

Altmetrics: Six Years of Changing Scholarly Appraisal

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Abstract

The last decade of the 20th century was marked by Internet and communication revolution, which added new dimensions to information and knowledge society. The scholarly community of today's knowledge society communicates between each other in a non-traditional way besides the traditional way. The arrival of web 2.0 and scientists' gradual use of said platforms as tools for the diffusion and receipt of scientific information and with part of the scientific community relatively receptive, that scientometrics 2.0 began to be discussed. Another milestone in the era of scientometrics 2.0 is the 'Wikimetrics'. After the 'Wikimetrics' next footprint comes with the advent of 'Article-level metrics'. Article-level metrics followed by Altmetrics, i.e. Alternative Metrics. The term altmetrics was coined by Jason Priem in 2010, as a generalization of article level metrics, and rooted in the twitter #altmetrics hashtag. Although altmetrics usually functions as metrics about articles, but it can also be applied to people, journals, books, data sets, presentations, videos, source code repositories, web pages, etc. Altmetrics does not cover just citation counts, but also other aspects of the impact of a work, such as how many data and knowledge bases refer to it, article views, download, or mentions in social media and news media. In this paper, the altmetric scores of top-cited altmetric papers are presented. Also, the contents of the same are analysed and presented. It is interesting to note that all top-cited papers appeared from diverse subject domains, i.e. big data in science, biological science, medical science, research methodology, social studies, citation studies and scientometrics, different issues involved in social networking et al. The subject domain altmetrics is a highly interdisciplinary field covering all major areas of universe of knowledge. This study reflects other notable feature, i.e. the discord between traditional metric (times cited) and modern metric (altmetric score).

Keywords: Altmetrics, Altmetric Score, Article-Level Metrics, AS/TC Ratio, Citation Count, Content Analysis, Informetrics, Open Source Metrics, Scholarly Appraisal, Scientometrics, Wikimetrics

1. Introduction

Evaluation of scholarly performance is an essential way to maintain quality in education and research. Quality maintenance ensures standard that is the most important criteria. Scholarly communication is the process of academics', scholars' and researchers' sharing their findings so that they are available to the wider community and beyond. Borgman¹ described scholarly communication as *the study of how scholars in any field use and disseminate information through formal and informal channels. The study of scholarly communication includes*

the growth of scholarly information, the relationships among research areas and disciplines, information needs and uses of individual user groups, and the relationships among formal and informal method of communication. The advancement of Internet and the World Wide Web had a major influence on scholarly communication. The mode of scholarly communication has drastically changed today with the introduction of interactive Web that is Web 2.0. Web 3.0..... With web 2.0, scientists have platforms such as blogs, You Tube, and Facebook that enable them to disseminate their studies and views to the wider public, as well as to interact and have discussions with the public².

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Scientists are increasingly visible on the web and the social media. They are discussing, sharing, and bookmarking scholarly articles online and discussing on their research topics in the social forum in a large numbers. As scholarly communication disseminate through formal and informal channels, the impact measurements of these processes have measured in consideration of both formal and informal discussions. In this way the impact measuring techniques that is the world of metric sciences has turned into different dimensions and is developing incessantly in different subject domain. Besides classical metrics that is the 'Bibliometrics', 'Scientometrics', 'Informetrics' etc., there are several other metrics used today that include social networking effects and open source communication model, for instance, 'wiki metrics', 'open source metrics', 'journal metrics', 'article-level metrics' and the newcomer in the field, the 'Altmetrics' that changed existing ways of scholarly appraisal since 2010, as an alternative non-traditional metrics contrasting traditional citation impact metrics, i.e. impact factor and h-index. The term *altmetrics* was proposed in 2010, as a generalization of article level metrics, and has its roots in the #altmetrics hashtag³. One of the major complains about today's Internet culture is that it's flooded with too much junk. The keyword *bad content* has resulted nearly nine lakhs retrieval in Google on July 31, 2016 indicating it as today's prime threat. The ocean is enormous but made of salt water horrendous to people dying of thirst. If the Internet is conceived as the ocean of the knowledge society, definitely people are dying of thirst for quality content today. It's the time when people are literally drowning in massive content, but that's actually a calamitous lack of quality and an overabundance of non-quality content. It's like probing for a fresh water oasis (quality content) in the middle of mile after mile and gallon after gallon of never ending saltwater (low quality, crappy content). It's true that Internet tries to pluck our favourite rose from the forest. It is thus rather cynic to complain about the crap that's out there. The prime objective should be just to filter information from the galaxy of gigabytes.

2. Brief Background of Metrics

The term metric originated from the Latin word *metricu* and French word *métriqu*, indicating measure for something or any mean of deriving quantitative measurement⁴. This word was first used in 1864⁵. This word envelops number of subject domains, e.g. general relativity under physics, networking, mathematics, software analysis etc. One of the most well-known uses of this word is found as unit of measurement in various subjects and LIS also. Any system

of measurement invariably involves statistics and related techniques, which may be applied in depth to any subject domain to form new subjects like sociometry (application of statistics to social science or sociology), econometrics, educametry, psychometry etc. In the field of library and information science, the applications of quantitative techniques are very popular today. The early works in this subject domain goes back to mid 1920s and the studies involving applications of quantitative techniques to library and bibliographical work are commonly known as *statistical bibliography*. Wittig⁶ discussed about the history of statistical bibliography indicating that the origin of the term could be traced to its first use by Cole and Eales⁷ in 1917 and by Hulme⁸ in 1922. The term "statistical bibliography" signals application of quantitative methods to library and bibliographic works. Ranganathan suggested as early as 1948 at the Aslib conference in Leamington Spa "that it is necessary for librarians to develop "librametry" on the lines of biometry, econometry and psychometry, since many of the matters connected with library work and services involve large number"⁹. The word 'librametry' or 'librametrics' is the couple of two separate words, library and metrics, which indicates application of mathematical models and statistical techniques to evaluate library systems and services. It is well-known fact that any library report comprising either library collection or library services can be picturesquely objective only when presented through statistical techniques. As Rao⁹ commented, "In spite of his early attempt to define the scope of librametry, the subject hardly developed until the early 1970s" and Pritchard¹⁰ used the term 'bibliometrics' in 1969 to describe all studies which seek to quantify the process of written communication. He defined the term as follows, "The definition and purpose of bibliometrics is to shed light on the process of written communication and of the nature and course of a discipline (in so far as this is displayed through written communication) by means of counting and analyzing the various facets of written communication". According to Rao⁹, the concept of bibliometrics in East Europe was known as scientometrics in early seventies. Hood and Wilson¹¹ mentioned that in 1969, Nalimov and Mulchenko¹² coined the Russian equivalent of the term 'scientometrics' ('naukometriya'). The name of this term is self-explanatory and mainly used for the study of all aspects of the literature of science and technology. This term had achieved extensive acknowledgment by the foundation in 1978 of the journal *Scientometrics* by Tibor Braun in Hungary. The word *information* is inbuilt in the term informetrics and information is just like air, that is here, there and everywhere or ubiquitous. In the

context of any subject the concept of information may be conceived as the fundamental building block, because if there is no information, no learning or thinking or knowledge sharing/cultivation process can start. The inbuilt units in the previously discussed three words, i.e. librametrics, bibliometrics and scientometrics are library, bibliography and science respectively. These three words are not as fundamental as information. An instant tally of these three words with information instantly signals the originality or fundamentalism of the word informetrics compared to either librametrics or bibliometrics or scientometrics. The term informetrics was coined by Otto Nacke of West Germany in 1979¹³, while the other three terms were coined in the years 1948 (librametrics) and 1969 (bibliometrics and scientometrics). Although *informetrics* is recent than other three terms, but it is logical to accept it contextually and conceptually more fundamental and preceder to libra-, biblio- and scientometrics. Informetrics may be conceived as a most generalized term that subsumes scientometrics and more specifically bibliometrics. Rajan and Sen¹⁴ from INSDOC (Now NISCAIR), New Delhi, framed the objectives of informetrics in 1985 to be the provision of reliable data for research and development; for policy-making and planning; and for the measurement of institutions, projects, programmes and activities. Brookes¹⁵ in 1989 pointed out that this definition of informetrics is the widest and deepest of the three metrics terms, i.e. biblio-, sciento- and info- metrics. The inception of the concept of informetrics, however unveiled a new horizon to metric sciences.

3. Altmetrics: Brief History

The last decade of the 20th century may be reckoned as the opening gateway to Internet and communication revolution, which added new dimensions to information and knowledge society. The scholarly community of today's knowledge society communicates between each other in a non-traditional way besides the traditional way. The growing pervasiveness of the web is creating an environment in which scholars and other users create new kinds of tracks that reveal once-invisible scholarly activities. Inexorably, the daily work of scholars, like other knowledge workers, is moving online¹⁶. In this context, with the arrival of web 2.0 and scientists' gradual use of said platforms as tools for the diffusion and receipt of scientific information and with part of the scientific community relatively receptive, that scientometrics 2.0¹⁷ began to be discussed. Though the word scientometrics 2.0 coined in

2010, the earlier footstep of this was appeared with the term 'Webometrics', coined by Almind and Ingwersen in the year 1997. 'Webometrics' is defined as "the study of web-based content with primarily quantitative methods for social science research goals using techniques that are not specific to one field of study"¹⁸. Another milestone in the era of scientometrics 2.0 is the 'Wikimetrics'. The term 'Wikimetrics' is considered as the amalgamation of the terms wiki and metrics. It facilitates data analysis of Wiki pages, establishing standardized metrics across the movement and improved workflow between data stakeholders. After the 'Wikimetrics' next footprint comes with the advent of 'Article-level metrics'. Article-level metrics are metrics for measuring the usage and impact of individual research articles. Traditionally the usage and impact of research were evaluated on the basis of bibliometrics or informetrics, which was normally focused on journals, such as the impact factor or immediacy index. Some researcher-level metrics such as the h-index, g-index or i-10 index were developed in the last decade. Article-level metrics, unlike journal or author metrics did not focus on journals or authors but on the individual article. After the Article-level metrics, another new concept 'Altmetrics' comes in this context. 'Altmetrics' are new metrics proposed as an alternative to the widely used journal impact factor and personal citation indices like the h-index, g-index or i-10 index. The term altmetrics was coined by Jason Priem in 2010, as a generalization of article level metrics, and rooted in the twitter #altmetrics hashtag³. Although altmetrics are often thought of as metrics about articles, they can be applied to people, journals, books, data sets, presentations, videos, source code repositories, web pages, etc. Altmetrics does not cover just citation counts, but also other aspects of the impact of a work, such as how many data and knowledge bases refer to it, article views, download, or mentions in social media and news media. Altmetrics are a very broad group of metrics, capturing various parts of impact a paper or work can have.

4. Review of Literature

Though the concept of 'Altmetrics' is new but some work has already been done. The features of altmetric tools in general (Zhang, 2012) and their validation as a sources of impact assessment has been investigated in some studies¹⁹. Li, Thelwall and Giustini²⁰ studied the strengths, weaknesses and usefulness of two reference management tools for research evaluation. Their findings showed that compared to CiteULike, Mendeley seems

to be more promising for future research evaluation. Wouters and Costas²¹ compared features of 16 Web based tools and investigated their potentials for impact measurement for real research evaluation purposes. They concluded that although these new tools are promising for research assessment, due to their current limitations and restrictions, they seem to be more useful for self-analysis than for systematic impact measurement at different levels of aggregation. Another popular reference manager, Zotero, has received less study. Papers and Read Cube are newer, smaller reference managers. Connotea and 2Collab both dealt poorly with spam; both have now closed²². Before the curtain raiser of altmetrics there are several studies have been conducted to judge the validity of different types of alternative tools for impact assessment. Lewsion²³ tracked mass media mentions of scholarly articles, finding little relations between journal citation rates and citedness by major news outlets, suggesting that this is a legitimately distinct form of impact. However, other work shows that these mentions seem to affect citation rates, implying that the two are not completely unconnected²⁴. Till now, the Wikipedia is perhaps the one of the most exciting leader project of 21st century. Jimmy Wales and Larry Sanger launched Wikipedia on January 15, 2001 and just after fourteen years of beginning i.e in February 2015, The New York Times reported that Wikipedia is ranked fifth globally among all websites. For much of the world, especially students, Wikipedia is the first stop for information. Therefore influencing 'wikipedia' means influencing the world in a profound way^{25,26}. Nielsen²⁷ has shown that citations in Wikipedia correlate well with data from the Journal Citation Reports, establishing a relationship between impact on Wikipedia and in more traditional contexts. Prime et al²⁸ reported that around 5% of PLoS articles are cited in Wikipedia, and report correlations between 0.1 and 0.4 between normalized Wikipedia citations and traditional citations, depending on the journal. Twitter presents a rich source of data, but a difficult one for investigators of scholarly impact. Twitter is heavily used by some scholars but non scholars make up the bulk of Twitter users¹⁶. For this reason, near zero correlation between tweets and citations found in the PLoS dataset, suggests that the high visibility of PLoS attracts many nonscholarly readers²⁸. On the other hand, studies found that there is a distinct link between tweeting and citation. In spite of these more research is needed that delineates the identity of Twitter users. As social media are becoming the strong field of scientific discourses several studies have been conducted with the social media to determine the impact of an article²⁹. Shuai, Pepe and Bollen³⁰ examined the reactions

of scholars to the newly submitted preprints in arXiv.org, showing that social media may be an important factor in determining the scientific impact of an article. Social blogs are very much popular for scientific conversations. In this context, "scholarly blogging" is distinguished from its popular counterpart by the expertise and qualifications of the blogger. While a useful distinction, this is inevitably an imprecise one¹⁶. Blogging in the academic field has grown steadily in visibility; academics have blogged their dissertations³¹, and the ranks of academic bloggers contain several field medalists, Nobel laureates, and other eminent scholars³². In spite of that there are few altmetrics have been conducted on the basis of scholarly blogging. Extant Research, however, has shown that blogging shares many of the characteristics of more formal communication, including a long-tail distribution of cited articles^{33,34}. Although science bloggers can write anonymously, Shema and Bar-Ilan³⁴ studied that most blog under their real names. The count of PDF downloads is also considered an important altmetric tool and several studies have been conducted investigating article downloads and their relation to later citation. Several researchers have found that downloads predict or correlate with later citation³⁵. Shuai, Pepe & Bollen³⁰ showed that downloads and twitter citations interact, with Twitter likely driving traffic to new papers, and also reflecting reader interest. Though these researches are conducted on downloads but most of the research on downloads today does not isolate HTML views in PDF downloads. Some other studies have focused whether altmetrics can be used as predictor of citations. For example in case of F1000, it has been found that recommendations have a relatively lower predictive power in indicating high citedness as compared to journal citation scores³⁶.

Several studies have been conducted to mention that Altmetrics is the new data source and investigated the association between altmetrics and citation impact. However, there are very few studies have been conducted for the content analysis of research articles on altmetrics. As the child Altmetrics complete its six years from the birth i.e 2010, this study reflects the ways altmetrics research is going on and which areas of altmetrics are popular to the researchers for their topic.

5. Growth of Literature

Figure 1 shows year wise variation in no. of altmetrics articles published from worldwide since 2011 to 2015. In all, 388 articles came out over this time span. The number of articles in the year 2011 was only 6, while that in 2015 was 388. The lowest no. of articles published in the year

2011 and it is obvious as the concept ‘Altmetrics’ came out in the year 2010. Figure 2 shows year wise variation of percentage of articles. From the figure it is reflected that in 2013 to 2014, the percentage of growth of literature is highest i.e 31.7%. But the figure is also reflected that in 2015 total numbers of published articles go down compare to 2014. Figure 3 shows year-wise distribution of cumulative no. of articles which is steady in number. The number of articles published along with corresponding fluctuations, percentages and cumulative numbers are presented in Table 1. It shows that fluctuation of published articles is negative in the year 2015. So the conclusion is that there is slight decrease in the growth of published literature on altmetrics.

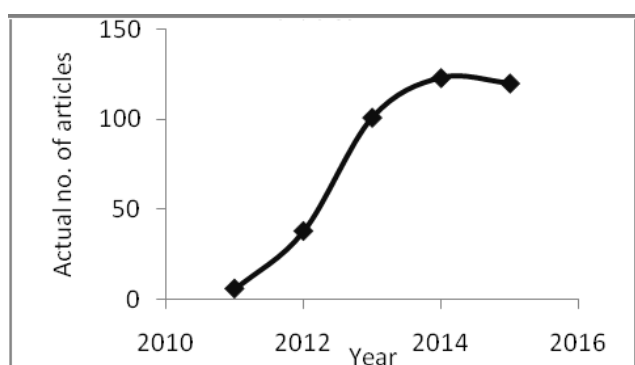


Figure 1. Year-wise variation of No. of articles.

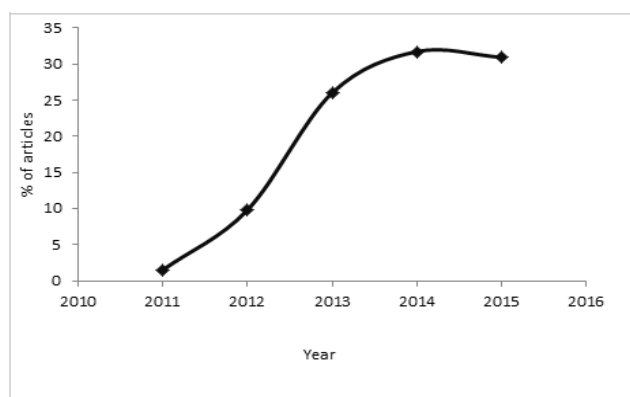


Figure 2. Year-wise variation of percentage of articles.

Table 1. Year-wise variation of Altmetrics articles since 2011

Sl. No.	Year	No. of articles	% of articles	% of fluctuation	Cumulative No. of articles
1	2011	6	1.5		6
2	2012	38	9.8	533.3	44
3	2013	101	26.0	165.8	145
4	2014	123	31.7	21.8	268
5	2015	120	30.9	-2.44	388
Total		388			

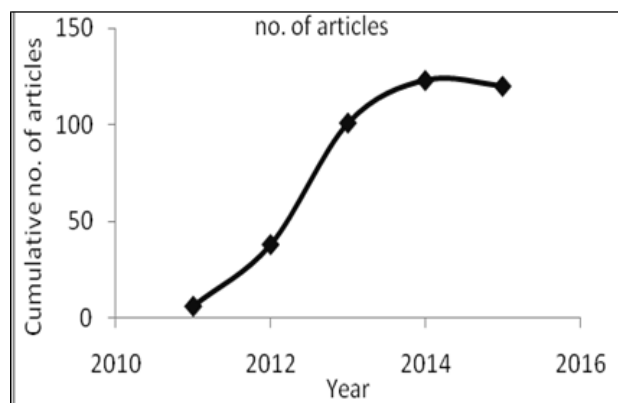


Figure 3. Year-wise distribution of cumulative no. of articles.

6. Objectives

The major purpose of this research is to find out current trend in altmetrics research and to analyse content and keywords of highly cited articles on altmetrics. The highly cited articles signals popular or heavily circulated papers, and their contents indicate popular core and allied subject areas associated with the domain of altmetrics. Actually It is a highly interdisciplinary field and embraces numbers of areas. The content analysis would be carried out by analysing the abstracts and the keywords (both author-assigned and index keywords will be considered). Besides, the altmetric scores of all highly-cited articles would be found out and compared with the number of citations received to see, whether these two indicators are in consonance.

7. Scope and Methodology

The data for the study of growth of literature in altmetrics is collected from SCOPUS database. In all 388 articles was retrieved from the database. For downloading the data the search term was “Altmetrics” or “Alternative Metrics” or “altmetrics” or “alternative metrics”. As this paper actually focused on the content analysis of highly cited articles on altmetrics, the growth of literature on altmetrics have to be studied. For the content analysis the retrieved articles were arranged in respect of times cited (Highest to Lowest). The article which received at least 10 citations consider as highly cited articles among the all retrieved articles from the database. By this method all around 38 articles were above the cut off mark of 10 citations achieved. Among this 38 articles, the highest citation achieved by an article was 69 and as obvious lowest was 10. The content analysis of these 38 articles has been done through the analysis

of abstracts. From the abstracts of the articles following parameters are considered for study. These are: 1. Article Type; 2. Research Type; 3. Object of Study; 4. Discussed feature of altmetrics; 5. Present of absent of quantitative discussions; 6. Target Audience; 7. Keywords, and 8. Subject Domain. These parameters are collected from abstracts and collated for the content analysis.

8. Results and Analysis

The titles, authors, sources, publication years and times cited of top-cited 38 ranked papers are presented in Table 1 (Appendix). The ranking is done on the basis of times cited. The altmetric scores with necessary altmetric indicators and times cited are presented in Table 2 (Appendix).

Table 2. Keyword analysis of top-cited 38 articles

Sl. No.	Rank by Frequency	Keywords (Author Keywords + Index Keywords)	Frequency
1	1	Human	13
2	1	Internet	13
3	2	Information dissemination	9
4	2	Social media	9
5	3	Article	8
6	3	Medical research	8
7	3	Peer review	8
8	3	Publishing	8
9	3	Research	8
10	4	Bibliometrics	7
11	4	Citation analysis	7
12	4	Not available	7
13	4	Review	7
14	5	Priority journal	6
15	6	Biomedicine	5
16	6	Blogging	5
17	6	Publication	5
18	6	Social network	5
19	7	Information service	4
20	7	Medical literature	4
21	7	Quality control	4
22	7	Research evaluation	4
23	7	Scientific literature	4
24	8	Access to information	3
25	8	Altmetrics	3
26	8	Animal	3
27	8	Biomedical research	3
28	8	Communication	3
29	8	Computer program	3
30	8	Database	3
31	8	Information processing	3
32	8	Interpersonal communication	3
33	8	Knowledge management	3
34	8	Online system	3
35	8	Science	3
36	8	Scientist	3
37	8	Software	3

The ratio of altmetric score to times cited (AS/TC) is also shown in Table 2 (Appendix), reveals a maximum value 35.9 for fourth ranked paper and a minimum value of zero for four papers. The highest value 35.9 is followed by 26.2, 16.8, 14 and 11.2, while other values are less than ten. The ratio AS/TC thus varies over zero to 35.9 and not a constant. Such wide variation indicates that Altmetric Score (AS) is not directly proportional to Times Cited (TC), or it may also be said that the traditional metric TC is not in consonance with the modern metric AS. They change independently with each other. The analysis of different characteristic features of the articles is presented in Table 3 (Appendix).

Table 3. Authorship pattern

Authorship	Frequency
Single author	7
Two authors	12
Three authors	11
Four authors	3
Five authors	1
Six authors	1
Ten authors	1
> 10 authors	2

The author-assigned and indexing keywords are presented in Table 2, which shows 37 different keywords ranked from 1 to 8 in accordance with respective frequencies. The top-ranked keywords are human and Internet (frequency 13 each) followed by information dissemination, social media, article, medical research, peer review, publishing, research et al. The authorship pattern presented in Table 3 shows that there is 7 single-authored papers followed by 12 two-authored and 11 three-authored papers. Only one paper was contributed by ten authors and two papers were contributed by more than ten authors. The top contributing high-cited author is M. Thelwall with frequency 10 followed by S. Haustine, J. Bar-Ilan, R. Costas et al. It is observed that, PLoS One is the highest contributing journal with frequency 6 followed by Journal of the Association for Information Science and Technology (frequency 5), Scientometrics (frequency 5) and Nature (frequency 3). Other 19 journals contributed one article each. Of the 38 top-cited items, 25 papers are research articles, 8 papers are review articles, 2 papers are pre-prints, and there are three items belong to editorial, letter and note respectively.

9. Conclusion

In this paper, the altmetric scores of top-cited altmetric

papers are presented. Also, the contents of the same are analysed and presented. It is interesting to note that all top-cited papers appeared from diverse subject domains, i.e. big data in science, biological science, medical science, research methodology, social studies, citation studies and scientometrics, different issues involved in social networking et al. The subject domain altmetrics is a highly interdisciplinary field covering all major areas of universe of knowledge. This study presents comparative layout between traditional metric (times cited) and modern metric (altmetric score).

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Appendix

Table 1. Top-cited 38 articles with ranks 1-21

S. No	Rank by Times Cited	Titles of the top cited (≥ 10) articles	Authors	Sources	Year of Publication	Times Cited
1	1	Do Altmetrics Work? Twitter and Ten Other Social Web Services	Thelwall M., Haustein S., Lariviere V., Sugimoto C.R.	PLoS ONE	2013	69
2	2	Altmetrics: Value all research products	Piowar H.	Nature	2013	46
3	3	Validating online reference managers for scholarly impact measurement	Li X., Thelwall M., Giustini D.	Scientometrics	2012	43
4	4	An Introduction to Social Media for Scientists	Bik H.M., Goldstein M.C.	PloS Biology	2013	38
5	5	The Altmetrics Collection	Priem J., Groth P., Taraborelli D.	PloS ONE	2012	31
6	6	Research blogs and the discussion of scholarly information	Shema H., Bar-Ilan J., Thelwall M.	PloS ONE	2012	30
7	7	Scholarship: Beyond the paper	Priem J.	Nature	2013	28
8	7	Applying social bookmarking data to evaluate journal usage	Haustein S., Siebenlist T.	Journal of Informetrics	2011	28
9	8	Tweeting biomedicine: An analysis of tweets and citations in the biomedical literature	Haustein S., Peters I., Sugimoto C.R., Thelwall M., Lariviere V.	Journal of the Association for Information Science and Technology	2014	27
10	8	How the Scientific Community Reacts to Newly Submitted Preprints: Article Downloads, Twitter Mentions, and Citations	Shuai X., Pepe A., Bollen J.	PloS ONE	2012	27
11	9	Deep impact: Unintended consequences of journal rank	Brembs B., Button K., Munafo M.	Frontiers in Human Neuroscience	2013	25
12	10	Moving from impact to influence: Measurement and the changing role of medical journals	Nallamothu B.K., Luscher T.F.	European Heart Journal	2012	23
13	11	Bibliometrics and research data management services: Emerging trends in library support for research	Corrall S., Kennan M.A., Afzal W.	Library Trends	2013	20

S. No	Rank by Times Cited	Titles of the top cited (≥ 10) articles	Authors	Sources	Year of Publication	Times Cited
14	12	A decadal view of biodiversity informatics: challenges and priorities	Hardisty A., Roberts D.	BMC Ecology	2013	19
15	13	An online database for plant image analysis software tools	Lobet G., Draye X., Perilleux C.	Plant Methods	2013	18
16	13	Open drug discovery teams: A chemistry mobile app for collaboration	Ekins S., Clark A.M., Williams A.J.	Molecular Informatics	2012	18
17	13	The most-cited law review articles of all time	Shapiro F.R., Pearse M.	Michigan Law Review	2012	18
18	14	Research Blogging: Indexing and Registering the Change in Science 2.0	Fausto S., Machado F.A., Bento L.F.J., Iamarino A., Nahas T.R., Munger D.S.	PloS ONE	2012	17
19	15	How well developed are altmetrics? A cross-disciplinary analysis of the presence of 'alternative metrics' in scientific publications	Zahedi Z., Costas R., Wouters P.	Scientometrics	2014	16
20	15	Do blog citations correlate with a higher number of future citations? Research blogs as a potential source for alternative metrics	Shema H., Bar-Ilan J., Thelwall M.	Journal of the Association for Information Science and Technology	2014	16
21	15	Altmetrics: Rethinking the Way We Measure	Galligan F, Dyas-Correia S.	Serials Review	2013	16
22	16	Improving the culture of interdisciplinary collaboration in ecology by expanding measures of success	Goring S.J., Weathers K.C., Dodds W.K., Soranno P.A., Sweet L.C., Cheruvilil K.S., Kominoski J.S., Ruegg J., Thorn A.M., Utz R.M.	Frontiers in Ecology and the Environment	2014	15
23	16	F1000 recommendations as a potential new data source for research evaluation: A comparison with citations ludo	Waltman L., Costas R.	Journal of the Association for Information Science and Technology	2014	15
24	16	Social Media Release Increases Dissemination of Original Articles in the Clinical Pain Sciences	Allen H.G., Stanton T.R., Di Pietro F, Moseley G.L.	PloS ONE	2013	15
25	16	Git can facilitate greater reproducibility and increased transparency in science	Ram K.	Source Code for Biology and Medicine	2013	15
26	16	Peer review: Recent experience and future directions	Ware M.	New Review of Information Networking	2011	15
27	17	Mendeley readership altmetrics for the social sciences and humanities: Research evaluation and knowledge flows	Mohammadi E., Thelwall M.	Journal of the Association for Information Science and Technology	2014	14
28	17	Journal impact evaluation: A webometric perspective	Thelwall M.	Scientometrics	2012	14

S. No	Rank by Times Cited	Titles of the top cited (≥ 10) articles	Authors	Sources	Year of Publication	Times Cited
29	18	Altmetric: Enriching scholarly content with article-level discussion and metrics	Adie E., Roe W.	Learned Publishing	2013	13
30	19	Altmetrics: New indicators for scientific communication in web 2.0	Torres-Salinas D., Cabezas-Clavijo A., Jimenez-Contreras E.	Comunicar	2013	12
31	19	Research impact: Altmetrics make their mark	Kwok R.	Nature	2013	12
32	20	Ready to put metadata on the post-2015 development agenda? Linking data publications to responsible innovation and science diplomacy	Ozdemir V., Kolker E., Hotez P.J., Mohin S., Prainsack B., Wynne B., Vayena E., Coskun Y., Dereli T., Huzair F., Borda-Rodriguez A., Bragazzi N.L., Faris J., Ramesar R., Wonkam A., Dandara C., Nair B., Llerena A., Kilic K., Jain R., Reddy P.J., Gollapalli K., Srivastava S., Kickbusch I.	OMICS A Journal of Integrative Biology	2014	11
33	21	Disciplinary differences in Twitter scholarly communication	Holmberg K., Thelwall M.	Scientometrics	2014	10
34	21	Top trends in academic libraries: A review of the trends and issues affecting academic libraries in higher education	NA	College and Research Libraries News	2014	10
35	21	Academia.edu: Social network or academic network	Thelwall M., Kousha K.	Journal of the Association for Information Science and Technology	2014	10
36	21	Assessing non-standard article impact using F1000 labels	Mohammadi E., Thelwall M.	Scientometrics	2013	10
37	21	Improving data and knowledge management to better integrate health care and research	Cases M., Furlong L.I., Albanell J., Altman R.B., Bellazzi R., Boyer S., Brand A., Brookes A.J., Brunak S., Clark T.W., Gea J., Ghazal P., Graf N., Guigo R., Klein T.E., Lopez-Bigas N., Maojo V., Mons B., Musen M., Oliveira J.L., Rowe A., Ruch P., Shabo A., Shortliffe E.H., Valencia A., van der Lei J., Mayer M.A., Sanz F.	Journal of Internal Medicine	2013	10
38	21	An analysis of high impact scholarship and publication trends in blended learning	Halverson L.R., Graham C.R., Spring K.J., Drysdale J.S.	Distance Education	2012	10

Table 2. Altmetric scores and times-cited with ratios (AS/TC) of top-cited 38 articles

S. No.	Rank by Times Cited	Altmetric Indicators									Alt Score (AS)	Times Cited (TC)	AS/TC
		Viewed	Discussed				Saved		Recom- mended				
			Blog	Facebook	Twitter	Google+	Cite U Like	Men- deley		Con- notea			
1	1	22069	8	7	264	5	21	335		246	69	3.6	
2	2	14723	28	9	305	13	24	266		228	46	5.0	
3	3	18	3	0	28	0	22	254		34	43	0.8	
4	4	156952	30	96	1971	45	27	558		1365	38	35.9	
5	5	12105	2	2	41	1	3	148		37	31	1.2	
6	6	29481	22	5	269	12	27	174		288	30	9.6	
7	7	40672	16	14	633	39	12	197		469	28	16.8	
8	7	453	0	0	6	0	11	40		3	28	0.1	
9	8	108	6	2	226	0	5	113		202	27	7.5	
10	8	21053	6	3	186	7	3	242		131	27	4.9	
11	9	88460	23	40	798	61	5	365		655	25	26.2	
12	10	6	0	1	3	0	0	11		3	23	0.1	
13	11	67	1	0	5	0	0	10		11	20	0.6	
14	12	148	3	2	48	1	3	158		45	19	2.4	
15	13	74	1	0	38	0	1	42		31	18	1.7	
16	13	30	3	0	17	0	0	26		32	18	1.8	
17	13	NA	NA	NA	NA	NA	NA	NA		NA (~0)	18	0.0	
18	14	3438	0	1	3	0	1	10		2	17	0.1	
19	15	62	0	0	24	0	3	137		10	16	0.6	
20	15	127	7	1	74	0	4	79		67	16	4.2	
21	15	66	0	0	43	0	5	196		NA (~0)	16	0.0	
22	16	49	3	1	68	0	2	118		51	15	3.4	
23	16	27	0	0	34	0	0	1		10	15	0.7	
24	16	11320	3	3	127	3	0	74		81	15	5.4	
25	16	24621	9	3	197	16	24	195		168	15	11.2	
26	16	684	0	1	0	0	1	30		1	15	0.1	
27	17	370	0	3	0	0	0	114		1	14	0.1	
28	17	NA	0	0	0	0	2	49		NA (~0)	14	0.0	
29	18	2309	0	0	33	0	3	79		18	13	1.4	
30	19	12031	3	1	0	0	1	149		20	12	1.7	
31	19	NA	6	3	246	4	6	98		168	12	14.0	
32	20	NA	0	0	4	0	0	19		4	11	0.4	
33	21	NA	0	2	46	0	2	89		26	10	2.6	
34	21	NA	NA	NA	NA	NA	NA	NA		NA (~0)	10	0.0	
35	21	NA	0	0	18	1	3	67		16	10	1.6	
36	21	NA	0	0	1	0	0	59		1	10	0.1	
37	21	NA	0	1	3	0	2	37		1	10	0.1	
38	21	603	0	0	7	0	0	89		5	10	0.5	

Table 3. Analysis of different characteristics of top-cited 38 articles

S. No.	Rank by Times Cited	Art. Type	Research Type	Object of Study	Which Characteristics feature of Altmetrics or Metrics is discussed?	Presence of Quantitative Discussion	Target Audience	Subject Domain
1	1	RA	Case Study-Comparative Analysis	Journal Article	Discussed in social sites	Yes	Researchers	Metric Study
2	2	RA	Case Study	Funding for Research Projects	Discussed in social sites	Yes	Policy Makers, Researchers,	Research Methodology
3	3	RA	Comparative Study	Journal Article	Saved in Mendeley and Cite U Like	Yes	Researchers, Publishers	Impact Study
4	4	RA	Case Study	Journal Article	Discussed in social sites	No	Policy Makers, Researchers	Big data in science
5	5	RA	Comparative Study	Journal Article	Discussed in social sites	No	Policy Makers, Researchers	Citation studies
6	6	Rev. Article	Not Applicable	Research Blogs	Discussed in blogs	No	Researchers, Publishers	Social Media Study-Blog Analysis
7	7	Note	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
8	7	RA	Experiment-Bookmarking Analysis	Journal Article	Saved- Bookmarking in Cite U Like, Connotea, Bibsonomy	Yes	Researchers, Publishers	Web 2.0 – Social Bookmarking
9	8	RA	Experiment-Tweets Analysis	Journal Article	Discussed-Twitter Analysis	Yes	Researchers	Social Media Based Metrics
10	8	RA	Comparative Study	Journal Article	Discussed-Twitter; Downloads	Yes	Researchers	Impact Study
11	9	Rev. Article	Not Applicable	Journal Article	None	No	Researchers	Scientific impact study
12	10	Rev. Article	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
13	11	RA	Survey	Bibliographic and data support service	Not mentioned	No	Librarians and Researchers	Bibliographic Services
14	12	Letter	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
15	13	RA	Experiment	Software	None	No	Researchers	Computer Science-Image Analysis Software
16	13	RA	Applied Research	Research Topics	Discussed-Twitter	No	Researchers	Computer Science-Research Topic Aggregator app

S. No.	Rank by Times Cited	Art. Type	Research Type	Object of Study	Which Characteristics feature of Altmetrics or Metrics is discussed?	Presence of Quantitative Discussion	Target Audience	Subject Domain
17	13	Rev. Article	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
18	14	Rev. Article	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
19	15	Article in Press	Experiment	Journal Article	All Altmetrics indicators	Yes	Researchers	Metric Study-Statistical Application
20	15	RA	Experiment	Journal Article	Discussed in blog	Yes	Researchers, Publishers	Impact Study
21	15	RA	Experiment	Not Mention	None	No	Researchers	Metrics Study
22	16	RA						
23	16	RA	Experiment-F1000 recommendations analysis	Journal Article	Recommendation	Yes	Researchers	Impact Study
24	16	RA	Experiment	Journal Article	Discussed in social Media	Yes	Researchers	Social Media Metrics
25	16	RA	Experiment	Git-Version Control System	None	No	Researchers	Computer Science
26	16	Rev. Article	Not Applicable					
27	17	RA	Experiment-Comparative Study	Journal Articles	Saved in Mendeley	Yes	Researchers	Metrics Study
28	17	RA	Experiment-Evaluation Study	Journal Articles	Downloads	Yes	Researchers	Impact Study
29	18	RA	Experiment	Journal Articles	Discussed and Shared	Not clearly reflected	Researchers and Publishers	Altmetrics
30	19	RA	Experiment-Comparative Study	Journal Articles	Discussed	Yes	Researchers	Altmetrics
31	19	RA	No Data	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
32	20	Rev. Article	Not Applicable					
33	21	Article in Press	Experiment	Journal Articles	Discussed-Twitter	Yes	Researchers	Computer Science-Microblogging
34	21	Rev. Article	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
35	21	RA	Experiment	Users of Academic Social Networking Sites	Discussed in Academia.edu	Yes	Researchers	Computer Science-Social Networking

S. No.	Rank by Times Cited	Art. Type	Research Type	Object of Study	Which Characteristics feature of Altmetrics or Metrics is discussed?	Presence of Quantitative Discussion	Target Audience	Subject Domain
36	21	RA	Not Applicable					
37	21	Editorial	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
38	21	RA	Experiment-Analytical Study	Books and Journals	None	No	Researchers	Education-Blended Learning