

The Elephant in the Internet

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Although we live in a time of endlessly overhyped sociogeopolitical trends (the threat of terrorism, the Asian economic miracle, the genius of Eminem, etc.), the most revolutionary and important change taking place in human society is puzzlingly neglected, perhaps precisely because its earth-shaking status has delayed the development of a vocabulary adequate for the sort of discourse that is called for. I am referring, of course, to the rise of the personal computer and the internet and the resulting reorganization of the relationship between human beings and information.

Perhaps the most crucial aspect of this discussion is the question of how the Internet is to influence the existing global power dynamic. Glimmers of this debate are already slipping into the public eye; the legal battle over downloaded music has been deemed the most newsworthy, but it is merely a single node in a vast web of intellectual property conundra, which itself fits into a yet bigger picture cluttered with concerns about free speech, international trade, tax law, and so forth.

The crux of the issue is simple: like any invention that redefines the way we communicate, the Internet empowers some groups of people and weakens others. Again, the most widely publicized example is the radical shift in the interaction between consumer and producer in the music industry; other prominent instances include political activism, publishing, and, of course, sex and dating. When a sea change like this occurs, those whose dominance is threatened tend to become overwhelmed by paranoia; on the other side of the coin, a delighted alliance forms between

those who have been vaulted into power and those who instinctively support any revolution.

Of course, one must be careful to give no quarter to either side; nothing has been gained if the Internet merely serves to replace one unjust or oppressive ruling class by another. Instead, we should strive to use new technologies to right existing wrongs and open closed doors without creating new imbalances or leaving anyone behind; needless to say, this is no easy task. The mathematical community interacts with this headache in a primarily one-dimensional way, namely via the tension between print and electronic media, and particularly between high-priced corporate journals and everybody else. As is perhaps sadly emblematic of a broader pattern, mathematicians seem to be engaging primarily with the least complex issues that arise, namely the (astonishing) cost of privately owned journals and the administrative entity that needs to form in response to the widespread use of electronic archives that lack any kind of peer review.

Apparently I'm missing something, but each of these issues seems fairly straightforward to me. The question of journal pricing strikes me as essentially an economic one, rather than a moral one, notwithstanding the lexicon that is usually brought to the table. Simply put, *The Annals of Mathematics* delivers a product that compares quite favorably to that offered by *Advances in Mathematics* and at a fraction of the price. Thus, if library budgets are at all constrained, then given that mathematicians stay mindful of these disparities, *Advances* will remain able to engage in its aggressive pricing for only so long; if, by contrast, university libraries suddenly magically attain the ability to function like the American military, then the Halliburton-Elsevier axis will prosper for centuries to come.

In a similar vein, it's my belief that the level of concern surrounding the nexus of electronic

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archives and peer review is distinctly exaggerated. Leaving aside the (deeply fundamental) existential questions that arise automatically from the use of words such as *proof* and *correct*, let me just point out that no honest mathematician uses a result simply because it has been published. Rather, we use results that we trust are true; it is incumbent upon each individual to arrive at a considered personal decision about what the defining threshold for this notion is, but surely, for any of us, the answer lies in some complex mélange of what has been published, what has been accepted as true by a larger community, and (most importantly, one hopes) what we believe ourselves to understand. Presumably, even if we are to entirely abandon the stamp of peer review, we can take some comfort in the fact that the audience (of potential debunkers) reached by any given paper is now potentially much wider and more diverse than it ever could have been before.

On the other hand, I do believe that the Internet has the potential to influence the nature of research mathematics in a much subtler and potentially more pernicious manner than those we've addressed so far. To convey this, it's perhaps best to begin with a little discussion about the nature of the mathematical community, with particular attention to the features that make it unique and, in certain respects, uniquely attractive.

There is an oft-repeated analogy that holds that the relationship between mathematics and physics is akin to that between classical and popular music. Though shallow and imperfect, the analogy contains a grain of truth. A piece of classical music, the argument goes, is composed with painstaking attention to detail and subtlety; thus the resulting text is something close to sacred, and consequently, the devotion of countless hours to perfecting a rendering of a brief passage is a noble task. At the same time, one cannot expect such a delicate, carefully balanced creation to speak to us on a primal level (but try telling that to Igor Stravinsky!). By contrast, popular music is supposedly coarse and elemental; it is highly sensitive to cultural change and thus has urgency and currency, but it is disposable and too blunt to be worth burnishing (but try telling that to Thom Yorke!).

You can now surely see where this is going: physics lurches to and fro, replete with fads, false starts, and fanciful leaps of insight, whereas mathematics keeps pushing heroically forward, unencumbered by external concerns. A physics paper, like a newspaper article, is not meant for posterity; dotting of i's and crossing of t's is meant to happen after the fact, and is not in any case the "real" work of a physicist. A mathematics paper, on the other hand, is supposed to be a work of art: perfect, complete, and beautiful. We write in the hope that we will be read centuries from now (and,

indeed, we still delight in reading the works of the old masters, for reasons that extend well beyond the historical). Most mathematicians seem to feel that one should never write a paper whose ideas are not fully fleshed out, whose details are not all in place.

It is my belief that these stereotypes are extremely dangerous but not entirely without merit. Because exposing all of their shortcomings would carry us too far afield, let us instead take from all of this one crucial fact, namely that there exists in mathematics a tradition of great expository care and love, that (all evidence aside) mathematicians care deeply about how their papers look and sound and spend endless hours agonizing over wording, phrasing, and structure. It is my (aggressively clung to) belief that this is emphatically good. In fact, pretty much every mathematician has spent hours involved in debates about whether what we do constitutes an art or a science; surely the only meaningful answer is that it is neither, and the attitude we have toward our creations as purely aesthetic entities—which attitude is strongly reinforced by our approach to writing—is one of the crucial differences between our discipline and that of a scientist.

At this point, it's perhaps not clear what any of this has to do with the Internet. The answer lies in the fact that the Internet is a novel medium primarily in the ease with which anyone can make information publicly available. It consists of a vast and largely unfiltered pile that can quite easily bury a potential reader. This presents authors with a new challenge; rather than try to impress an élite group of professionals (publishers, referees, and the like) in order to attain a specific goal whose consequences are known quantities, one must now post writings for all to see and somehow hope to snatch the wandering attentions of a large enough slice of the audience. For readers, this has the effect of creating a vast and bewildering array of options, and our instinctive response is to reach out for whatever strikes us first. This in turn creates a system that rewards large gestures and makes it more difficult to reach any audience at all with subtleties that demand careful attention or even (God forbid) repeated readings.

This effect is easy to see in the arena of fiction. The weblog has given rise to a whole generation of young, trendy writers who have attained prominence on the strength of their popular websites and online journals. Most of these authors have extremely sharp wits and are absolute masters of the brief, comedic, and highly autobiographical essay. However, in spite of my admiration for their writing (and in spite of the extent to which they help ease the pain of my less mathematically productive days), I suspect that we can all agree that literature would suffer if success came to be equated

entirely with this type of cleverness. Indeed, it is still emphatically possible to attain success by sending a manuscript to a few influential agents, editors, or publishers; I have heard no one suggest that it would be likely or desirable for this to change in the foreseeable future.

By contrast, we seem to be reaching a moment during which essentially all mathematical writings are distributed first (if not exclusively) on cluttered archives. To be sure, there are important differences between the enterprises of mathematical (or, more generally speaking, scholarly) publication and broadly marketed fiction. In the first place, it is usually agreed that a mathematical publication is to be judged primarily on the content of its results; so long as the writing is at all competent, any expert should be able to identify these almost instantaneously and evaluate them accordingly. Therefore, preprint archives, at least in principle, allow researchers to quickly peruse the entire literature in a given area and decide which articles to read more carefully; this is almost exactly the orthodox argument in favor of the archives.

What, then, is the influence of the Internet on the nature of mathematical writing itself, as opposed to just its distribution? I have already conceded that it is unclear to what extent the information-glut aspect of the Internet induces us to produce shorter, punchier, flashier documents. However, another, somewhat different, force is in very clear evidence. Namely, the Web allows us to communicate in a less formal environment that is mediated by fewer norms and less historical baggage. Moreover, an electronic Web-based document is never necessarily completed; there is no publication date after which revisions become impossible. These two qualities have the effect of decreasing the author's emotional investment in the finer expository aspects of a mathematics paper. Indeed, the reasoning goes, if I do not intend to see this piece of work promoted to canonic status by virtue of its binding and typesetting, then why should I invest agonized hours in the aesthetic aspects of its writing? Furthermore, even if I do in principle intend to put in the required time, why should that occur now, given that this current version is not expected to be permanent in any case?

The effects of this phenomenon are already being felt: online, one often encounters articles that the authors readily admit to be unsuitable for paper-journal publication. (It is interesting to note that this self-policed dual standard arose organically, in spite of the fact that hardly anyone ever attempts to carefully articulate what sort of writing is "good enough to publish".) The more we feel that there is an acceptable outlet for these unpolished works, the less likely we are to devote the energy needed to bring them to what used to be considered completion. One could, of course, argue that

this merely has the effect of creating a second forum for mathematical publication, which has some advantages over paper journals (efficiency, breadth, and cost of distribution) and some disadvantages (lower standards that give rise to a general lapse in quality). However, although this already seems to contradict the vision of most advocates of Web-based publishing, I fear that there is a much more serious problem brewing.

Beautiful mathematical writing is already an unfortunately underemphasized, underpracticed, and underrewarded art; our community desperately clings to the untenable position that someone already recognized as a great mathematician is perhaps entitled to extra admiration by virtue of being an exemplary expositor but that an extraordinary writer who cannot back up this skill with amazing new theorems is of no particular value. Disappointing though this system may be, it at least ascribes some—albeit insufficient—worth to the creation of carefully designed articles, whose merits comprise not just correctness and readability but beauty and innovation in structure, use of language, and so forth. If we now expect to find most papers on the Web, where we demand less of writing and think of any document as an unfinished work, a mere attempt to get the facts out in advance of some subsequent "real" version (which might well never appear), then our interest in, or at least capacity to expect, beautiful writing cannot help but dwindle further yet.

It also surely does not help that the physical manifestation of an online article is either on screen and thus, well, not physical, or else an unbound printout. In addition to simply feeling informal, these formats do not encourage the reader to think of a paper as a single document whose global structure might be of some importance. Rather, we download a paper, print and skim it, and possibly even dispose of all but the most relevant pages: to most of us, these printouts instinctively feel like disorganized notes, so why not treat them that way? For this reason, I, for one, am hesitant to post my papers online; it always feels a little like leaving my infant in a dumpster.

The fact is that our current relationship to the Internet has the undeniable effect of degrading the sacrosanct status of the mathematical text. To me, this is inescapably sad: I became a mathematician because I fell in love many years ago. I fell in love with the writings of Poincaré, of Steenrod, and of Bott; these texts are filled with a divine light and extraordinary beauty and, like any great piece of writing, grant the reader proximity to and sympathy for the author. Without this light, this beauty, this proximity, and this sympathy—in other words, without sacred texts—mathematics can only go in one direction: toward the profane.