Ethics in Mathematics

—Catherine Buell and Victor Piercey

Editor's note: *The pronouns ze and zir are used in place of gendered pronouns throughout this article.*

The use and misuse of data has been a topic of political discussion for the last decade or more, from Snowden's revelations about the U.S. National Security Agency to the Cambridge Analytica scandal. These scandals directly involve mathematicians and computer scientists, and raise ethical issues for mathematicians. In April 2018, two Cambridge University academics, Maurice Chiodo and Piers Bursill-Hall, and their students organized the first Ethics in Mathematics (EiM) conference. Participants included mathematicians, legal scholars, computer scientists, and philosophers. In their ranks were Turing Award winners, whistleblowers, scholars, and leaders in their field from the UK and Australia, and the US. The conference was recorded, so you can visit bit.ly/EiMRecordings to see the presentations.

Some readers might be surprised that ethics has a place in mathematics, or they may feel that their work in pure mathematics is too far removed from applications to have to worry about ethics. While we see an abundance of ethics courses in business, finance, media, criminal justice, biology, environmental science, psychology, philosophy, and computer science, they are often lacking in mathematics. Many STEM-oriented ethics courses use case studies to touch upon ethical issues in academia (publications, intellectual property) and industry (monetary questions or whistleblowing). However, they rely heavily on the fields intersecting mathematics. Why is a mathematical ethics course so rare? Are we all good, wholesome, naturally ethical people? Is mathematics in its purest form unconnected to ethics? The answers: we don't know, probably not, and a resounding no. One of the presenters at EiM, Anna Alexandrova, stated "No research, no matter how pure, is immune from social responsibility."

The authors came away from the EiM conference convinced that we need to begin a conversation about the role ethics plays in our profession and how to teach ethics to our students.

Ethics and the Profession

There are obvious issues concerning mathematics research and publication, such as plagiarism and self-plagiarism. Beyond these publication processes, there are serious issues to consider surrounding the substance of the work done in research.

The clearer cases for ethical issues in mathematical research lie in applied mathematical areas. Statisticians have to address what informed consent means for a group when conducting clustered trials. Part of the cause of the financial crisis of 2008 involved abuse of the Black-Scholes model for pricing financial options. As financial products become more sophisticated, should one who conducts research in financial mathematics model new and potentially dangerous products?

Recent concerns about ethical behavior address the use and abuse of data. With modern computing power, countless dimensions of our lives are reduced to bits of data. Some of the ethical questions have to do with viruses and malware. Vint Cerf, one of the founders of the internet, recounted at EiM that in the early days the goal was to have internet speeds as fast as terabytes per second, but should we proceed with development before minimizing risk? Besides concerns about viruses, there are important questions about our data. Who should have access to that data? What is the appropriate level of privacy one should expect for their data? How should that data be used? Recent scandals involving the U.S. National Security Agency, the U.K. Government Communications Headquarters, and Cambridge Analytica strike at the heart of these questions.

The issues raised above could be encountered in academic research as well as in work in industry. When working in a business environment, the nature of the relationship between employer and the researcher raises ethical issues dealt with across legal, medical, and mathematical professions. A mathematician can create a product that can be used unethically. Consider the following examples:

- If there is an algorithm that makes it easier for police to racially profile, should the mathematician who authors the algorithm consider this application in zir work?
- Suppose the results of a mathematician's work risk losing a client whose business keeps a significant portion of the firm's workforce employed. The pressure from clients may tempt a mathematician into falsifying data. What should the mathematician do?
- If a mathematician sees zir employer misusing data, should ze publicize zir observations?

So what about pure mathematicians and their research? Clearly, research in number theory has applications in cryptography. These applications raise ethical questions. Howev-

Buell speaking at the EiM conference at Cambridge.

er, to what extent is the pure mathematician responsible to society-at-large for the applications of their research? Whitfield Diffie raised this question in the context of applications which aren't conceived until 150 years after the conclusion of the original work. Mathematicians must nevertheless ask how pure one's work really is. Perhaps even more critical is to ask whose agenda one's work (no matter how pure) really serves, especially when grant funding is involved.

Ethics in Teaching

In academia, our teaching work also raises questions about ethical obligations attached to those duties. As with those teaching other disciplines, mathematicians must teach well and in an equitable fashion, and write letters of recommendations for students or advisees who are applying to work for employers whose ethical reputation is dubious.

However, mathematics plays a unique role in education that raises particular ethical issues. Often mathematics is used as a filtration device, separating students who can proceed to professions with high earning potential and those who cannot (see also the article by Bill Velez in this issue). This inappropriate use of the teaching of mathematics has profound implications for income inequality. Michael Harris and Reuben Hersch go even further, arguing that the culture of mathematics is one of elitism which turns the mathematics classroom into part of a system that replicates existing power structures. If this is the case, our profession must reflect on the ethical implications and the need for change.

Overall, there are questions that all members of the mathematical profession should ask:

- Whose interest is our work serving?
- How does our work impact existing power structures?
- Is a particular problem, no matter how interesting, pure, or abstract, worth dedicating our intellectual capital to as opposed to more pressing societal problems?

In his presentation at EiM, Whitfield Diffie challenged us to consider what is distinct about mathematics and the consequences of those distinctions for the application of ethics.

What is needed is an "ethical consciousness" among the mathematical profession. This frame of mind regularly grapples with these problems, including promoting thorough public discussion.

Teaching ethics to the next generation

James Franklin (University of New South Wales), a speaker at the EiM conference, wrote "How I taught the world's only ethics in mathematics course" (bit.ly/2Q8R0vD). A policy, instituted in the mid 1990's, required all undergraduates to take a course in "Professional Issues and Ethics" in their major. The class ended in 2012, but Franklin continued his work and created the Ethics in Mathematics Wikipedia page (bit.ly/2xdFh0P).

A stand-alone course at the undergraduate or doctoral level in mathematics could inform professional and academic mathematicians. Discussion of the ethics of the mathematics we create or use in both pure and applied mathematics serves to both ethically self-regulate and create a culture of discipline regulation. However, if ethical thinking in mathematics is deemed important, then having one course, just a checkbox on a course list, may not create the desired cultural shift. Much like reading and writing, ethics and social responsibility in mathematics would benefit from cross-mathematical-curriculum integration.

Pre-calculus, calculus, discrete math, linear algebra, computational mathematics, statistics … show us your ethics! Small, yet meaningful discussions or activities highlighting ethics historically or case studies (environmental justice in calculus or decision theory and algorithms) could support these efforts. A mathematics curriculum can be both rigorous and socially responsible.

We find the K–12 curriculum in the US modeling this integration of ethical conversations into mathematics to support learning, interest, and transference of knowledge. Examples can be found at the Chicago-based Math For a Change (bit.ly/2FPvSFD) and Radical Math (bit.ly/2rgv4Qd). Another EiM speaker, Paul Ernest, recently came under criticism for his analysis of K–16 education in a new textbook chapter *The Ethics of Mathematics: Is Mathematics Harmful?*, where he provided his "recommendation for the inclusion of the

philosophy and ethics of mathematics alongside its teaching all stages from school to university, to attempt to reduce or obviate the harm caused; the collateral damage of learning mathematics."

Colleges and universities do seem to be engaging students in ethics and social justice in mathematics classes aimed towards non-STEM students. Courses like *Mathematics in Society, Liberal Arts Mathematics, Quantitative Reasoning, Ethnomathematics* or social justice-themed courses like *Statistics* or a *First-Year Seminar* may provide students access to mathematics intertwined with social responsibility and citizenship. Why are these courses created this way? Here are some ideas.

- Desire for mathematics to be accessible and contextualized.
- Creating a society of critical thinking citizens with mathematical literacy.
- Personal engagement with material improves student buy-in.
- Culturally-inclusive content and pedagogy helps to engage a wider audience who haven't experienced success in mathematics classrooms.
- Mathematics is not necessarily rigorous, but still builds problem-solving skills and necessary math skills.

There are likely many more reasons; however, we'd argue that those mentioned above should be of importance to all STEM and mathematics students. So why aren't these courses part of their experiences? Typically, discussions surround the last item, where faculty suggest that a mathematics curriculum cannot be both mathematically rigorous and socially-responsible. This is a challenge of content and pedagogy, but also mathematical culture.

Piercey speaking at the EiM conference at Cambridge.

Challenges and an Invitation

Perhaps the first challenge is convincing the community that mathematics is not neutral. The world not being divided into "good and ethical people" and "evil and unethical people" and the gray areas and ambiguity may be difficult in mathematical culture. Both users and innovators of mathematics need to be aware of the equity issues encountered through mathematics research and teaching. Others may suggest that incorporating ethics or social justice will water down the mathematics, i.e., "this isn't a social science" course. We first must acknowledge the harm we may be causing math research and math education based on who or what we value to include and exclude.

We would like to see mathematics professional societies critically evaluate and expand their statements on ethics into a more comprehensive set of guidelines. This might be something worth exploring jointly. The ASA has guidelines (bit.ly/2zzIlaV) that could serve as a model.

In Francis Su's January 2017 address on the Mathematics for Human Flourishing he says,

> I want us as a mathematical community to move forward in a different way. It may require us to change our view of who should be doing mathematics, and how we should teach it. But this way will be no less rigorous and no less demanding of our students. And yet it will draw more people into mathematics because they will see how mathematics connects to their deepest human desires.

If we do not include humanity, equity, and the desire to create a just world into a mathematics curriculum or mathematics class, then we are likely unable to achieve the goal of changing the culture or mathematics to one of inclusiveness. Truly, it is only one piece of the puzzle and it will take a village. Therefore, we invite others to join the community dedicated to ethics in mathematics and building a just world through mathematics. The authors are proposing a Special Issue of PRIMUS on Mathematics and Ethics and seeking articles and experiences on ethics courses for majors, general education, and undergraduate research. Talks and presentations at a future Joint Mathematics Meetings and MAA MathFest are in preparation, and of course EiM2. ■

Catherine Buell is an associate professor at Fitchburg State University where she conducts research across mathematics and mathematics education and teaches with a passion for social justice and equity. In addition to her duties at Fitchburg, she teaches in various Massachusetts Correctional Institutes. Victor Piercey is an associate professor at Ferris State University where he is the Director of General Education. Before becoming a mathematician, he was an attorney, and is dedicated to using his life experience to enhance the teaching of underprepared undergraduates with math anxiety.