

# Digital Communication and Scientific Progress: The Issues Underneath the Surface

by Manjil Saikia - Monday, April 30, 2018

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The major scientific and mathematical [1] progresses that are made, are first reported in academic journals, and if something catchy and news-worthy appears then it captures the public imagination via numerous blogs, news articles and social media shares. But, the process of discovery or invention has many intermediate steps, the most important in some sense is the communication between scientists and mathematicians. In the infancy of such a thing, during the early medieval period, the sole means of such communication was through letters written by many distinguished men [2] among themselves, first announcing their discoveries, and sometimes even challenging each other with problems to which one possessed his own solution. Nowadays, this is replaced with emails between people and/or uploading one's work into online academic repositories (like arXiv for mathematics, physics, etc.).

The letters that people like Euler, Gauss, Leibniz, Hooke, Darwin, etc. wrote have been preserved for posterity wherever they exist, to this day. These scribblings, or words among these men are a tangible testament to the intellectual richness of the human mind, and even a cursory glance at them would not fail any individual to have a deep respect for their work, as well as have a motivation to carry forward this intellectual legacy to some extent. Closer home, Srinivasa Ramanujan, the brilliant 20<sup>th</sup> century Indian mathematician wrote almost exclusively most of his new results into notebooks, which fortunately have been preserved and many people all over the world are working towards proving or refuting [3] his statements. His first stellar rise into the world of mathematical fame was through his now famous letter to G. H. Hardy at Cambridge, which is one of the most famous mathematical letters of the world, some even say all of history.

It is clear, that such communication is an essential part of progress in science and mathematics. Contrast this to the modern day, when communication channels have become exclusively digital in most cases. People prefer to write emails, and social media messages, instead of paper and pen letters. These emails, and messages are restricted to only it's recipients, and in the case of the death of both the sender and the recipient, it will most likely be lost for ever. Major breakthroughs [4] have occurred after receiving a short email from some colleague or student. Even more important, major historical events have been announced via emails, whose tangible nature for preserving it to posterity is a bit questionable. In the last couple of decades, one of the most spectacular mathematical breakthrough occurred in Russia, when Gregori Perelman solved an outstanding open problem in mathematics. He uploaded his paper into arXiv, a repository of mathematical research where each individual can upload his work, provided some basic rules are followed. When the mathematical community realized that this has happened, some of them wrote to Perelman over email, asking if he had solved the conjecture. His reply email in most of the cases consisted of a single word 'yes' [5]. It seems absolutely impossible to imagine that, had he written a letter back perhaps he would have written more than one word. A major mathematical milestone was thus reported with a single word.

In September, 2016 at Heidelberg the author met Prof. Guillermo P. Curbera, a professor of mathematics

at the University of Seville, who is also the archivist of the International Mathematical Union, a body overseeing among many other things the organization of the International Congress of Mathematicians every four years, the largest gathering of mathematicians anywhere in the world. Over several discussions about various issues pertaining to mathematics, the issue of this lost history of letters was also discussed. Prof. Curbera rued the fact that, if the email servers were to stop suddenly, or if someone changed email servers then the previous communications of many would be lost entirely. This is somewhat alarming, let's take an example. The proof of a 360 year old problem called Fermat's Last Theorem by Andrew Wiles in 1994-95, was announced by Wiles over email. Wiles subsequently changed his affiliation and it might now not be possible to access those emails as a historical record. This is certainly a loss for the history of the subject. Incidentally, Fermat made his observation in a copy of a book, he just scribbled his conjecture on the margins of the book, which later his son published with Fermat's scribbles.

The question of whether an email carries the same weight as a letter is becoming obsolete as more and more people, as well as organizations prefer to communicate over emails rather than letters. The examples illustrated so far are just a tip of the ice-berg and many more would surface if one looks further down. But, let us also analyze a related but slightly different issue. Almost all scientific journals now have a digital edition as well, which is exactly similar to its print issue and in many cases even more informative because of exciting graphics or embedded videos, etc. There also exists a large class of journals which are online-only, that means they do not have any print copy of their publication. More and more such journals are coming up, and not all, but at least some of them are very well respected journals in their respective fields.

This again stems the issue of what happens if such a respected online-only journal were to lose its server. What happens then to the research reported in these journals. They would most likely be lost or exist only on the personal files of people who had written them or downloaded them into their computers. This looks quite innocent on the surface, but is a major cause of concern. For instance, the work of Perelman referred to earlier in this article is such an example. Perelman, for reasons which we will not discuss here did not publish his work in any mathematical journal, his work is available online in a repository of research papers. Although the repository is well funded but its lack of physical existence [6] is a cause of worry, in the unlikely event that its servers stopped working, then there is a very real chance of everything on it disappearing.

In the same meeting at Heidelberg in 2016, the author also met Prof. Vint Cerf, one of the Vice Presidents of Google, Inc. Prof. Cerf raised another alarming issue which he termed as the *digital dark ages*. This refers to digital content which are not accessible now. This is increasingly becoming a problem, because with frequent updates of softwares and introduction of new formats every few years, some of the old files that one might have are no longer compatible with the present system or vice-versa, files generated by present systems might not be accessible to someone who has older hardware or software. If at some point, the way data is written in the online-only research journals (mostly pdf files) becomes obsolete, what happens to all the information that is rendered useless. This is perhaps too extreme a situation, but nonetheless one worth keeping in mind when thinking about doomsday predictions.

So much progress has been made since the last century, the shift this progress has taken is hardly reversible and is also not wanted. But with this progress has come some worries which are mild on the surface, but once you scratch them off, they reveal very dangerous precipices. It is probably now late to try to reverse or at least contain the issues highlighted here, perhaps a collective consensus or a discussion

is worth pursuing about this. Although only mathematics has been highlighted here, the problems are equally true for any field of human intellectual endeavor [7]. Imagine if some songs were only available as gramophone records, then with the disappearance of gramophones from our lives so would these songs. It has already happened with many film rolls of Indian classics which are now rendered useless due to it's format or it's shabby preservation methodology. This is a serious matter of concern.

1 This also captures all fields of technology, medicine and engineering; we use this convention throughout this article.

2 And women (but the prevalence of women in science is a very recent construct, due to various historical reasons which this article will not discuss).

3 In very rare cases (cf. G. E. Andrews, abstract for a talk to be delivered in Hagenberg, May 2018).

4 And some minor ones, as well.

5 This incident was heard by the author from one of the people who had emailed Perelman.

6 In the form of a paper copy somewhere (although some might argue that digital data is also physical).

7 Including the arts, cinema, music, etc.

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