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Anatomy of Open Access Mathematics Journals

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Abstract

Present study focuses on analysis of open access journals in the field of mathematics based on data collected from DOAJ. It highlights various facets of open access publishing like growth, publishing country, language, publisher, funding model and licensing. Open access journals in mathematics are published in 22 languages from 64 countries by 394 publishers across the globe. It was seen that mathematics OA journals started appearing in DOAJ during 2002; afterwards there has been incessant flow of new titles; 96 new titles were added in 2011. Interestingly developing countries like India, Egypt, and Brazil have embraced OA. English is the most preferred language, Professional's organisations, commercial publishers are involved in OA mathematics publishing, of which Hindawi Publishing Corporation (9%) is the leading contributor. The study also reaffirms pervasive nature of mathematics owing to the existence of large array of multi-disciplinary OA journals. It is seen that majority of OA journals do not charge APC.

Keywords: Bibliometrics, Directory of Open Access Journals, DOAJ, Mathematics, OA Journals, Open Access

1. Introduction

In the present knowledge economy, universal access to relevant information and knowledge is indispensable. Subscription-based access to scholarly information (predominantly print journals) not only poses significant hurdles (pricing and legal restrictions) to free dissemination but also restricts the potential impact of 'research output'. The emergence of Open Access (OA) has challenged the prevailing publishing model. Triggered by information and communication technology (especially Internet), OA has revolutionized scholarly publishing. The mechanism that primarily emerged as 'an alternative publishing model' to manage the 'serial crisis', eventually transformed the scholarly publishing landscape[1]. Different stakeholders of scholarly communication systems (viz. researchers, affiliated institutions, funding agencies, publisher and society) can and will benefit substantially from OA[2]. Despite, faster publication and easier access, OA publication brings increased visibility and usage which leads to greater impact[3] and citation[4]. Thus, Open Access provides far-reaching benefits to users and responds to the limitations of traditional subscription-based publishing system[5].

1.1 Open Access Journals: Philosophy and Facility

In the context of scholarly publishing, Open Access refers to unrestricted free access to digital information. According to Suber[6], OA removes price barriers (subscriptions, licensing fees, pay-per-view fees) and permission barriers (copyright and licensing restrictions) thereby making resources available with minimal restrictions. The essential premise of OA publishing is that society in general benefits from open exchange of ideas and innovations unencumbered from the limitations of subscription costs, licensing fees and copyright restrictions of subscription-based publishing models[7]. Ever since OA publishing came into practice as an alternative mode for dissemination of scholarly information, there has been a plethora of OA journals in all branches of knowledge. Mathematics influences the entire gamut of science and scientific research[8]. Mathematics as a discipline is very mush distinguished for its universality. It has been aptly called as language of science[9]; queen of science[10] and whetstone of intelligence[11]. Evidently, mathematics advances through the creation of new concepts and methods.

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2. Review of Literature

Open Access movement has gained support across the globe with a number of initiatives to promote and facilitate OA. Numerous papers have been published to interpret viewpoints, demonstrate methodological approaches and potential benefits of OA publishing. Here we highlight some subject-specific studies focusing on features of OA literature in major disciplines of humanities[12-14]; natural science[15-22]; social sciences[23-25]; besides a few studies in the field of library and information sciences[26-32] and technology[33-34]. This review is not exhaustive.

3. Scope and Objectives

The present study is limited to mathematics OA journals retrieved from DOAJ. In spite of some criticism[35] DOAJ is preferred because of its comprehensiveness and flexible policy towards accessibility and discoverability[36]. OA journals that are not registered in DOAJ and other titles in other disciplines covered in DOAJ but do not explicitly focus on Mathematics are not included in this study. The specific objectives of the study are as follows:

- To examine the growth of OA journals in mathematics;
- To identify the leading publishers of mathematics OA journals;
- To map distribution of OA journals in different branches of mathematics;
- To show geographical distribution of mathematics OA journals; and
- To determine language-wise distribution of OA journals.

4. Data Collection and Methodology

Keeping in view the aforesaid objectives, a search for: "Journal" and "subject" = 'mathematics' in the *DOAJ* database, was made which yielded 601 hits on 31/12/2014 (Figure 1). Noteworthy is the fact that, the 'subject' data field of *DOAJ* invariably contains more than one 'subject'. Bibliographic attributes of retrieved journals like – title, ISSN, Publisher, country of origin, language, starting date, APC, licensing type, URLs, etc. were collected and transcribed to MS Excel spread sheet. Retrieved URL of individual journals was confirmed by searching the title as phrase query in leading search engines like Google and Yahoo. Access policy (free/ partially free / subscription-based), authoritativeness and functionalities of particular e-journals were further ascertained by visiting the URL of retrieved journals. Relevant bibliometric techniques were applied to analyze the retrieved dataset objectively.

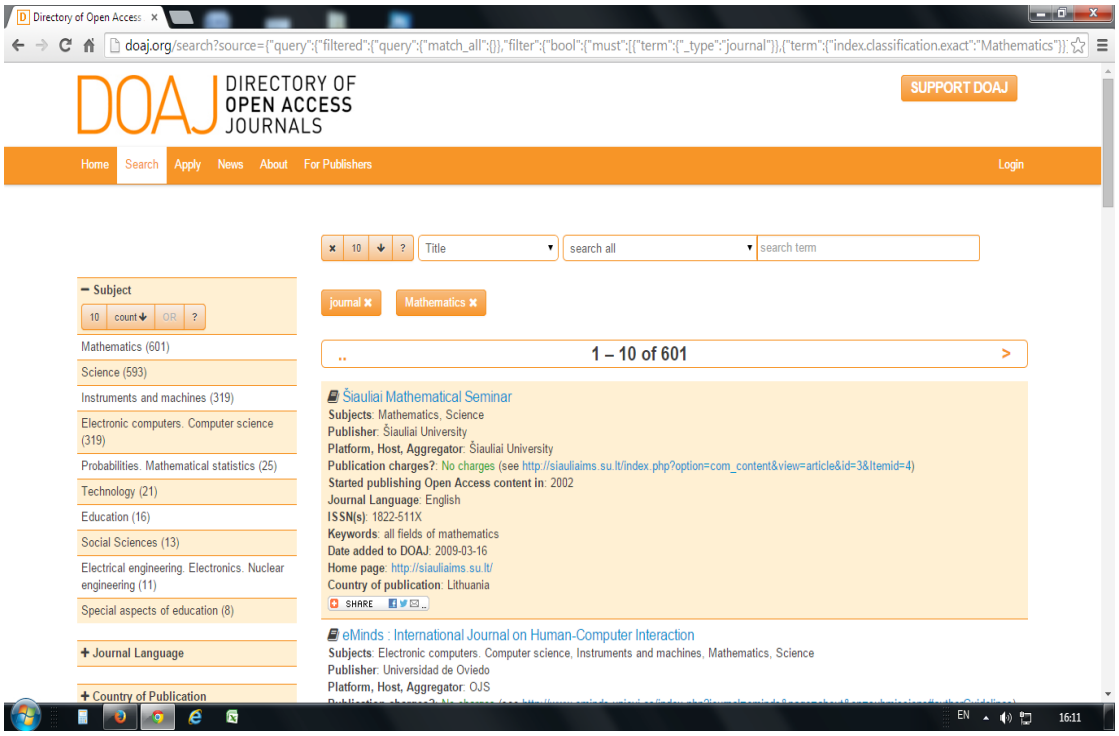

Figure 1. Search result of DOAJ (as on 31/12/2014).

5. Analysis and Findings

To assess the growth and impact of open access mathematics journals, different bibliometric parameters of journals have been analysed.

5.1 Year-wise Growth of OA Mathematics Journals

Table 1 shows chronological growth of OA journals in mathematics. There were only 4 OA journals in mathematics up to 1980, another 4 new journals appeared in the next decade, another 81 appeared during 1990s. But 21st century has witnessed tremendous proliferation of 308 (51.24%) of mathematics OA journals followed by moderate growth 204 (45%) during 2010s. It is evident that during the last two decades there has been a steady growth of mathematics OA journals. It is also significant, that though maximum growth was recorded during 2000s, the year 2011 shows maximum growth (96) in terms of new journals. Mathematics OA journals started appearing in DOAJ during 2002, when more than 100 OA mathematics journals already existed.

5.2 Country-wise Distribution of OA Journals in Mathematics

Table 2 represents the distribution of OA mathematics journals by country of origin. 64 countries across the world have contributed to publish 601 mathematics OA journals. The top six countries have produced more than

Table 1. Growth of Mathematics OA journals

Decade	Year of Origin	Frequency (Year-wise)	Frequency (Decade-wise)	%	Date of DOAJ appearance	%
Up to 1980	1978	4	4	0.67		
Up to 1990	1981	2	4	0.67		
	1990	2				
1990s	1991	2	81	13.48		
	1992	2				
	1993	7				
	1994	6				
	1995	4				
	1996	9				
	1997	11				
	1998	11				
	1999	11				
	2000	18				
2000s	2001	13	308	51.24		
	2002	15			3	0.50
	2003	13			36	5.99
	2004	19			17	2.83
	2005	23			29	4.83
	2006	35			23	3.83
	2007	29			25	4.16
	2008	36			32	5.32
	2009	62			38	6.32
	2010	63			90	14.98
2010s	2011	96	204	33.97	92	15.31
	2012	65			70	11.65
	2013	39			138	22.96
	2014	4			8	1.33
Total		**601**	**601**	**100.00**	**601**	**100.00**

Table 2. Country-wise distribution of OA Mathematics journals

Rank	Country of Origin	No of Jls	%	Cum. %
1	India	83	13.81	13.81
2	USA	82	13.64	27.45
3	Egypt	58	9.65	37.10
4	Germany	32	5.32	42.43
5	Romania	30	4.99	47.42
6	Spain	17	2.83	50.25
7	Brazil	14	2.33	52.58
8	Canada, Hong Kong & Iran	13 each	2.16 X 3	59.07
9	Japan	12	2.00	61.06
10	Indonesia, Malaysia, Serbia, S. Korea	11 each	1.83X4	68.38
11	France, Italy, UK	10 each	1.66X3	73.38
12	Bulgaria, Pakistan, Poland, Singapore, Switzerland, Turkey	9	1.50X6	82.36
13	Austria, Colombia, Ukraine	6 each	1.00X3	85.36
14	Australia, Finland, Russian Federation, Slovakia	5 each	0.83X4	88.69
15	Chile, Jordan, Mexico, New Zealand, Taiwan	4 each	0.67X5	92.01
16	Croatia, Czech Republic, Hungary, Kosovo, Netherlands, Portugal	3 each	0.50X6	95.01
17	Argentina, Cuba, Georgia, Lithuania, Moldova, Slovenia, UAE & Venezuela	2 each	0.33X8	97.67
18	Another 14 Countries	1 each	0.17X14	100.00
	Total 64 Countries	**601**	**100.00**	**100.00**

half (50.25%) of the total OA journals in mathematics. Significantly, India being a developing nation is the most productive country (marginally overtook USA) in terms of number of OA journals in mathematics. Notably countries like China, UK (11th), France (11th) and Switzerland (12th) are not found among the top countries. Therefore, prevalence of developing countries (India, Egypt and Brazil) is observed in this study which might be a good sign for global OA movement. The observation seems to comply with other studies[37] about country-wise production of OA journals.

5.3 Language of OA Mathematics Journals

Table 3 provides information about the language of OA journals in Mathematics. OA journals in mathematics

Table 3. Language-wise distribution of OA Mathematics journals

Language-wise distribution of OA Mathematics Journals	
Mono-Lingual Journals	**Frequency**
English	509
Spanish	6
Chinese	5
French	2
Portuguese	2
Russian	2
German	1
Croatian	1
	Total = 528 (87. 85%)
Bi-Lingual Journals	**Frequency**
English, French	13
English, Spanish	11
English, German	4
English, Portuguese	4
English, Indonesia	3
English, Italian	3
English, Japanese	3
English, Russian	3
English, Arabic	1
English, Indonesia	1
English, Chinese	1
English, Malay	1
English, Polish	1
English, Romanian	1
English, Turkish	1
	Total = 51(8.49%)
Tri-Lingual Journals	**Frequency**
English, Russian, Ukrainian	5
English, Portuguese, Spanish	4
English, French, German	2
English, Czech, Slovak	1
English, French, Italian	1
English, French, Portuguese	1
English, French, Romanian	1
English, French, Spanish	1
English, Georgian, Russian	1
	Total = 17 (2.83%)
Quadra-Lingual Journals	**Frequency**
English, French, Portuguese, Spanish	2
English, French, German, Russian	2
Total = 4 (0.67%)	
Penta-Lingual Journals	**Frequency**
English, Catalan, Galician, Portuguese, Spanish	1
Total = (528+ 51+ 17+ 4 +1) = 601	

are published in 22 different languages. Out of the total 601 journals, 528 (87.85 %) are monolingual, 52 are bilingual and the rest (21) are multi-lingual. Among 528 monolingual journals, 509 (96%) are published only in English language. Out of 51 bi-lingual journals, English-French and English-Spanish combination dominated. Among the multi-lingual journals, French, Spanish, Portuguese, and German predominate besides English. Of which the journal - *TEXTOS de la Ciber Sociedad* (*The TEXTS Ciber Sociedad Magazine* (ISSN: 1577-3760) is published in five languages (English, Catalan, Galician, Portuguese, Spanish) simultaneously. Thus, language of mathematics OA journal shows clear domination of European languages with English as the dominant language.

5.4 Publishers of OA Mathematics Journals

An attempt was made to find out leading publishers of OA journals in Mathematics and categorize them. A publisher was considered 'Commercial' if the website clearly indicated a commercial organization like corporation, registered company for profit. Similarly, professional societies, universities and government organizations were respectively identified and categorized. Table 4 shows that as many as 394 publishers are involved in publishing 601 OA journals in Mathematics. Of which, 342 publishers publish only a single OA journal, while 52 publishers publish more than one OA journals. Hindawi Publishing Corporation publishes 55 (9.15%) journals followed by Academy and Industry Research Collaboration Centre (AIRCC) (24 journals), Springer (13 journals) and Scientific Research Publishing (12 journals). Noteworthy is the fact that along with several not for profit agencies (universities, professional and learned societies) some leading commercial publishers (Springer, De Gruyter Open) are into OA publishing. Therefore, a change of

Table 4. Leading Publishers of OA Mathematics journals

Leading Publishers			
Sl. No.	**Publisher**	**Type**	**Contribution**
1	Hindawi Publishing Corporation	Commercial Publisher	55 (9.15%)
2	Academy & Industry Research Collaboration Centre (AIRCC)	Professional Society	24 (3.99%)
3	Springer	Commercial Publisher	13 (2.16%)
4	Scientific Research Publishing	Academic Publisher	12 (1.99%)
5	International Association of Comp. Science & Inf. Tech. (IACSIT)	International Association	8 (1.33)
	Multidisciplinary Digital Publishing Institute (MDPI AG)	Commercial Publisher	
	Science & Engineering Research Support Society (SERSC)	International Association	
6	Hikari Ltd	Commercial Publisher	7 (1.16%)
7	Computer Science Journals	Individual Journals	6 (0.99%)
	MECS Publisher	Commercial Publisher	
8	Bonfring	Commercial Publisher	5 (0.83%)
	Science Publishing Corporation	Academic Publisher	
9	Academy Publisher	Commercial Publisher	4 (0.66%)
	American Mathematical Society	Professional Society	
	American V-King Scientific Pub. Ltd. (AVSP)	Commercial Publisher	
	Hans Publishers	Commercial Publisher	
	Institute of Mathematical Statistics	Professional Society	
	International Scientific Publication & Consulting Services (ISPACS)	Commercial Publisher	
	VERSITA (Now De Gruyter Open)	Commercial Publisher	
	Asian Network for Scientific Information (ANSI net)	Commercial Publisher	3(0.499%)
	Canadian Center of Science and Education (CCSE)	Commercial Publisher	
	Institute of Advanced Engineering and Science (IAES)	Professional Society	
	Modern Science Publishers	Commercial Publishers	
	SCIENPRESS Ltd.	Commercial Publishers	
	Society of Digital Information & Wireless Commun. (SDIWC)	Professional Society	
	University of Bologna	Academic Institution	
	Vasyl Stefanyk Precarpathian National University	Academic Institution	
11	Another 25 Publishers having		2 each
12	Another 342 Publishers having		1 each
Total 394 Unique Publishers			601

attitude towards OA publishing could be noticed among publishers.

5.5 Discipline-wise Distribution

Mathematics finds its application in different branches of science, engineering, medicine, and social sciences. Moreover, due to ever-increasing trends of interdisciplinary research, a large number of journals have emerged which deal with many subjects, one of which may be mathematics, like *British Journal of Mathematics and Computer Science; Advances in Mathematical and Computational Methods; American Journal of Computational Mathematics* and many more. This paradigm shift might have forced publishers to shift to publishing multidisciplinary journals such as *Interdisciplinary Journal of Information, Knowledge, and Management; Human-Centric Computing and Information Sciences; International Journal of Innovative Research in Computer and Communication engineering*. Therefore, to categorize these journals under precise subject headings is not feasible. So these journals have been classified under broad subject headings, like computation mathematics, general mathematics, engineering mathematics - which may not be mutually exclusive (Table 5).

Table 5. Subject coverage of OA Mathematics journals

Subject	No of Titles	%
Computational Mathematics (Electronic computers, Instruments & Machines)	287	47.75
Mathematics General	229	38.10
Mathematical Statistics (Probability)	25	4.16
Engineering Mathematics (Engineering General, Civil & Industrial)	17	2.83
Mathematical Science - Special Aspects of Education	12	2.00
Econometrics (Economics modelling, Forecasting, Growth Theory)	9	1.50
Mathematical Physics (General & Applied Physics)	8	1.33
Mathematical Biology (Biological Sciences, Medicine, Chemistry)	7	1.16
Arts in general (Fine Arts, Visual Arts)	3	0.50
Linguistics & Philology (Mathematics - Mass media & Literature)	2	0.33
Law in general (Comparative &Uniform law, Jurisprudence, etc.)	1	0.17
Philosophy (General), Psychology, Religion	1	0.17
Total	**601**	**100.00**

About 48% of journals are in computational mathematics; followed by general mathematics (38%) and mathematical statistics (4%). Rest 10% titles are from engineering mathematics, educational mathematics, econometrics and mathematical physics. Results indicate that the journals categorized under 'mathematics' in the DOAJ, could also be useful for many other disciplines like computer science, electronics, engineering, media and communication, law, business management, thereby reaffirming the ubiquitous nature of mathematics as discipline.

5.6 Funding Model of OA Mathematical Journals

Even for OA journals, publishing is a costly affair. To meet the cost of production, maintenance of servers, publishers of OA journals rely on 'author-pays model' among which Article Processing Charge (APC) is the predominant mechanism frequently used for generating revenue[36]. It is the fee levied on author upon acceptance of article. Generally, amount of APC is journal-specific and negotiable and could be waived totally for some authors[37].

Table 6 shows variations of publication charges of mathematics OA journals. APC data was not readily available in DOAJ; so it was collected by visiting web sites of individual journals. However, results show that about 20% of journals in our dataset do not have specific information about publication fee. While majority of journals (67%) do not charge any fees, about 4% (23) journals impose some charges (APC/ handling charge/ processing charges, etc.); about 9% journals impose conditional article processing charges which varies considerably. Finding seems to agree with those of earlier studies[38] that majority of OA journals do not charge authors for publishing.

Table 6. Publication Fee of OA Mathematics journals

Publication Fee	No of Journals	%
Journals charging No APC	403	67.05
Journals with APC	23	3.83
Journals with Conditional APC	54	8.99
Information Missing	121	20.13
Total	**70**	**100**

5.7 Licensing Model of OA Mathematical Journals

Accessibility and re-usability of Open access content depends on the license under which said document was published. It is found that majority (62%) of

journals were devoid of specific licensing information. However, among the used models are different Creative Commons licensing variants, (http://creativecommons.org/), maximum (155) journals have adopted the least restrictive 'Creative Commons License'(CC BY), followed by the most restrictive 'Non Commercial - No Derivative' (CC-BY-NC-ND) attribution (37 journals).

Table 7. Licensing model of OA Mathematics journals

Acronym	License Description	Frequency	%
CC BY	Creative Common Attribution	155	25.79
CC BY-NC	Attribution-Non Commercial Uses	21	3.49
CC BY-NC-SA	Attribution-Non Commercial-Share Alike	11	1.83
CC BY-ND	Attribution-No Derivatives	2	0.33
CC BY-NC-ND	Attribution-Non Commercial - No Derivatives	37	6.16
CC BY SA	Attribution-Share Alike	5	0.83
No Licensing Information		370	61.56
Total		**601**	**100**

6. Conclusion

During the last couple of decades there has been a rapid growth of OA journals across geographical regions and scientific disciplines. Interestingly developing countries such as India, Egypt, and Brazil have been active, which might be a good sign for global OA adoption. Growing involvement of commercial publishers might be a boost for OA movement. Mathematics OA journals are highly multidisciplinary as majority of these journals could be useful for researchers in other disciplines. The study also demonstrates that large majority of OA journals in our study do not charge any fees for publishing. Creative Commons Attribution (CC-BY) is the most commonly used licence model offered by the mathematics OA journals. It was also found that there are some journals, which are neither truly open access nor ostensibly mathematics journals. Probably, some hybrid and some converted multidisciplinary OA journals might have crept into our study population due to their inclusion in DOAJ. One could argue that inclusion of these journals would dilute the inferences! Therefore, the study justifies DOAJ's decision to be stringent about journal selection policy[39-41]. There are numerous ways to extend and complement the present study as there are unexplored areas like digital preservations issues, coverage in indexing and abstracting databases, citation performances, and concerns over predatory journals, etc.

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