

Mathematical Journals: Past, Present and Future— A Personal View

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As most people in the mathematical research community are aware, there is a revolution taking place in the way information—in particular, mathematical research—is being produced and disseminated throughout the world. I am, of course, referring to the electronic revolution taking place in scholarly publishing. In this article I will give my personal view on how this is affecting and will affect the publication of mathematical journals.

The Past

For the past two hundred years original mathematical research was disseminated primarily through refereed paper journals. In addition, during the past twenty-five to thirty years many authors disseminated preprints of their papers via mail so that colleagues would be apprised of their new results a year or more before they were published. The libraries collectively archived the journals by basically keeping them dry and accessible to the mathematical community, just as they had been doing for centuries with the world's scholarly literature. By utilizing interlibrary loans, the libraries were able to make virtually the entire research literature available to the mathematical community.

During most of the twentieth century journals such as *Mathematical Reviews* (MR) and *Zentralblatt für Mathematik* (ZBL) have aided mathematicians in finding and evaluating the exponentially growing amount of research literature.

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Although the predictions made in this article are strictly my own, the lively discussions of the AMS Committee on Publications have helped me immeasurably in focusing on these issues. I am also sure that several past and present members of the Committee will disagree, probably strongly, with some of my prognostications.

—Donald Babbitt

Until a few years ago these too were paper journals which also grew exponentially in size with the literature being reviewed, as librarians can readily attest. Beginning in the early 1980s, MR and ZBL became available online on a “per hit” basis. (This means a user is charged for the amount of time he/she is “online” and for the number of search results printed out.) In 1989 MR became available on a searchable CD-ROM (MathSciDisc). These were just an inkling of the electronic revolution to come.

Finally about twenty years ago Donald Knuth invented the highly flexible typesetting/word-processing language T_EX that was especially suited for typesetting mathematics. With a significant input of resources by the AMS this typesetting language became the standard for publishing mathematics, especially for journals. One very important outgrowth of this was that mathematicians themselves were able to typeset their own papers, and a surprisingly large number of mathematicians chose to do so, often with great virtuosity. (This virtuosity, however, has the down side that journal publishers often have to significantly modify such author-prepared manuscripts before they can be used to produce the journal.) But a more important byproduct was that papers written in T_EX were now electronic files which could be transmitted over the Internet.

The Present

Although most journals remain paper only, many now are published in dual format, i.e., there is both a paper and an electronic version. The latter typically is available over the Internet, either as a free add-on to the paper subscription or with a modest premium. In some cases one can subscribe only to the electronic version for somewhat less than the paper subscription. The electronic versions vary in their level of functionality.

Some are only an electronic version of the printed copy, viewable on screen in $\text{T}_\text{E}\text{X}$ code and downloadable and printable in one or two formats. Others have additional functionality, such as being hypertext-linked HTML documents with real mathematics on screen (as opposed to $\text{T}_\text{E}\text{X}$ code), which, for example, can link MathSciNet subscribers to the reviews of papers in the bibliography. In many of these journals there is the opportunity for readers to post comments to go along with the electronic version of the article.

A new form of journal publishing in mathematics began in 1993: free electronic-only journals on the Internet. Papers in these journals are refereed and are reviewed in MR and ZBL just as the papers in the traditional paper journals. The hardware, software, and system administration for the journal are provided typically by the mathematics department of one of the principal editors at no cost to the journal. (*The Electronic Research Announcements of the AMS* [ERAAMS], created in 1995, is somewhat of an exception to this model.) Authors submit $\text{T}_\text{E}\text{X}$ files of their articles to the journal in question following fairly flexible format restrictions; the journal editors arrange for the refereeing of the articles and, if accepted, provide the editing of articles for publication. Consequently, all of this is done by free contributions of material and labor, which is why these journals can be made available for free. Simplifying somewhat, the model here is author-to-editors-to-readers with no intervention of a publisher. It should be mentioned that the functionality of most of these journals is relatively minimal. Almost all of them now disseminate their journals from their own Web sites.

The AMS has just begun to publish electronic-only specialty journals with the rather modest subscription prices of \$125 for institutions and \$50 for individuals, with a lengthy free subscription period (*Representation Theory, An Electronic Journal of the AMS*; and *Conformal Geometry and Dynamics, An Electronic Journal of the AMS*). At the present time these journals have a higher level of functionality than the free e-journals, with the exception of ERAAMS.

As already mentioned, preprints have been around for some time in the mathematical community. In the early 90s, however, preprints went electronic with a vengeance. Preprint servers were set up in several departments by mathematicians interested in specific areas, such as mathematical physics, K-theory, and algebraic geometry. Mathematicians in these areas were invited to post their preprints at these sites. There were also preprint servers such as the one at MSRI which posted preprints from many fields, although the preprints themselves mostly arose out of workshops, etc., that had taken place at MSRI. The AMS set up a preprint

server for all fields in January 1995. The vast majority of preprints posted on these servers are still destined for refereed journals. Perhaps the most important preprint server for mathematics, at least as a model, is one that is primarily outside of mathematics but in the closely related field of theoretical physics: the Ginsparg preprint server at Los Alamos. Despite having strict format requirements, this server has an extraordinary number of preprint submissions and an equally extraordinary amount of traffic. It is divided into various fields, such as quantum field theory/string theory, condensed matter physics, and now even some mathematical fields of special interest to theoretical physics such as algebraic geometry. The NSF has thought enough of the Ginsparg preprint server that it is investing more than a million dollars in supporting further developments of the preprint server as a tool for disseminating scientific information.

As mentioned above, MR and ZBL had already developed electronic access to their databases by the early 90s. What the mathematical community began to ask for, especially with the arrival of the World Wide Web (WWW) and sophisticated browsers such as Mosaic and then Netscape, was to have unlimited access to the MR and ZBL database at their desk and even at home. This possibility was realized for those mathematicians affiliated with institutions that subscribed to MR with the introduction of MathSciNet in January 1996. This is a user-friendly hypertext-linked online version of MR with a powerful search engine and with the capability of browsing as one can do with the paper version of MR. A subscription is based on site license, so that all individuals—including the mathematicians, computer scientists, physicists, etc.—at the site can have unlimited access to the MR database. One important caveat is that this mechanism for delivering the MR database depends on the robustness and speed of the World Wide Web, something that is not always present even in the U.S. Because of this, there still is considerable demand for both the paper and CD versions of MR and ZBL.

Document Delivery has been around for many years and, until recently, has been a complement to the interlibrary loan service. This is a service provided by several organizations, including the AMS (MathDoc), that obtains copies of journal articles to which a library or scholar otherwise would not have access. This is done for a fee depending on the journal, with a portion of the fee being paid to the journal in question. In the past two to three years, a small number of academic libraries have cancelled a significant number of journal subscriptions, including some to mathematics journals, and have replaced these subscriptions by the commit-

ment to their patrons to obtain, via Document Delivery, any article from these cancelled journals that they need. These libraries have found that by and large they save a considerable amount of money, while, of course, the publishers receive considerably less revenue from the Document Delivery fees for the articles delivered than they would have had the subscriptions not been cancelled. This is being widely discussed in the library community.

The Future

In my prognostications below, I will not attempt to go beyond ten to twelve years. I also will be assuming that there is a robust WWW or a successor in place. Despite the increasing occurrence of bottlenecks and time delays for many users of the current Web, I think the huge and increasing investment in the Web by Microsoft, Netscape, and others makes this assumption not totally unrealistic.

- After ten or so years, all primary research journals will have highly functional electronic versions, and almost all of these will be electronic-only journals. Only the most selective general journals will survive, while the remaining ones will be specialty journals. The electronic files of the articles will have a standard structure (SGML?) with varying degrees of functionality and will be part of the “universal” database of the mathematical research literature. The files of individual articles will be structured so that they are technically accessible from the reviewing journals (by now solely electronic); their reviews will be technically accessible from the article; and the articles and reviews of the articles in the bibliography, when they are in a reviewing journal’s database, will be accessible from the article. By accessible I mean readable online in real mathematics and downloadable and printable in the standard formats of the time. I use the word “technical” because there may, and often will, be barriers to access due to subscription requirements.

Above I have predicted that only the most selective general journals will survive. (I obviously have been very careful not to name them.) This has less to do with the electronic milieu than with Document Delivery. Because most of the articles in the other general journals have very limited readership, libraries will realize, as some already have, that it is much more economical to utilize Document Delivery than to subscribe to such journals. These journals will then become economically unviable. The electronic-only specialty journals should avoid this fate, because they will be quite inexpensive, with many individual subscribers.

- In the next few years much of the important preelectronic research literature in journals will be converted into electronic files. At a minimum, articles in these journals will be electronically accessible from major libraries and will have hypertext links to the reviewing journals (expected to be purely electronic in five to six years). The first step in realizing this gigantic task has recently been undertaken by JSTOR, an independent non-profit corporation established with the assistance of the Mellon Foundation. They are currently creating electronic files for all of the articles in the pre-1991 issues of several major journals, including the AMS primary journals.
- Those journals that have not made credible arrangements for their electronic archiving in perpetuity will probably not survive. By electronic archiving in perpetuity I mean that as electronic formats evolve over time the electronic files of the journal’s articles will be changed accordingly so that they will always be electronically readable and easily accessible (not necessarily for free) to the mathematical community.
- Many if not most of the free electronic-only journals will either disappear or become subscription-based journals in the next decade. Some of the main reasons for this predicted demise are: most of the free journals receive a substantial subsidy by way of equipment, system support, etc., from a university or similar institution, an inherently unstable situation; the required enthusiasm, time, and energy of the founding editors are very difficult to pass on to a second generation of editors, especially with the additional work required of editors of free journals; although authors seem willing to produce usable \TeX files, especially if they are given considerable leeway in format, they almost certainly will be much less interested in producing the standardized and highly structured files required for the upcoming electronic milieu; making arrangements for electronic archiving will be a special challenge for these journals.
- There is the question of the cost of electronic-only journals versus paper or dual journals and the economic effect on libraries when the transition from paper and dual journals to primarily electronic-only subscription-based journals takes place. For both print and electronic journals the most significant value-added (to the authors’ contributions) is provided by the journal editors and referees. This is oftentimes free, but not always: publishers will frequently pay for



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secretarial assistance, provide computing equipment, pay for reduced teaching time for managing editors, etc. For a print journal the additional value-added provided by the publisher consists of paper; printing; distribution, including postage; some key-boarding; editing for language; and appropriate paper journal format. For an electronic journal the cost of the paper; printing; distribution, including postage; some key-boarding; and editing files for appropriate format of the paper journal is replaced by the cost of hardware, software, and system support to produce and distribute the electronic journal, and editorial work to produce an appropriately structured file from the authors' submissions. There could be in some cases additional costs for creating interactive files and elaborate graphics. It seems reasonable to expect that the steady-state cost of producing an adequately functional electronic journal compared to the cost of producing a print journal of comparable "size" could be significantly less than the latter, provided almost all of the work needed to create the files for producing the journal is done by the authors, editors, and nonproprietary software. If the electronic journal has state-of-the-art functionality and/or puts minimal burden on the authors, then the cost could be higher, although probably less than that of a corresponding paper journal. It seems safe to predict that the cost to libraries of the primary mathematical research literature in the electronic milieu will be less per unit of information than in the paper/dual journal environment that presently exists. The above discussion also implies that revenues and therefore income derived from publishing mathematics journals could decrease significantly in the next ten to twelve years. In particular this could impact the activities of the AMS supported by the income from its journal publications.

In the end it will be the authors who will determine what the electronic publishing environment of the future will be. It is they who will decide how much nonmathematical effort they want to put into publishing their mathematical research; which journals will offer a sufficient guarantee of having their work electronically archived in perpetuity; how much, if anything, they feel libraries or individuals should pay to have access to their work; and how much functionality a journal (or whatever other electronic publishing model that may arise) in which they publish their research should have.