

AIM Research Community Proposal — `code4math`

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In December 2023, AIM supported a workshop on **Open-source cyber-infrastructure supporting mathematics research**, devoted to building capacity for the creation and promotion of open-source software supporting mathematics research. In the spirit of the White House Office of Science and Technology Policy’s declaration of 2023 as the “Year of Open Science”, workshop participants gathered to share their knowledge on open-source solutions such as the LMFDB database of examples from number theory, the PreTeXt XML language for authoring scholarly documents, the SageMath mathematics software system, and more.

Discussions also explored the tools mathematicians use to collaborate, including services as GitHub, arXiv, MathOverflow, and social media. We wanted to envision what the future of mathematics *could* look like in the 21st century — and to figure out how we can steer it towards a collaborative, inclusive environment for all mathematicians. The workshop hosted working groups on several topics: interoperability of formalized math with computer algebra systems, databases of mathematical visualizations, databases of mathematical databases, canonical tagging of mathematical concepts, knowledge tracing in mathematics education, the future of mathematics research, on-ramping mathematical research software engineers, and the values of our community of mathematical researchers and research software engineers.

A key outcome of this workshop was the formulation of a **Consortium of Digital Ecosystems for Mathematics** (<https://code4math.org>). Today, the Consortium has grown beyond the 29 initial workshop participants into a community of over 100 mathematicians who connect via the `code4math` Zulip chat to advance the sociotechnical infrastructure of mathematics research.

It is time to strengthen our role in advancing research across all mathematical disciplines by supporting researchers who develop or use mathematical software. We propose an AIM Research Community to nurture our members’ activities and expand the ecosystem of contributors to math cyberinfrastructure.

This Community will enable mathematicians using research software to collaborate more effectively, scale projects, and apply advanced tools to mathematical problems. Currently many math software projects are driven by small groups, making them vulnerable to disruptions that cause the loss of vital knowl-

edge and progress. By fostering collaboration across a larger network, we'll aim to increase resilience even in the face of individual setbacks. Together we might succeed, whereas individually many would fail.

Mathematics Informed by Computing

Recent work by researchers such as Kevin Buzzard [1] and Terence Tao [2] point to a near future where computers will advance beyond mere calculation and brute force case-checking, but have an active role in the inquiry and logical verification necessary for classical mathematics research. To quote Tao, “Before this can happen, however, the formalization process needs to become more efficient. The [...] ratio between the difficulty of writing a correct formal proof and a correct informal proof is still well above one (I estimate ~ 20), but dropping. I believe there is no fundamental obstacle to dropping this ratio below one, especially with increased integration with AI, SMT solvers, and other tools; this would be transformative to our field.” Providing a “town square” bringing together experts in these fields to create these necessary advances is a primary goal of our proposed AIM Research Community.

The integration of mathematical research and computing is an active area of scholarship. At the Joint Mathematics Meetings 2025, a special session on “Mathematics informed by computing” will be held, featuring eighteen talks spanning databases, visualizations, formalized mathematics, machine learning, education, accessibility, and much more. These advances more often manifest as improved research infrastructure, but more rarely as citable research artifacts; a goal of `code4math` is to help mathematicians who are advancing this infrastructure to better quantify their efforts for the purposes of traditional academic metrics, particularly those early-career scholars who need citeable artifacts of their work for tenure and promotion.

Advancing connections between Computing and Mathematics is also a priority for the National Science Foundation. In spring 2024, NSF announced its Artificial Intelligence, Formal Methods, and Mathematical Reasoning (AIMing) solicitation, which “seeks to support research at the interface of innovative computational and artificial intelligence (AI) technologies and new strategies/technologies in mathematical reasoning to automate knowledge discovery.” A key requirement of this solicitation is that proposals should involve a partnership of researchers in mathematics and computer science; accordingly, `code4math` will encourage the participation of computer science researchers in our Community whose work can advance the discovery of mathematical knowledge.

Structure and Activities

Currently, `code4math` is run by a Steering Committee, consisting of Katja Bercic, Steven Clontz, James Dabbs, David Lowry-Duda, and Christelle Vin-

cent, and the majority of its activities take place on the `code4math` Zulip instance. As the Consortium grows into its next phase, the current Steering Committee wishes to establish plans for formal long-term governance, including a process by which to rotate members of the Steering Committee as needed over time. In addition, we have plans to establish Special Interest Groups on topics of interest to our membership, such as databases of mathematical objects, formalization of mathematics, open-source software in mathematics education, etc. These Groups will work to establish repositories of best practices and instances, to foster collaboration and cross-pollination between projects that have similar aims.

`code4math` plans to have a presence at as many major American mathematical gatherings (MathFest, Joint Math Meetings, etc.) as possible in the coming years, including a confirmed presence in the JMM2025 Exhibit Hall. These events are opportunities for the community to connect with each other and meet new potential collaborators, in addition to important professional development opportunities. At this time, a main goal of the Steering Committee is to improve the visibility of `code4math`, and once we are an AIM Research Community, promote the good done by the American Institute of Mathematics in advancing our field through improved research cyberinfrastructure.

References

- [1] Kevin Buzzard. What is the point of computers? A question for pure mathematicians. In *International Congress of Mathematicians, 2022*.
- [2] Terence Tao. Machine assisted proof. *Notices of the American Mathematical Society, to appear, 2024*.