

We (virtually) solved it!

Remote collaboration in mathematics

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Introduction

Overview

- ▶ History
- ▶ The present
- ▶ The future?
- ▶ Practical advice

History

Letters

- ▶ Lovelace & Babbage
 - High frequency communication
- ▶ Germain
 - Used the nom de plume “Antoine-August Le Blanc” to submit course essays
 - Experienced difficulties accessing the work of others, in part effecting her ability to contribute to a theory of elastic surfaces. Ch. 9 of [1].
- ▶ Hardy & Littlewood [2]
 - Sent notes by college servant
 - Agreed rules for collaboration

Letter rules

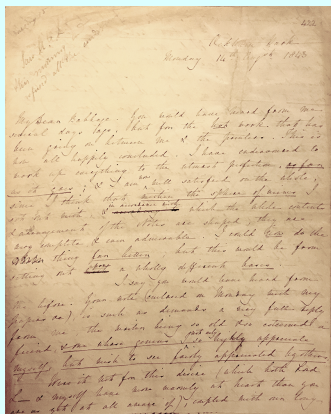


Figure 1: Lovelace outlines collaboration

- 1 When one wrote to the other, it was completely indifferent whether what they wrote was right or wrong.
- 2 When one received a letter from the other, he was under no obligation whatsoever to read it, let alone to answer it.
- 3 Although it did not matter if they both thought about the same detail, still, it was preferable that they should not do so.
- 4 It was quite indifferent if one of them had not contributed the least bit to the contents of a paper under their common name.

Figure 2: Hardy-Littlewood collaboration rules

Telephones

- ▶ Telephones?
- ▶ Fax?
- ▶ Early internet?

Blogs

- ▶ Michael Nielsen [notes](#) the unique cultural affordances of blogs
 - “Informal”
 - “Rapid-fire”
 - “Could not easily be published in a conventional way”
 - “Widely distributed in both time and space”
 - “Searchable[... and] filtered access to new sources of information”
- ▶ David Roberts had a publication, borne of interactions on the n-category café, with Urs Schreiber
 - “We had met only once before at a conference, though I already knew of him before then through his blogging.”
 - “I appreciated the asynchronous nature of the work, and our complementary styles of thinking helped.”
 - “Certainly I’m not averse to this method of collaboration with people in the northern hemisphere”

Polymath

- ▶ Timothy Gowers asked **Is massively collaborative mathematics possible?**
- ▶ Reflected on interaction dynamics
 - “My feelings at the moment are that blogs are too linear[...] [M]y guess is that the ideal forum would probably be a forum”
 - He would “create new posts if I feel that genuine progress has been made that can be summarized and then built on.”
- ▶ Outlined rules of collaboration

1. The aim will be to produce a proof in a top-down manner.
2. Comments should be as easy to understand as is humanly possible.
3. When you do research, you are more likely to succeed if you try out lots of stupid ideas
4. If you can see why somebody else's comment is stupid, point it out in a polite way.
5. Don't actually use the word "stupid", except perhaps of yourself.
6. The ideal outcome would be a solution of the problem with no single individual having to think all that hard.
7. If you are convinced that you could answer a question, but it would just need a couple of weeks to go away and try a few things out, then still resist the temptation to do that.
8. Suppose that somebody has an imprecise idea and you think that you can write out a fully precise version don't rush ahead and do it. First, announce in a comment what you think you can do.
9. Actual technical work, as described in 8, will mainly be of use if it can be treated as a module.
10. Keep the discussion focused.
11. However, if the different track seems to be particularly fruitful, then it would perhaps be OK to suggest it
12. The paper will still be submitted under a collective pseudonym with a link to the entire online discussion.

Figure 3: Polymath rules

- ▶ Polymath 1, a new proof of density Hales-Jewett [3]
 - "number settled down to a handful" of contributors
- ▶ Polymath 8, improved Zhang's prime gaps bound [4]
 - Went further with Maynard
 - "factory production line"
 - "Quick payoff" for progress
- ▶ Other projects stalled but partial progress was implemented in further research
 - Ideas from Polymath 7 were used to solve the "hot spots" conjecture for acute triangles
 - Tao solved the Erdős discrepancy problem and used some ideas from Polymath 5
- ▶ Historical record of research

▶ Community

- Valuable social experience
- “academic spectator sport”
- Willing to share “dumb” ideas

▶ Practice

- Good leadership
- Impact of chance remarks. Literature found
- Swift progress
- D.H.J. Polymath

▶ Technology

- Blog - linear structure
- Wiki or summary posts

▶ Criticisms

- Hard to catch up. “perhaps we should just artificially slow ourselves down.”
- Favoured research styles and tech users
- Issue-tracking tools?
- Sacrifice for young researchers
- “ad hoc structure [...] allowed us to scale up the size of the collaboration [...] closer to 10^1 ” Tao

▶ [CrowdMath](#) follows the same model

- Resulted in publications for undergraduate researchers

▶ MiniPolymath projects for school students

▶ In addition, see Ursula Martin [2] and Michael Nielsen [5]

Wikis and Fora

- ▶ Wiki: structured knowledge
 - Community contributions
 - Less appropriate for ideas in development
- ▶ Forum: threaded conversation
 - Dominico Fiorenza had a publication borne from an [nforum](#) conversation. “[T]his experience has been extremely useful to me in advising a PhD student from another university.”
 - Google wave implemented multi-threaded chat(see Rizzoma)
- ▶ [mathoverflow](#): widely used academic forum
 - Documents research impact in its [success stories](#)

The present

Collaboration during the pandemic

- ▶ Asynchronous
 - Email
 - File sharing
 - Overleaf
- ▶ Synchronous
 - Videoconferencing
 - Screen share
 - Doc-cam / Tablet + whiteboard app

Improvements

- ▶ Accessibility
 - Asynchronous. Record videos or audio
 - Readable resources
 - Update expectations, maintain and continue
- ▶ Virtual communities (e.g. on Discord)
 - Social presence, networking, new collaborative relationships
- ▶ Version control (e.g. GitHub)
- ▶ Use travel allowance to travel virtually?

The future?

Improvements

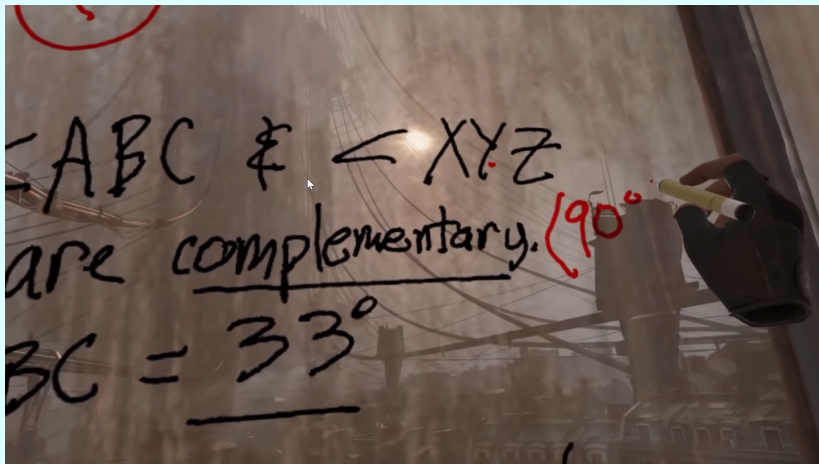


Figure 4: Teaching maths in Half Life

Researcher perspectives

▶ Domenico Fiorenza

- “I would like to see a more collaborative mathematics, in the spirit of the Polymath Project. Career pressures to publish as a named author is going to prevent a real spreading of these kinds of collaborations in a near future.”

▶ David Roberts

- “We are quite close to having a full suite of remote collaboration tools (GitHub, video chat, email, Overleaf, etc), but [a suitable whiteboard alternative] seems to be the last barrier.”

▶ Cater, Kang, and Pollanen [6]

- “Handwritten mathematics cannot be easily reused, searched, and edited.”
- “[I]t might be possible to have a writing environment that frees the mind, allowing one to think more deeply about core concepts.”

Practical advice

- ▶ Agree on collaboration practice, update as necessary
 - How will you communicate? How frequently? What requires an update?
- ▶ Establish a persistent collaboration space(s)
 - Cloud Folder, Discord Server (+ MathBot), Forum, Blog, GitHub
 - Share relevant files, keep references, record meetings, note tasks
- ▶ Reduce cognitive load
 - Turn off notifications, use fewer distinct tools, practice with tech
 - Wear headphones, use a good quality microphone, dual screens
- ▶ Be social/share a cup of tea
 - Establish trust and understanding
 - Use cameras for *start* of meeting

Tools

- ▶ Discord
- ▶ GitHub (or similar)
- ▶ Dropbox
- ▶ Overleaf
- ▶ OneNote
- ▶ MediaHopper

References

- [1] L. L. Bucciarelli and N. Dworsky, *Sophie Germain, An Essay in the History of the Theory of Elasticity*, ser. Studies in the History of Modern Science. Springer Netherlands, 1980.
- [2] U. Martin and A. Pease, “Hardy, littlewood and polymath,” in *Mathematics, Substance and Surmise: Views on the Meaning and Ontology of Mathematics*. Springer International Publishing, 2015, pp. 9–23.
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- [4] D. Polymath. (Sep. 30, 2014), “The ” bounded gaps between primes” polymath project - a retrospective.,” version 1.
- [5] M. Nielsen, *Reinventing Discovery*. Princeton University Press, 2011.
- [6] M. Pollanen, S. Kang, and B. Cater, “Manipulation of mathematical expressions in collaborative environments,” in *Learning and Collaboration Technologies. Technology in Education*, P. Zaphiris and A. Ioannou, Eds., Springer International Publishing, 2017.