

## A Case for Ethics in the Mathematics Major Curriculum

Feryal Alayont  
*Grand Valley State University*

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## A Case for Ethics in the Mathematics Major Curriculum

### Cover Page Footnote

I would like to thank John Gabrosek for sharing his ethics assignments, and my colleagues from the internship Faculty Learning Community for providing information on how they teach ethics in their internship seminars. These assignments have served as valuable examples for the manuscript. I also would like to thank the reviewers for their valuable feedback and suggestions that helped improve the organization and readability of the manuscript.

# A Case for Ethics in the Mathematics Major Curriculum

Feryal Alayont

*Department of Mathematics, Grand Valley State University, Allendale, Michigan, USA*  
alayontf@gvsu.edu

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## Abstract

When our students enter the workforce, be it in academia or in business, industry, government, they will be forced to make decisions about various ethical dilemmas. Once in a while, the scandalous stories like that of Enron, the three German auto-makers' diesel fuel pact, and the Equifax data breach make the headlines. However, employees at every workplace are faced with small to large-scale ethical situations almost daily. In our majors' future careers, a manager can be using an inappropriate graphic to display data to make the numbers look better, or the data collection processes used in a large public policy project can be completely skewed to support one conclusion that the client desires vs. another more reasonable conclusion. How well are our students prepared for dealing with these dilemmas? Can they even recognize an ethical dilemma? Do we provide them with the tools to be more vigilant about these situations and to make the appropriate decisions when the difficult choices have to be made? In this paper, I would like to invite us all to think about possible ways we can incorporate ethical decision making frameworks and case studies into our classes, particularly if our university does not have an ethics requirement for all majors. Even if there is a general ethics requirement, it is especially important for our students to be exposed to scenarios that are more relevant to the use of mathematics in the workforce since a general ethics course will not necessarily prepare them well for identifying subtle abuses of data processing and mathematical modeling.

**Keywords:** ethics, applied ethics, ethics in mathematics

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## 1. Introduction

In my undergraduate and graduate studies, I was not required to complete any ethical training. The only official ethical training I received to date is the human subjects research training I completed for a research project long after I started working as a professor. Similarly, in my department, our undergraduate mathematics majors are not required to complete any specific ethics training before graduation. There is no ethics component in our math curriculum and there is no explicit ethics requirement in the general education program. However, our students will certainly encounter a spectrum of ethical dilemmas in their future careers, some more mathematics-specific than others. At one end, they might be confronted with their boss showing favoritism toward a colleague or just the opposite, abusive behavior toward one or more colleagues — two of the most common types of observed misconduct in the workplace [10]. On the other end, they might have to decide whether using a specific parameter in a mathematical model or a specific algorithm is appropriate for a given problem in terms of the impact that the resulting conclusion will have. Consequences of these decisions can have serious societal impacts such as in the case of predictive policing and recidivism prediction algorithms that were trained using historical data and received further data based on their predictions creating a feedback loop [11]. Such dependence on potentially biased data causes the model to “reproduce and in some cases amplify those same biases” and can result in overpolicing of communities of color [17].

When our students enter the workforce, will they be ready to deal with all of these situations, whether they are mathematics-specific dilemmas or general ethical considerations? Will they even be able to recognize an ethical dilemma in the context of their future careers, most likely a non-academic career? Will they notice the social impact of their mathematical work? Can we expect all of our students to train themselves on various aspects of ethical behavior, including how their mathematical work affects the world, on their own by reading rules and policies, and reflecting on ethical principles? Chiodo and Müller note that “[j]ust as physicists had to recognise the enormous ethical implications of their work after the atomic bombing of Hiroshima in August 1945, socially responsible mathematicians must also realise the existence of ethics in mathematical practise, which leads to issues far more

complex and harder to characterize than publishing-related decisions” and ask, “ [w]e train [our students] in a wide range of mathematics, but do we teach them to be aware of possible ethical issues in its use?” [7] In this article, I would like to argue for the need to do so and to propose some possible models for including ethics into the curriculum.

## 2. Ethics in the Mathematics Curriculum

Ethics can be embedded into the mathematics curriculum through multiple ways, such as 1) via the use of an activity or assignment within a capstone class, 2) through a professional development course with a significant ethics component, 3) in small doses throughout the curriculum, 4) via an activity focused on academic integrity, 5) by offering workshops to students outside of class on ethical topics, or 6) by outsourcing the ethics requirement to courses offered by other disciplines. Each of these options are detailed below.

### 2.1. Ethics in a capstone course

At my institution, applied mathematics majors have two capstone options: a project-based applied mathematics course (a PIC Math course [27]) and a mathematics-focused internship. Theoretical or teaching-emphasis mathematics majors also have two options: a course on the history of mathematics and a senior thesis. In the statistics program (under the Statistics Department), students complete a statistical consulting project. An ethics assignment focused on applications of mathematics or statistics can be embedded into any one of these types of courses.

One example of such an assignment is analyzing and writing a report on a case scenario. This assignment can be an individual assignment submitted as a short paper. Students can also analyze various case scenarios in small groups and discuss their thought processes as a whole class. The group work approach will allow students to possibly be exposed to different ethical reasoning frameworks in analyzing the same scenario during group and whole class discussions. In this assignment, students can be allowed to select case scenarios based on their preferences or future career choices. A case scenario about data sampling might attract a student interested in a data science career while a scenario on stock market modeling might be more attractive for a student interested in a financial career. Yet another student interested

in teaching might prefer a scenario on the effect of implicit bias in teaching. Many examples of cases along with guiding questions and/or suggestions for how to use cases in teaching of ethics can be found in the resources in Section 4.

A second type of assignment is reading, analyzing, and reflecting on the code of ethics of a discipline-specific professional society, possibly in connection to a brief case scenario. The reading portion of the assignment may also include a short paper or blog post discussing ethical issues in the discipline. An example of how to use the Joint Software Engineer's code [12] in teaching ethics is discussed in [13]. However, choosing a code of ethics to use in such an assignment for math majors is not straightforward. Although the American Mathematical Society (AMS) and the Mathematical Association of America (MAA) have statements of ethics [4, 18], both statements contain minimal references to mathematics in the workforce outside teaching and research. In the AMS Policy Statement on Ethical Guidelines, the only portion that applies to the ethical considerations of mathematics in non-research contexts is the following short paragraph under the section "Social Responsibility of Mathematicians":

When mathematical work may affect the public health, safety or general welfare, it is the responsibility of mathematicians to disclose the implications of their work to their employers and to the public, if necessary. Should this bring retaliation, the Society will examine the ways in which it may want to help the "whistle-blower", particularly when the disclosure has been made to the Society.

The MAA Code of Ethics seems to be guidelines governing behavior specific to MAA members and employees in the context of conducting MAA related activities. If we contrast these codes with those of other professions such as the codes of ethics of actuaries [2, 3], data scientists [9, 15], engineers [24], software engineers [12] or statisticians [5], we see that the codes of mathematicians lack significant depth and coverage. One possible reason for this is that mathematicians do not have narrowly defined job responsibilities in the workforce and our students may end up working as an actuary, an engineer, a programmer or a data scientist. Another possible reason is

that “being a scientist and engaging in research does not necessarily entail a career with characteristics traditionally associated with professions such as law, medicine, architecture, some subfields of engineering, and accounting” [22]. As researchers, many mathematicians do not have direct paying clients. Therefore, for an assignment focused on an analysis of a code of ethics, providing students with a list of codes in these specific professions and allowing them to choose a code related to their future interests might be a better solution.

A third possible assignment could be for students to interview an experienced professional in careers they are interested in on ethical issues [33]. The interview could involve asking the professional about common ethical issues that arise at their work, how they make ethical decisions, how to analyze a specific case scenario jointly with the student, etc.

Finally, students can be required to complete a responsible conduct of research training during their capstone course. If the institution offers access to an online training program, the students can complete this training outside of class. Otherwise, with the help of the offices of research and/or institutional review, an ethics workshop tailored for the specific class can be designed. Although this training will naturally be focused on ethics of conducting research only, students heading into the non-research jobs will still gain valuable information from the training and subsequent discussions in the classroom.

### *2.2. Ethics in a professionalism course*

Other disciplines with a longer tradition of infusing ethics into the curriculum, such as engineering and business, often offer a separate 1-3 credit professionalism course to help students prepare for the duties and responsibilities they will hold in their future careers. The course might cover additional topics relevant to professionalism in practice, such as the laws and rules the professional is subject to, professional behavior in the workforce and professional communication. As describing such a course in detail itself will require a whole article itself, we refer the reader to [6, 14] and [R5] for more details.<sup>1</sup>

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<sup>1</sup> EDITORS’ NOTE: Also see the next article in this [Special Issue on Ethics in Mathematics](#) by Allison N. Miller [21].

### *2.3. Bite-sized ethics throughout the curriculum*

Ethics does not have to be confined to one single class in the curriculum. In fact, it is better to infuse ethics throughout the curriculum to emphasize its importance, as argued by Shulman in [30], where it is described how ethical considerations can be embedded into various courses through analyzing the “unexamined premises” in ordinary problems and including short ethical dilemmas for class discussions and/or in assignments. An unexamined premise example in [30] is how societal and environmental impact is ignored when solving a cost optimization problem in calculus.

Another method for focusing on ethics in math classes could be using specific questions written to elicit attention to ethical issues in applied mathematics topics or even in purely abstract mathematical topics. Some examples are provided in the Cambridge Ethics in Mathematics Project website [R1].

Using an ethics across the curriculum approach, however, requires coordination among colleagues in a department so as to ensure that all students are exposed to at least some ethical discussions no matter who their instructors are. Some colleagues might not want to spend class time on ethical topics and/or preparation time to develop interesting mathematical questions that incorporate ethical issues. The latter of these two challenges can be overcome by maintaining a collaboratively created list of questions in the department that can grow over time. Limited class time concerns can be remedied by adding these questions in homework assignments, possibly coupled with online supplementary videos. In other words, if enough people in the department are willing to work together, these challenges are both surmountable.

Despite these challenges, Shulman argues that ethics across the curriculum is the best option since “[t]o make it clear that the ability to make reasoned ethical decisions is an important part of expertise in our respective disciplines, we must value it enough to actually devote some time to discussion of ethics in our classes, not merely rely on stand-alone courses that are not viewed by students as an integral component of their professional training” [30].

### *2.4. Ethics in the context of academic integrity*

Since 2007, an assignment students complete in the first week of my courses is a quiz on academic integrity. Conversations with a few students involved



in academic integrity violations in my first year at my current institution prompted me to design this assignment. My main goals with this quiz are 1) to help students discern which situations would be considered academic integrity violations, 2) to help establish an academic integrity culture in the classroom, and 3) to familiarize students with the institution's policies on academic integrity.

In the quiz, students analyze short scenarios to determine whether the situations are academic integrity violations. They complete the quiz first individually before class and then complete a second copy in groups in class, using their individual work and coming to a consensus within their group. Only the group versions are collected and the quiz is graded on completeness. The latest version of the quiz is included in Appendix A.

It is quite satisfying to observe students come to class identifying an incident as a “not cheating” case and change their mind during group discussion. The group discussions are influential in establishing a culture of integrity in the classroom and moving beyond a culture of compliance. In a culture of compliance, the goal simply becomes not getting caught by the instructor or pleasing the instructor, and is focused on external guidance. Although rules and codes are essential, a culture of integrity is more community-oriented, and encourages and supports students in being ethical in and out of the classroom [20]. Because this assignment is focused on academic integrity solely, it is easier to incorporate into any course in the curriculum. However, for the same reason and also because the case scenarios are constrained to a yes/no answer not allowing for much contemplation, the assignment has limited impact on the ethical training of the students.

One way to remedy the limited impact of an academic integrity focused assignment would be to expand the case scenarios in the quiz to involve more significant ethical reasoning. Another way could be using the assignment in connection with explicit discussion questions related to the future professional lives of the students. Such a strategy is described in [26, 32]. Students watch a video titled “Academic Integrity: The Bridge to Professional Ethics” produced in 1994 by the Duke University Center for Applied Ethics,<sup>2</sup>

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<sup>2</sup> Video is at <https://youtu.be/48GQ6nRYYQ8>, last accessed on July 26, 2022

introducing students to various academic integrity situations and analyze the cases along with their relevance to future professional situations.

### *2.5. Ethics workshops*

If the departmental culture is appropriate, in the sense that there is an active academic student club in the department or that students come together often to study topics on their own outside of class, ethics instruction could be covered in a workshop or series of workshops that are offered as co-curricular events. Chiodo and Bursill-Hall describe such a model of an optional course with 20 contact hours in [6]. Using the online resources on embedding ethics into the curriculum listed in Section 4, students can study the material themselves or under the guidance of a faculty member or graduate student. Involvement in these workshops could be encouraged through extra credit in courses or required by certain upper-level classes as an out-of-class assignment. Chiodo and Bursill-Hall recommend starting small with the ethics in mathematics emphasis, by offering one or two seminars initially and developing additional materials as interest grows [6].

### *2.6. Outsourcing the ethics training*

Even though Chiodo and Bursill-Hall argue in [6] that a professional ethics course for math majors should be taught by mathematicians as we are more familiar with the applications of mathematics in real-life than an ethicist would be, the realities of your department's limited resources might not allow this. If your department thinks math majors should learn ethics, then one other possibility is to outsource the requirement. Math majors can be encouraged to learn of ethics in the profession through courses offered by another department on campus. It is possible that there is already a course on your campus titled "Professional Ethics" offered by the philosophy department, or a "Business Ethics" course offered by the business school, or "Ethics in Engineering" offered by the college of engineering. A math major will learn useful ethical principles by completing such a course even if the course is not focused on mathematics in the real world. This option also provides another opportunity for students to learn ethics in the context of their intended future careers, as a student interested in a programming career, for example, can take the "Ethics for Programmers" course offered by the computer science department, while another student might find its counterpart offered by the business school more useful or relevant to their future plans.

### 3. Additional Curriculum Considerations

One additional consideration in incorporating ethics into the mathematics curriculum is to note what is NOT in the curriculum. The focus of any ethics embedded into the mathematics curriculum will be on applied and professional ethics, most likely regarding issues arising from the practice of mathematics in the real world. Any discussion of formal philosophical ethics will be incidental to the practical ethics. Detailed instruction of formal ethics topics is best relegated to courses offered by ethicists. In fact, Chiodo and Bursill-Hall suggest avoiding formal philosophy language in the course as they found that undergraduate mathematics students were generally not receptive to formal ethics [6]. However, we cannot expect a general ethicist to understand the nuances that arise from applications of mathematics. Using the words of [28], mathematicians cannot outsource “moral reflection to ‘moral experts’, [and] should cultivate their own moral expertise.” In other words, we as mathematics educators should incorporate the applied ethics topics into our curriculum in context as much as possible to help our students develop their own moral expertise.

Just as I do not propose to teach formal ethics in detail, I do not propose a specific ethical decision making framework for dilemmas in issues regarding applications of mathematics, or recommend to students a specific order of actions when confronted with ethical situations. The role of the curriculum is to provide students the tools to identify ethical dilemmas and make appropriate decisions themselves in the future. To quote Shulman [30]

I’m not trying to tell students what is right or wrong. Instead, I’d like to enable students to make explicit what their values are, encourage them to examine their bases and principles, and give them practice in making moral choices based on them.

Similarly, Chiodo and Bursill-Hall mention in [6]

We regularly have students ask us, unsurprisingly, for the ‘right answer’ or the ‘axioms and algorithms of ethics’ . . . We strongly suggest aiming to avoid ethical conclusions, and instead getting students to face the difficult job of coming to their own conclusions for their own reasons.

The fact that we do not provide the right answer or the right ethical lens to use in deriving conclusions does not mean we let each student decide on a course of action individually, without any guidance. We will still be guiding students on a journey to elicit their own values and negotiating possible actions in a team setting based on each individual's values. In fact, Snieder and Zhu argue that our professional lives cannot be separated from our personal lives and values, and that educators should teach value-based ethics that incorporate students' values, beliefs and goals [31].

#### 4. Resources

Below is a list of select resources that might be helpful for anyone planning to incorporate ethics into their courses. The online sites (all last accessed on July 26, 2022) contain free materials such as videos and cases to be used in an ethics class and guidelines for how to teach such a class. An online search will yield many other resources especially for general applied ethics topics.

- [R1] The Cambridge University Ethics in Mathematics Project website at <https://www.ethics.maths.cam.ac.uk/> contains resources specific to ethics in mathematics to help anyone wanting to construct a course for teaching this topic. Resources include video lectures gathered under a course titled "Ethics for the Working Mathematician" covering a variety of topics including financial mathematics, cryptography, surveillance, AI algorithms and the office politics.
- [R2] *Weapons of Math Destruction* [25] is a book about how the use of algorithms and mathematical models in the big data world is increasing inequality with case studies on the topic.
- [R3] The Online Ethics Center for Engineering and Science website, hosted at <https://onlineethics.org/> by the University of Virginia, focuses on teaching and learning about ethics in engineering and science. The site contains many case examples, instructional materials for ethics courses and articles on the instruction of ethics.
- [R4] The Ethics Unwrapped website, hosted at <https://ethicsunwrapped.utexas.edu/> by the McCombs School of Business of the University of Texas Austin, offers free educational resources including free videos on ethical topics and cases, grouped based on ethical topics.

- [R5] The University Module Series on Integrity and Ethics website, hosted at <https://www.unodc.org/e4j/en/tertiary/integrity-ethics.html> by the United Nations Office on Drugs and Crime, offers a collection of course materials to teach various ethical topics at a university level in 3-hour modules. The materials include guidelines on how to structure class time in the module and how to turn each topic, including the professional ethics topic, into a stand-alone course.
- [R6] Santa Clara University's Markhula Center for Applied Ethics website at <https://www.scu.edu/ethics/> contains resources such as ethical cases, articles, and blogs on ethics, a guide for making ethical decisions [19], and curriculum materials for incorporating ethics into the classroom, including free online courses, teaching modules, and guidelines for how to write ethics case studies.
- [R7] The National Institutes of Health, on its website titled Annual Review of Ethics Case Studies, available at <https://oir.nih.gov/sourcebook/ethical-conduct/responsible-conduct-research-training/annual-review-ethics-case-studies>, offers a list of detailed cases along with facilitator notes and accompanying videos for guidance for facilitators.
- [R8] The Society of Ethics Across the Curriculum hosts a Resource Library online at <https://www.seac-online.org/resources/>, containing a variety of resources, including books, videos, articles, syllabi and more.

## 5. Conclusion

The Accreditation Board for Engineering and Technology (ABET) has an Applied and Natural Science Accreditation Commission that accredits programs like geomatics and health physics. Among the criteria for student outcomes of such programs at the baccalaureate level, one is specifically devoted to professional and ethical behavior to highlight its importance [1]:

An ability to understand ethical and professional responsibilities and the impact of technical and/or scientific solutions in global, economic, environmental, and societal contexts.

If we note that this is only one of six criteria listed among other more expected ones such as technical skills, and effective communication and teamwork, the importance of this criterion becomes even more salient. Even though mathematics departments are not accredited by this commission of ABET, we can learn from their experience and expertise in the topic, and elevate the ethical behavior outcome to its proper place in our programs as well. Indeed, our students need to understand that the work they will complete will impact the world in various ways and that they cannot excuse themselves from ignoring this impact because they are just doing the calculations. Consequently, we as educators have to ask ourselves if our students have enough chances to practice thinking about ethical implications of their work and deciding on appropriate actions in ethically challenging situations taking into account all relevant information. Are they even aware of ethically challenging situations when they arise in various contexts?

In discussing the results that the interns in their study had a difficult time identifying ethically questionable behaviors, Lubbers, Bourland-David, and Rawlins note that “because they have limited [ethical] training, the students are less likely to even perceive an ethical issue” [16]. In other words, the ethics training will help the students not only with how to handle an ethical dilemma, but also with identifying the dilemma in the first place. For a mathematics major, the challenge of identifying ethical situations might be even greater. Therefore, ethics is a crucial component for any mathematics curriculum in preparing students successfully for a future career and life.

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### A. Academic Integrity Quiz: Are They Cheating?

**Instructions:** After reviewing the “Academic Misconduct” section of the code of academic integrity, consider each of the following situations. Are the students violating the academic honesty policy? You will discuss your answers within groups in class and turn in (online) a group sheet for credit with explanations of your answers, so make sure to jot down enough of your thoughts to be able to remember what your reasoning was to share with teammates.

For the following scenarios, unless indicated otherwise, assume that the professor allows collaborative work in assignments and students need to turn individual work. (These pre-coronavirus case scenarios are using in-person interactions. Adjust them accordingly to our current situation.)

1. Alice, Bob and Carol get together to work on their calculus homework in MAK hall. Each person works individually on problems for about an hour and then the three of them compare their answers. If they disagree, Bob and Carol erase their solutions and copy Alice’s, because Alice had calculus in high school and they believe that Alice is smarter than they are.
2. Alice, Bob and Carol get together and work as in problem 1 above, except when they have different answers, they then help each other to figure out who made the mistake and how to fix it.
3. Alice, Bob and Carol get together to work on their calculus homework in MAK hall. They take turns - one person goes to the board and works on a problem while the other two write it down. Occasionally, one of the other students will correct the person at the board when that person makes a mistake.
4. Alice, Bob and Carol get together to work on their cryptography homework (which involves writing explanations, solving hard puzzles, etc.) in MAK hall. All three of them work on one problem together. They try out different ideas, write down different approaches to solving the problem, and have a lively discussion. Each person contributes to the discussion and everyone feels that the problem would have been much harder to solve individually. When they solve the problem, each person sits down and copies the solution down.

5. Alice, Bob and Carol work as in problem 4, except that when they finish discussing the problem, each person writes down a sketch of the solution and then later writes up a complete solution individually.
6. An online study site claims to provide 24/7 homework help and solutions to any textbook or homework problem. Alice is struggling with a homework problem that is assigned for that week. She posts the problem on this site to obtain an answer for it, and modifies the posted answer and submits in her own homework solution.
7. Alice and Bob get together to work on their calculus homework. They discuss different ideas and come up with solutions to all problems. When they go home, Alice types up her solutions and sends the file to Bob. Bob copies equations from Alice's file into his solution file so that he won't have to type them again and then he writes his own explanations next to the equations.
8. Why does the university expect all students to do their own homework and insists on ethical methods of collaboration? How does this benefit the students currently and in the future?
9. Imagine your future self at work. Suppose you face an ethical dilemma (e.g. boss assigning unfair amount of heavy work to another coworker; one coworker not pulling their weight in teamwork; one coworker reporting that a product passes a test while it failed; boss adding personal items to office supplies order; a coworker being harassed; one coworker taking credit for someone else's work, etc.). What steps would you take to deal with the situation? (This is a general question on purpose as I'm not looking for steps specific to the situation but rather your general thinking process and framework.)

*This assignment is a modified version of an assignment that was available at <https://homepages.gac.edu/~kaiser/fts-crypto/honor-code-writing.html> Access date: November 26, 2006.*