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WASP (Write a Scientific Paper): Understanding research metrics

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ABSTRACT

Research metrics are quantitative measurements that identify and acknowledge research output while enhancing article, author and journal impact within the academic community. The article impact depends on the number of times that same article is cited by other authors, while an author's impact depends on the number of citations received on the total number of published articles by the same author. With the advancement in technology and the increased availability of open access journals, article-level metrics has become a popular metric. This is the aggregation of the traditional article citations and the article online presence through blogs, tweets and newspapers, which further enhances the author's impact within the academic community. A journal's impact will depend on the average number of citations received by the articles published within the journal over a period of time. The academic reputation within the academic community will therefore depend on both article and author metrics and is further enhanced by publishing in high impact journals.

1. Introduction

Publishing is influenced by a tripod of forces: authors wish to publish more, readers are inundated and wish to read less, and editors are mainly interested in enhancing their journal's profile. Authors, for whom this manuscript is crafted, must be cognizant of these opposing forces in order to succeed.

Publishing scientific papers and establishing publishing prominence is a prime requirement for academics and researchers, a task that may seem initially daunting to many. The art of successful publishing lies in the ability of the author to produce original and striking manuscripts representing research output, identifying a suitable journal and whet the editor's appetite enough to consider the article for publishing. The article under consideration must contribute originality and appeal to a substantial number of other academics and researchers. But how could one quantify the cumulative impact and relevance of the academic-researcher research output?

Embarkation into the academic world requires the academic-researcher to possess a good grip on research metrics, i.e. the impact of his/her personal work within the scientific community and the impact of the articles and journals considered. Research outputs are quantitatively measured in various facets of metrics, which enable the evaluation of the success of an article, author and journal within the academic-scientific community. Bibliometric studies are also an important requisite for grant research funds, awarding academic rank, selection of keynote speakers in scientific conferences, as well as for policy makers and science managers in order to support research assessment decisions [1,2].

2. Citation tracking

Citation tracking is the fundamental basis of tracing researchers' work, understanding the impact of an article or journal within the academic-scientific community and discovering further research within the same field or topic under consideration. A scientific paper will receive citations depending on the subject and quality of the research [2]. Citation tracking is performed by means of bibliometric tools which collect data from large citation databases such as 'Web of Science', 'Scopus' or 'Google Scholar' [3]. These databases count the number of times a particular published article has been cited by other papers. However, each database incorporates slightly different journal lists or specific types of articles such as original papers, letters, reviews, commentaries but may exclude conference papers, chapters and technical reports, therefore only papers indexed in the same database are considered. This leads to potential overlap or unaccounted citations. Table 1 summaries the different citation tracking tools available [4].

3. Author metrics

The publishing impact of an author is based on the total publications and the number of times these publications were cited. The use of author metrics enables the identification of other authors in the same field, tracking the work of colleagues, as well as following the literature evolution in a

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Table 1
Summary of the different citation tools available.

Citation tool	Provider	Overview of tool
Citation Report	Web of Knowledge®	(1) Identify total number of article citation (2) Count the number of times article cited without self-citations (3) Count citing articles (4) Count average citations per item (5) Count the *h*-index
Scopus™ tool	Elsevier®	(1) Identify total number of article citation (2) Count the number of documents that cited the article since 1996 (3) Count the *h*-index
Google Scholar Citations	Google®	(1) Identify total number of article citation (2) Count the *h*-index
Academic Search Premier	EBSCOhost®	(1) Find similar articles to the original (2) Identify total number of article citation (3) Citation matching
PsycINFO	American Psychological Association®	(1) Identify total number of article citation

specific field of study [5]. Different databases calculate author's impact depending on the journals they index and metrics used.

3.1. The h-index

A commonly used author's metric is the '*h*-index', which was proposed by Hirsch in 2005 and measures the impact and the productivity of an author's research. This index is based on the author's most cited published papers and the number of citations those articles received in other publications [5,6]. Therefore an author has an *hx* index if exactly *h* of the published papers has been cited *h* or more times and the other published papers have no more than *h* citations each. Using such a metric would enable easily comparison of the overall scientific impact between two or more academic-researchers, even if the total number of papers or citations varies. When comparing two academic-researchers of the same scientific age with similar number of papers and citations but with different *h*-index, the individual with the highest *h*-index is likely to be the more accomplished academic-researcher within the academic community [6]. The *h*-index is freely available to academic-researchers through Google Scholar®. It is also made available by other databases through subscription such as Web of Science® and SCOPUS®. This bibliometric index was reported to be reliable in healthcare researcher when compared between SCOPUS, Google Scholar and Web of Science [7].

However *h*-index has a number of limitations including inter-field differences, so comparisons of academic-researchers between different disciplines should not be performed [6]. The *h*-index is also discipline-size dependent, where highly specialized academic-researchers will have fewer citations in view of a lesser audience and this will lead to a low *h*-index [2]. Whether the academic-researcher has a first authorship or a co-authorship will not be discriminated in the *h*-index calculation, even though in the academic world it is standardized that the first author has higher research output. Self-citations are also not considered in the *h*-index measure [8].

The *h*-index depends on the pool of publications and citations over a period of time, so the index cannot be used to compare scientists at different stages of their careers [9]. Once a paper has been determined as a highly cited *h*-indexed paper, the number of citations received will be unimportant. In fact Egghe proposed another index, the *g*-index to try to overcome this problem, by quantifying the scientific productivity by considering the publication record [6,10]. Technical limitations are also evident such as academic-researchers having common names will provide difficulty to obtain a complete and accurate research output. Also self-citations can increase the academic-researcher *h*-index but the effect of such citations is much smaller than the total citation count since only self-citations with a number of citations with $> h$ are considered as relevant [1,6]. The *h*-index also underestimates the achievements of academic-researchers with "selective publication strategy". These are authors who do not publish a large number of articles but still achieve a high international impact [1].

3.2. g-index and e-index

The *g*-index proposed by Egghe was aimed to give more weight to the highly cited articles and overcome one of the limitations of the *h*-index [10]. The *e*-index was proposed in order to differentiate between academic-researchers with similar *h*-index but with different citation patterns [11].

3.3. i10-index

The i10-index is used only by Google Scholar and it represents the number of publications with at least 10 citations [12].

3.4. Bh-index

The B*h*-index enhances the *h*-index by adjusting for young academic-researchers with fewer publications but are nevertheless highly cited from the mature academic-researchers with many publications but are less cited and therefore have low impact within the academic community. The calculation is based on the *h*-index and then considers a threshold value for the known "*h*-core articles". Therefore from two academic-researchers with the same number of publications and citation counts, the academic-researcher with a homogenous increase in citations will establish a higher score than the academic-researcher with a skewed citation towards few publications [2,13].

3.5. Times cited

"Times Cited" is a popular metric used by Web of Science® and is used to determine both an article and author's impact. This metric is composed of a search function that enables the identification of an author, single article or topic and through this find how many times the articles had been

cited within the Web of Science databases. Conversely there are a number of problems that may arise from utilizing this type of metric, namely, authors can cite themselves and raise their citation count and there may be a bias in article citations where certain journals articles are more favored [14].

4. Article metrics

An article is considered to have a high impact value within the academic-scientific community by the number of times it is cited by other articles. Generally, the higher the citation counts, the greater the article value. Determining the number of citations of an article will identify not only the potential impact of the paper but also identify journals in which one could consider to publish in, as well as pinpointing the leading academics in a particular field. However citation counts of an article may occasionally be misleading. A poor quality article may establish a high citation count from those refuting them while an excellent article may not be cited or read [15]. When a poorly defined research is published, other authors may write to the editor or in the commentary section of a journal criticizing the poor research article. Despite the poor research quality of the article, metric tools are unable to distinguish the quality of the research output but would count the multiple citations and provide a high citation count towards that particular article.

4.1. Article-level metrics (ALM)

As electronic dissemination has surpassed print and the open access era continues to dominant the scientific world, a new article metric was created. This article-level metric enables not only the tracking of an article's citation but also tracks different online markers including the counting of article page views, downloads, mention in blogs as well as the inclusion of the article in social bookmarking tools [16]. Therefore an aggregation of article-level metric (ALM) showcases the academic-researcher's research output by incorporating the traditional data (citations) and online data sources (altmetrics) in order to define the global article impact within the academic world [17]. Examples of ALM include Altmetric, Plum Analytics, Public Library of Science-Article-Level Metrics and ImpactStory [18].

A number of publishing houses (e.g. PLOS, BioMed Central) have incorporated this article-level metrics in their publishing process and therefore automatically links and features the accepted manuscript on the academic-researcher's online public profile pages such as on ResearchGate, Academia.edu and Linkedln, while providing the article citation tracking. A feature of BioMed Central publishing house is the ability of providing the “most viewed” and “highly cited” articles published within their remits and allow readers to comment on the articles [16]. Other publishers also enable readers to comment on articles, such as Frontiers, Nature Publishing Group and PLoS.

4.1.1. Altmetric

Altmetric assesses the research impact by focusing on the research's online activity by means of how such research is being shared and discussed within academic community and beyond while incorporating the traditional citation tracking [3]. The Altmetric score considers the number of times a specific article was mentioned online in blogs, newspapers as well as on popular social media platforms such as Facebook and Tweeter. The score rates the ‘mentions’ by order of importance, so a mention in a newspaper is given a higher score than a mention in a tweet [19]. Caution needs to be present when using this metric since the score may not necessarily reflect the true importance of an article in the academic community but the high score may be contributed to the viral spread through the public.

4.1.2. Plum analytics

Considering the shift from printed articles to online based articles with the amalgamation of social media, blogs and scholarly online sources, lead to the development of an ‘Altmetric’ provider Plum Analytics® [20]. This product was created with the aim to gather metrics about a particular research from multiple online sources and activities (e.g. article downloads, views, favorites, watchers, blog posts, Wikipedia links, likes, shares, tweets, citation indexes) that will enable the academic-researcher understand how their research is being used, communicated and what impact it is having within the online community [21]. This product is being integrated into several Elsevier research products and is being made available to academic-researchers that utilize these services [21,22].

4.1.3. Academic networks

Another tool of ALM are academic networks such as ResearchGate.net (https://www.researchgate.net) and Academia.edu (https://www.academia.edu). The academic networks enable academic-researchers to share different types of academic and research output, provided there are no copyright restrictions, onto their personal profile within the academic network platform. These networks score the academic-researcher and provides a metric which complements the traditional metrics [2,18].

4.1.3.1. ResearchGate. This network has a measurement metric, the ‘RG score’, which is a calculation of an author's scientific reputation based on how peers receive the author's work on ResearchGate. The RG score depends also on the author's activity on ResearchGate such as creating a project and updating projects, asking questions or responding to another researcher's question, following researchers as well as commenting or recommending peer's research, projects and questions [23]. ResearchGate provides a comparable individualised percentile value, based on RG scores, of an author as compared (through RG scores) to the rest of the ResearchGate community. The more traditional *h*-index metric is also portrayed on the author's scores page. Furthermore ResearchGate provides the author with a summary of the number of research items being showcased on the network by the author and the amount of reads generated and the amount of citations generated over a timeline.

5. Journal metrics

A journal is a publication composed of a number of articles written by different authors and is released periodically. Journal metrics rank the journal's overall contents and thus permits comparison with other journals [24]. There are several types of journal metrics.

5.1. Journal impact factor

A commonly utilized journal metric is the 'Journal Impact Factor' (IF), which assesses the articles citation frequency of a journal's papers within other journals. The citation impact is then compared between two journals based on the Web of Science citation index database [2,25,26]. It scores a journal impact over a particular year by measuring the mean number of citations received by articles published in the journal in the preceding 2 years [27]. Therefore an example of an Impact Factor is; Impact Factor (2016) = (citations 2014 + citations 2015) / (articles 2014 + articles 2015) [2,8]. The citations considered for the Impact Factor includes not only original articles but also reviews, reports, letters to the editor as well as editorials [2].

The journal impact factor defines the impact and significance of that academic journal within its field of research. Therefore a high impact journal will contain articles that eventually garner a large number of citations. As a rule, the impact factor follows a 80–20 rule, where the top 20% of the published articles would contribute to 80% of the journal's total citations [2]. Therefore the Impact Factor measure is a proxy for a journal's prestige and redounds on the authors whose papers are published within that journal [27].

5.2. h5-index

Another type of journal metric is the *h5-index*. This index is based on articles that were published by a journal over a period of 5 years, where the *h* is the highest number of articles that have each been cited *h* times. Therefore a journal with an h5-index of 50 means that 50 published articles have had 50 or more citations over a 5-year period [24].

5.3. Eigenfactor™ metrics

This metric is composed of two scores (Eigenfactor™ score and Article Influence score) that together aim to improve the evaluations of scholarly archives by utilizing the Eigenfactor Algorithm.

5.3.1. Eigenfactor™ score

This score measures the importance of the journal in the academic community by basing its calculation on scholarly citation network, where top journals will have greater citations than low-tiered journals. The Eigenfactor™ score counts the total number of citations over a 5-year period [19]. The advantage of the Eigenfactor™ score over the Impact Factor is that the former weights the citations depending on the journal's quality while also eliminating self-citations, considers citations to journals in both science and social science and weights each reference depending on the researcher's reading time of the journal [2].

5.3.2. Article influence score

This score measures the influence of a journal based on each article published. This is measured by dividing the journal's Eigenfactor™ score by the total number of articles published within that journal. This score is then normalized to achieve the average Article Influence Score [19]. When the score is more than 1, this indicates that each of the journal's article have an above-average influence, whereas a score less than 1 indicates that the articles have a below- average influence [2].

5.4. SCImage journal rank

The SCImage Journal Rank emphasizes on publications published in high-impact journals rather than on the number of citations per publication. This metric can be used to compare between journals as it ranks the journals in accordance to their average prestige per article [28].

5.5. Source normalized impact per paper (SNIP)

SNIP metric considers the subject field of the journal and how well the journal covers the subject field literature as well as counts the frequent author citation to other papers [29]. Therefore SNIP calculates the ratio between the journal's citation number per paper to the citation potential in its subject area. The metric can be used to rank and compare journals between different research fields and is essential for academic-researchers working in multidisciplinary fields [2].

6. Conclusion

All academics should have a good understanding of the various research metrics in order to evaluate their impact and excel within the academic world. Developing high impact articles in their field of research is the first step to establish a high citation tracking. Authors with a large number of citations in a particular field will be recognized as experts in the area, and this may lead to invitations for review articles or editorials, as well invitations to speak at academic meetings. Publishing in high impact journals will further enhance an author's academic reputation; in fact it is more appropriate to perform quantitative metric in conjunction with other metric types in order to showcase the global impact of an academic-researcher. Unfortunately no single metric completely evaluates the impact of an academic-researcher's work; such metric is still to be developed.

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The inspiration for this series of papers arises from the international WASP (Write a Scientific Paper course) [30,31]. A wide variety of related topics that are also covered in WASP will also be discussed as part of this ongoing series of medical education papers in *Early Human Development*.

Conflict of interest statement

There are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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