A Survey of Ethics Courses in U.S. STEM Bachelor of Science Programs

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This article explores the frequency with which scientific ethics courses are available to biology, chemistry, and physics students for credit towards their B.S. degrees in United States undergraduate institutions. After examining undergraduate catalogs for ethics-related course requirements and elective offerings in the fields of biology, chemistry, and physics (along with each discipline's sub-degree-level concentrations), we identified each relevant course as either "focusing on scientific ethics" or "including scientific ethics at some level." We categorized each institution by governance type (public or private) and size (large or small). We found that scientific ethics courses are offered infrequently among most institution and program categories, and tend to include scientific ethics as a secondary focus. Additionally, we found that scientific ethics courses are most frequently offered to biology students at large public institutions, and least frequently offered to physics students at large private institutions.

Introduction

Scientific ethics addresses issues including research data falsification, equity and inclusion, and professional conduct in the STEM fields. Historical cases of research misconduct have produced multi-dimensional consequences. When data are falsified or faulty, time and money are wasted, public policy decisions can be prolonged, and the validity of science in the public eye is jeopardized. A recent example of such implications can be found in the realm of vaccination research. Intensive research during the COVID-19 pandemic by medical bodies like Pfizer and Moderna produced sufficient evidence to suggest that mRNA vaccines effectively prevented infection, but many individuals were skeptical (Savoia et al. 2021). Some of that public skepticism towards vaccines was likely influenced by faulty studies. For example, Andrew Wakefield's 1998 study (Wakefield 1998) erroneously linked the MMR vaccine to autism based on sample sizes that were too small. This study was later debunked in 2010 by the UK General Medical Council due to its flawed results (The Editors of the Lancet 2010), but many members of the public continue to cite the study as a reason to avoid vaccines and other inventions of modern medicine. By handling data ethically, scientists can curtail such sentiments and ensure public dissemination of scientific material is accurate and beneficial to society.

Aside from its data-oriented applications, ethics must also exist among the interpersonal relationships of a scientific workplace. Conspicuous unethical behavior includes general harassment and exclusionary practices, but a recently-expanding pool of dialog over the importance of diversity, equity and inclusion (DEI) in science has encouraged workplaces to monitor for subtle discriminatory behavior and microaggressions that target underrepresented populations. AlShebi, Rahwan, and Woon (2018) suggest that ethnically-diverse teams of scientists tend to generate publications with a greater impact factor, while Yang et al. (2022) suggest that publications by mixed-gender teams in medical science tend to accumulate a greater number of citations. Because the white male demographic has traditionally dominated the practice of science, studies like these suggest that adopting DEI-consistent ethical standards in the workplace may be an important step in the advancement of scientific discovery as a whole.

An understanding of the consequences that follow from all types of unethical conduct is an important characteristic of a modern scientist. Professional STEM bodies have updated ethics codes in recent decades: in 2025, the American Physical Society and the American Chemical Society updated their guidelines on ethics (APS 2025, ACS 2019), while the American Society for Microbiology updated their Code of Ethics and Conduct in 2021 (ASM 2021). Ethics committees have also been recently established in these organizations to oversee ethics-oriented conflict proceedings. In accordance with the growing professional interest in scientific ethics, are colleges teaching their STEM students to become ethics-minded scientists?

Formal ethics education has long been a common requirement for accredited graduate degrees in engineering (Bates & Starrett 2020), in law since 1974, and in medicine since 1957 (Eaglen et al. 2017, Resnik et al. 2023). In addition, to achieve ABET accreditation, undergraduate engineering programs must be able to document that their graduates have attained "an ability to recognize ethical and professional responsibilities in engineering situations" (ABET 2025). This requirement has given rise to ethics education becoming part of the undergraduate engineering curriculum. While some STEM graduate programs incorporate ethics into their curriculum, many students enter the STEM workforce immediately upon receiving an undergraduate degree, thereby missing the opportunity for an education in ethics–unless the undergraduate curriculum emphasizes ethics. Since, for the most part, there is no formal accreditation process in science programs, the recommendations to incorporate ethics education into the undergraduate curriculum (see, e.g., APS 2022) carry less weight.

At Eastern Michigan University, undergraduates majoring in physics are required to complete

PHY 406–Ethical Issues in Physics, a one-credit course in which students study STEM ethics codes and discuss the impact of ethical conflicts in professional and broader societal contexts. In this paper, we report on our findings related to one aspect of STEM ethics education: at what frequency are physics, biology, and chemistry departments within other institutions offering courses like PHY 406? Among different programs, there is variability in ethics education methods: some programs may choose to offer a course specifically on ethics, while others may offer courses with a single unit on ethics. Still others may hold an ethics-centered lecture or workshop. This study is not intended to represent a complete picture of STEM-related ethics education at the undergraduate level but rather a snapshot of one possible component of a robust experience in undergraduate ethics education.

Method

We searched the degree requirements and course catalogs of 80 undergraduate institutions in the United States with biology, chemistry, and physics Bachelor of Science programs. 20 schools were chosen from each of four categories: Large Private, Small Private, Large Public, and Small Public. Institutions were examined from a variety of geographical regions, and chosen based on categorical criteria.

Only those institutions that had physics, chemistry, and biology undergraduate majors were included in the survey, and the institutions were selected to ensure there would be 20 in each of the categories above. The Institute of Education Sciences indicates that there are approximately 2300 4-year college level institutions in this country (IES 2023), However, the American Institute of Physics has record of just 778 of those institutions as providing 4-year degrees in physics (AIP 2024). Since we surveyed only those institutions that had physics, biology, and chemistry programs, we drew from a sample no more than 778 institutions, with a sample size thus corresponding to about 10%.

The criterion for "Large" institutions requires that 10,000 or more undergraduates are reported as enrolled in the most recent enrollment report (from 2020 onwards); similarly, the criterion for "Small" institutions requires that less than 9,000 undergraduates are reported as enrolled in the latest report. A "Public" school is one that tends to fund programs and pay employees with monetary support from its state government, while a "Private" school is one that tends to utilize donations from non-governmental entities. Both types of schools may receive public funds for research activity and may be subject to regulations such as the Higher Education Act.

We accessed the most recently-published online undergraduate catalogs for each institution in order to examine the requirements for STEM degree programs. Most institutions utilized the Modern™ Campus catalog web page system or similar web page systems, in which undergraduate course descriptions are directly linked to corresponding course titles. If such a web page catalog was unavailable for an institution, we accessed the most recent digital version of the undergraduate catalog. Most catalogs detailed the 2024-2025 school year; a few institutions only had the 2023-2024 catalog available. When all course descriptions were not published in the most recent undergraduate catalog, we consulted the previous year's catalog to examine courses offered only during alternating years.

Our course search focused on three Bachelor of Science degree areas: biology, chemistry, and physics. The requirements for all concentrations of each degree program (e.g., "Evolutionary Biology," "Biochemistry") were examined, usually by means of a "degree map." Secondary education concentrations were excluded based on their tendency to require courses on ethical classroom practices rather than ethical STEM academic research/industry practices. In order to extract information on scientific ethics courses, course titles for each B.S. program were scanned for ethics-related keywords (Table 1).

Table 1: Example Keywords for Scientific Ethics Courses

	Biology Discipline	Chemistry Discipline	Physics Discipline	All Disciplines
Keywords	animal handling, bioethics, genetics, healthcare, privacy	drug(s), chemical handling, safety	machine safety, nuclear	accessibility, best practices, data, diversity, ethics, etiquette, equity, fabrication, falsification, forge(ry), fraud, honesty, inclusion, integrity, misconduct, law, policy, society, subject(s), regulation, workplace

If the title of the course did not contain an ethics-related keyword, its course description was not examined. When a course title included a keyword, we closely analyzed the course description to assess the emphasis on ethics and categorize the courses: "ethics-focused," where course content focuses solely on ethics-related topics, and "ethics-inclusive," where course content includes ethics-related topics as a secondary focus.

Furthermore, we determined whether ethics courses were either required or offered as electives in their respective degree programs. The departments offering courses were not limited to the department granting the degree. For example, an ethics course required for a B.S. in physics might be administered by the mathematics department rather than the physics department. Additionally, a single STEM ethics course might be offered by multiple programs.

This search method does not identify all possible methods of including ethics in a B.S. program. Some ethical issues may be addressed in courses that do not include the keywords listed above in their catalog copy. For instance, it is likely that some lab courses address ethical issues (e.g., laboratory safety), even if the issues are not explicitly identified as relating to ethics. Ethical issues may also be addressed in department seminar programs or other extracurricular activities. Our goal was simply to determine which departments include in their curriculum a course whose primary or secondary focus is on ethics.

Results

The data suggest that scientific ethics-focused courses are not included in a majority of B.S. curricula among all institutional categories. Table 2 exhibits some broad findings. Ethics-focused courses appear in 49% of biology curricula, 20% of chemistry curricula, and 6% of physics curricula. Among the institutional categories, large public institutions offer ethics in biology and chemistry programs most frequently, whereas small private and small public schools both offer ethics in physics programs most frequently. However, the numbers in the physics group are small enough that differences between the institutional categories are not likely to be meaningful.

Table 2: Categorized Percent of Schools with Ethics-Focused Courses in Respective B.S. Curricula

Type of School	Offers Course(s) in Biology Ethics to Biology Majors	Offers Course(s) in Chemistry Ethics to Chemistry Majors	Offers Course(s) in Physics Ethics to Physics Majors
Large, Private	50 %	10 %	0 %
Large, Public	65 %	35 %	5 %
Small, Private	40 %	10 %	10 %
Small, Public	40 %	25 %	10 %
All School Types	49 %	20 %	6 %

These results are not surprising. Students pursuing biological studies are more likely to enter the health sciences, and the relevance of bioethics to the health sciences puts biology departments in a position to offer such courses more frequently than other departments. Perhaps large institutions tend to offer biology and chemistry ethics courses more frequently due to a greater number of faculty, which may provide a wider range of expertise and allow for specialty courses to exist.

Upon expanding the course search criteria to count courses that include scientific ethics as a secondary focus, we found that for any institution type, the majority of biology curricula (57%) contained ethics-inclusive courses, followed by 34% of chemistry curricula and 17% of physics curricula (Table 3).

Table 3: Categorized Percent of Schools with Ethics-Inclusive Courses in Respective B.S. Curricula

Type of School	Offers Course(s) in Biology Ethics to Biology Majors	Offers Course(s) in Chemistry Ethics to Chemistry Majors	Offers Course(s) in Physics Ethics to Physics Majors
Large, Private	65 %	30 %	25 %
Large, Public	85 %	45 %	20 %
Small, Private	65 %	25 %	25 %
Small, Public	70 %	70 %	15 %
All School Types	71 %	42 %	20 %

No changes were made to the relative frequency of each course offering among disciplines. However, a striking difference occurs between Tables 2 and 3: while 25% of chemistry departments in small public institutions offer ethics-focused courses (Table 2), 70% of those departments in small public institutions offer ethics-inclusive courses (Table 3).

We also examined whether the institution category was correlated with course offerings. Large institutions offer scientific ethics-focused courses more frequently than small institutions with the exception of courses in physics, while public institutions offer such courses more frequently than private institutions (Table 4). The differences are not great, however: more institutions would need to be studied in order to determine if these differences are more than just statistical fluctuations.

Table 4: Scientific Ethics Courses offered with Respect to Institutional Size and Private/Public Status

Type of School	Offers Course(s) in Biology Ethics to Biology Majors	Offers Course(s) in Chemistry Ethics to Chemistry Majors	Offers Course(s) in Physics Ethics to Physics Majors	Mean Frequency of Ethics Course Offerings in Biology, Chemistry, and Physics
Large	58 %	23 %	3 %	28 %
Small	40 %	18 %	10 %	23 %
Private	45 %	10 %	5 %	20 %
Public	53 %	30 %	8 %	30 %
All School Types	49 %	20 %	6 %	25 %

Surprisingly, private institutions are least likely to offer ethics courses among all fields and especially in chemistry, despite the increased interest in ethics-forward policy among industry organizations such as the American Chemical Society. Further study would be required to understand this result.

Table 5 outlines whether ethics courses are required in their respective programs. Ethics courses are required in less than 25% of B.S. programs among all institution and program categories. Large public schools most frequently required ethics courses as part of their chemistry B.S. curricula, and taken as a group, public institutions were more likely to require ethics-related courses than private institutions.

Table 5: Categorized Percent of Schools with Required Ethics-Centric Courses in Respective B.S. Curricula

Type of School	Biology Program Requires Course(s) in Ethics	Chemistry Program Requires Course(s) in Ethics	Physics Program Requires Course(s) in Ethics
Large, Private	0 %	5 %	0 %
Large, Public	10 %	20 %	0 %
Small, Private	5 %	5 %	0 %
Small, Public	15 %	15 %	5 %
All School Types	8 %	11 %	1 %

Among the 80 institutions we surveyed, it is not surprising that only one small public institution required an ethics course as part of its physics B.S program, based on the small number of physics departments offering such a course as an option in Table 3. It is interesting that while chemistry departments had noticeably fewer ethics courses available than biology departments (see Tables 2 and 3), chemistry and biology departments were approximately equally likely to require such a course in their programs.

Table 6 suggests that ethics courses are more frequently offered as electives than requirements. Among all institution and program types, biology B.S. programs most frequently offer elective credit for ethics courses at large public institutions:

Table 6: Categorized Percent of Schools with Elective Ethics-Centric Courses in Respective B.S. Curricula

Type of School	Biology Program Offers Elective Course(s) in Ethics	Chemistry Program Offers Elective Course(s) in Ethics	Physics Program Offers Elective Course(s) in Ethics
Large, Private	50 %	5 %	0 %
Large, Public	65 %	20 %	5 %
Small, Private	35 %	10 %	10 %
Small, Public	35 %	10 %	5 %
All School Types	46 %	11 %	5 %

Some institutions both require ethics courses and offer ethics courses as electives in their respective programs, so the "elective" and "required" course categories are not mutually exclusive.

Some ethics course content is highly specialized, e.g., "Medical Laboratory Professionalism" (required 400-level course, 2 credits, Biomedical Lab Science program, Michigan State University). Other courses cover a broad range of ethical issues. Among other things, women in STEM, university politics, and communication with the public are mentioned in a "Tools of Science Seminar" (elective upper-level course, 2 credits, Biology program, Georgia Institute of Technology). A few courses are focused on DEI and/or workplace conduct topics, and have titles such as "Culture and Success in Science and Mathematics" (elective 200-level course, 3 credits, all STEM programs, Kennesaw State University).

When offered for credit in a degree program, ethics courses range from 1 to 4 standard credits. The average number of standard credits offered both for any course subject and any institution type is 2.3 credits.

Discussion

The National Science Foundation requires all students supported on NSF grants to receive training in the responsible and ethical conduct of research (RECR). The fact that this requirement applies uniformly over all STEM fields, and that this requirement in turn originated in the America COMPETES Act, is a sign that there is broad agreement that RECR is relevant to all STEM fields (NSF 2024). Moreover, leading professional societies in these STEM fields have well developed codes of ethics, and many now have committees whose focus is on ethics. In this context, it is noteworthy that the distribution of opportunities for undergraduate courses in STEM ethics is not uniform across all disciplines. This survey of course offerings suggests a clear order: biology provides ethics education opportunities most frequently, followed by chemistry and then physics.

It seems likely that biology ethics courses are most frequently offered because biological research involves living organisms, and that type of research often raises ethical issues involving weighing the concerns of one individual (or species) against those of another. We can speculate that, to the extent opportunities are available for RECR education in chemistry, they might be rooted in the partial overlap in the fields of chemistry and biology, and in the link between parts of the field of chemistry with environmental issues. It is possible that some historical research could help clarify this point.

The physics community appears to be more reluctant to embrace a comprehensive and focused approach to ethics education. There may have been a general sense that fraud cannot occur (or at least cannot survive long) in physics since physics relies on objective, numerical data. That myth was shattered by the separate cases of Ninov and Schon around 2002. While both cases seemed to involve fraud, they can both be used as case studies with positive components. The Ninov case (Schwarzschild 2002) illustrates the proper way for coauthors to take action when a problem with a publication is discovered. The Schon case (Levi 2002) led to the expansion of American Physical Society ethical guidelines by addressing the responsibilities of coauthors. These cases, however, did not lead to a significant increase in interest in the area of undergraduate RECR courses among physics degree programs. Furthermore, the physics community has continued to struggle with supporting underrepresented groups within its field, both in the student population and in the professional community.

As our results suggest, scientific ethics can be examined through many lenses in the classroom. Some courses seem to revolve around DEI topics, while others focus on building interpersonal skills to manage ethical dilemmas in the workplace; still others work through hazard management protocol in the lab. In general, many of the courses we explored aim to build students up as ethics-minded members of the scientific community.

Because our results are based on course catalog information, it is possible that our data may exclude some courses that include ethics as a secondary focus–catalog descriptions may not capture all elements of a course. Also, there may exist additional methods of integrating ethics into undergraduate curricula by non-classroom means: for example, a STEM department might sponsor an annual day of career exploration including a panel on scientific ethics. Future surveys of scientific ethics courses may find it useful to contact individual departments in order to determine where ethics are integrated, if not through courses with "ethics" or similar keywords in their titles or course descriptions. We would anticipate that this next level of investigation would provide greater insight into all the ways undergraduate students are exposed to ethics related training. That more detailed picture could then be used to develop new strategies for ensuring a comprehensive and complete ethics education in STEM fields.

Note: With two exceptions, we have chosen not to list the institutions that we used for this study. Our intent is not to provide information about programs at a given institution but rather to identify trends in the U. S. Researchers wishing to replicate this work or expand upon it can contact one of the authors (jthomsen@emich.edu) for further details.

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