to the variability in serving as an ordinary doctoral committee member it will not be used in determining the impact of a scholar's doctoral students' publications. To weight the impact of the other five types of doctoral students by their h-index,

$$\text{DS-index} \approx a \frac{\sqrt{N_D + \sqrt{N_{Co} + N_2} + \sqrt[3]{N_M} + \sqrt[3]{N_P}}}{2}, \qquad (9)$$

is proposed, where N refers to the number of their publications. The DS-index is intended to mimic the h' estimate. Presumably, setting a = 1 should suffice for general purposes.

2.3. Master's Theses

Although a similar argument could be made to include Master's theses chaired, there is too much academic variability to include them as a factor. Sometimes they are barely more than a formalized undergraduate senior project, guided only by the thesis advisor instead of a full committee, or not necessarily publishable. Furthermore, exceptional students are likely to continue into a doctoral program and will be included in those relevant indices. For these, among other reasons, Master's theses chaired are dismissed as an impact factor.

3. Editing and Reviewing

It is difficult to ignore the scholarly impact that accrues via service as an editor or ad hoc reviewer for peer reviewed publications. (However, ad hoc reviews for grants, commercial textbooks, book chapters, etc., which are better characterized as service to the profession, are excluded.) Certainly an editor, and to a lesser extent a reviewer, has an integral role in determining the direction of the discipline in terms of making (or recommending) publish or don't publish decisions. Hence,

$$S_6 = E + \sqrt{B} + \sum_{i=1}^{N} \frac{1}{R_i}, \tag{10}$$

is proposed, where E is the number of peer reviewed journals served as editor; B is the number of peer reviewed journals served as a member of the editorial board; and R refers to the number of peer reviewed journals served as an ad hoc reviewer, excluding those concurrently serving as E or B.

4. S-index

The comprehensive S-index, comprised of the most salient scholar impact factors, is obtained by concatenating the S_1 through S_6 scholar impact factors with the h-index:

$$\text{S-index} = h + D + \sqrt{D_C + D_2} + \sqrt[3]{D_M} + \sum_{i=1}^{N} \frac{1}{D_{O_i}} + \sqrt[3]{D_P} + E + \sqrt{B} + \sum_{i=1}^{N} \frac{1}{R_i}. \tag{10}$$

5. Examples

5. 1. Publications Weighted Index (PW-index)

The data to compute the numerator for the PW-index are compiled in Table 1. My highest rank of 19 would be multiplied by 418, which is the h-index of *Psychological Bulletin* (the journal in which that publication was published), plus 18 times the h-index for the journal associated with the next lower cited publication, and so forth. Note that tied citations are assigned the mean rank. The sum of article's rank × the associated publication's h-index is

25,631. The denominator, the sum of the ranks, is $\sum_{i=1}^{h} R_i = 1 + 2 +, ..., +19 = 190.$ Thus, my PW-index $= \frac{25631}{190} = 134.9.$ Alternately, the computation may be expressed as PW-index = $\frac{2}{19(19+1)} \times 25631 = 134.9.$

Table 1. Computation of the PW-index Numerator.

Article's Rank (Citations)	Publication Outlet	Publication h-index	Article Rank × Publication h-index
19 (160)	*Psychological Bulletin*	418	7,942
18 (81)	*Exceptional Children*	115	2,070
17 (68)	*Communications in Statistics*	84	1,428
16 (60)	*Review of Educational Research*	91	1,456
15 (56)	*Journal of Clinical Epidemiology*	182	2,730
14 (53)	*Educational & Psychological Measurement*	111	1,554
13 (50)	*Psychometrika*	155	2,015
12 (48)	*Journal of Youth and Adolescence*	109	1,308
11 (44)	*Psychological Methods*	91	1,001
9.5 (39)	*Journal of Educational and Behavioral Statistics*	69	655.5
9.5 (39)	Pro-Ed	80	760
8 (33)	*Journal of Experimental Education*	62	496
7 (26)	*Adolescence*	83	581
6 (24)	*Adolescence*	83	498
5 (22)	*Psychological Reports*	101	505
3.5 (21)	*Adolescence*	83	290.5
3.5 (21)	*Medical Teacher*	66	231
2 (20)	*Journal of Modern Applied Statistical Methods*	13	26
1 (19)	*Communications in Statistics*	84	84
190 (884)	Sum		25,631

5.2. P_{EC} (Excess Citations Index) and P_{EP} (Excess Publications Index)

According to *PoP*, I currently have 130 publications (of the 240 listed in my *c.v.*). They are cited 1,210 times. The publications used to derive the h-index of 19 are cited 884 times (Table 1). The minimum number of citations is 19^2 = 361, so there are 884 – 361 = 523 excess citations. There are 1,210 – 884 = 326 citations of publications not used to derive the h-index.

There are 130 – 19 = 111 excess publications. Hence, $P_{EC} = \sqrt{523} + \sqrt[3]{326} = 29.8,$ and $P_{EP} = \sqrt[3]{111} = 4.8.$

5.3. $S_1 – S_5$ (Doctoral Students' Impact Factors)

My data for these five impact factors are compiled in Table 2. My $S_1 = D = 72,$ $S_2 = \sqrt{D_{CO} + D_2} = \sqrt{0+15} = 3.9,$ $S_3 = D_M = \sqrt[3]{2} = 1.3,$ $S_4 = D_O = \sqrt[3]{43} = 3.5,$ and $S_5 = D_P = 0.$

Table 2. Data for the Doctoral Student $S_1 – S_5$ Impact Factors.

Scholar's Role	Symbol	Impact Factor	N
Major Professor	D	S_1	72
Co-Advisor and 2nd Advisor	D_{Co}	S_2	0+15
Cognate (Minor) Advisor	D_2	S_3	2
Ordinary Committee Member	D_O	S_4	43
Postdoctoral Supervisor	D_P	S_5	0

5.4. DS-Index (Doctoral Students' Publications Index)

The publication numbers needed to compute the DS-index for my students are compiled in Table 3.

Table 3. Computation rules for the DS-index.

Scholar's Role	Students' N_C	Rules for Computing N
Major Professor	615	N = publications
Co-Advisor	0	N = square root of publications
2nd Advisor	37	
Cognate (Minor) Advisor	3	N = cube root of publications
Postdoctoral Supervisor	0	

Thus, with a = 1.0, my $\text{DS-index} \approx \dfrac{\sqrt{615 + \sqrt{0+37} + \sqrt[3]{3} + 0}}{2} = 12.5.$ In comparison, based on their 5,401 citations the collective h' is 36.7 for work produced by doctoral students for whom I served as Major Professor. The DS-index = h' when a = 2.9, which is close to the minimum recommendation of a = 3 set by Hirsch.[2]

5.5. S_6 (Editing and Reviewing Factors)

I serve (or have served) as Editor for two journals, on the Editorial Board of four journals, and have provided ad hoc reviews for 25 different peer-reviewed journals. Hence,

$$S_6 = 2 + \sqrt{4} + \left(\frac{1}{1} + \frac{1}{2} +, ..., + \frac{1}{25}\right) = 7.8.$$

5.6. S-index

Concatenating h with $S_{1\text{-}6}$, my S-index = 19 + 72 + 3.9 + 1.3 +3.5 + 0 + 7.8 = 107.5.

5.7. Summary of Indices

The proposed indices and their descriptions are compiled in Table 4.

Table 4. Summary of Proposed Indices.

Index	Description	Value
S-index	Comprehensive Scholar Index	107.5
PW-index	Publications Weighted Index	134.9
P_{EC}	Excess Citations Index	29.8
P_{EP}	Excess Publications Index	4.8
DS-index	Doctoral Students' Publications Index	12.5

Conclusion

"I'm extremely famous"[18] – Ronald Bilius Weasley, Nineteen Years Later, *Harry Potter and the Deathly Hallows*. Perhaps so, but it is obvious scholar impact is an even more precarious construct than is fame. The different statistical approaches that have arisen in the past decade are indicative of the struggle necessary in capturing scholar impact, as measured by publications and citations. The S-index is an attempt to be more comprehensive in assessing scholarship than the h-index and its various modifications. Even the S-index, however, does not capture the impact of intellectual discourse among scholars via personal correspondence, mentoring junior scholars, etc., that leads to important contributions to the discipline.

Egon Sharpe Pearson (1895 – 1980, h-index = 33), Karl's son and co-inventor of the alternative statistical hypothesis (H_a:), opined "I have a natural sympathy with anyone who is trying to thrash out better ways of handling the problems of statistical inference."[19] His sympathy is necessary, but insufficient. We must continue exploring and refining this issue on all sides of the Pacific, Atlantic, and Indian oceans. A scholar's fame is ephemeral, whereas the scholar impact index is eternal – at least for now.

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