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Views on ethical issues in research labs: A university-wide survey

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ABSTRACT

In this article, we summarize the key findings of an exploratory study in which students and faculty completed a survey that sought to identify the most important ethical issues in STEM fields, how often these issues are discussed in research groups, and how often these ethical issues come up in the daily practice of research. Participants answered a series of open-ended and Likert-scale questions to provide a detailed look at the current ethical landscape at a private research university in the Midwest. The survey also looked at potential differences between faculty and undergraduate and graduate students' perceptions in answering these questions. The results indicate that while all community members tended to view issues that can be classified as research misconduct as the most important activities to avoid in STEM-related research, the level of discussion and actual witnessing of these practices was relatively low. The study points to a consensus among students and faculty about the important ethical issues in STEM and the need for more discussion and attention to be paid to communication, collaboration, and interpersonal relationships in the research environment.

KEYWORDS

Ethics, research ethics, responsible conduct of research, STEM, research culture

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I. Introduction

Responsible Conduct of Research (RCR) education has gone through a number of shifts in the past 30 years (Steneck and Bulger 2007). Where science was once seen to be self-regulating, a plethora of high-profile cases in all of the STEM disciplines have shown that there is a need for greater attention to be paid to the education of scientists and engineers in the areas of professional responsibility and research integrity (Martinson, Anderson, and De Vries 2005).

The National Institutes of Health (NIH) define responsible conduct of research as "the practice of scientific investigation with integrity. It involves the awareness and application of established professional norms and ethical principles in the performance of all activities related to scientific research" (National Institutes of Health 2009), and this is the definition used throughout this paper. Traditionally, this topic is broken down into the following themes: research misconduct; protection of human subjects; research involving animals; authorship and publication practices; mentor/training responsibilities; data issues, e.g., ownership, management, acquisition; and conflicts of interest (Office of Research Integrity 2000). RCR education along those lines has become an integral part of the education of STEM scientists. However, recent developments in the area of RCR education are pushing this curriculum to include more diverse subjects, such as issues of diversity and inclusion, sexual harassment, and collaboration – both internally in the research group and externally with colleagues from around the world, as well as new, emerging issues such as the use of big data in research (Watts et al. 2017).

For the purposes of this study, we define "lab culture" as "a common set of practices, beliefs, values, and symbols that are shared and or negotiated among members of a research lab." In this sense, the study seeks to investigate potential differences as to how students and faculty understand the importance, level of discussion about, and prevalence of a series of behaviors that have a bearing on the overall integrity of research. We also are using the definition of a research environment provided by the Institute of Medicine's 2002 report on scientific integrity that defines this term as "the combined social and cultural conditions that influence the life of an individual investigator, research unit, or research institution" (IOM 2002, 30). This survey did not seek to measure the ethical climate of research labs, though quite a bit of interesting work has recently been done in this area (Martinson, Thrush, and Crain 2013; Solomon et al. 2021).

The ethical culture in research environments and knowledge about and awareness of ethical issues in STEM research labs matter in several regards:

1. The ethical culture in research labs and the daily situation students and researchers encounter is of enormous importance not only for research integrity but also for the well-being of students, faculty, and staff (Weil and Arzbaecher 1996; Haven et al. 201; Schraudner, Hochfeld, and Striebing 2019; Woolston 2019).
2. The ethical culture in research labs directly relates to the quality of research emerging from these groups, future researchers' professional development, and ultimately public trust in science (Weil and Arzbaecher 1996; DuBois et al. 2013). In the 2017 report from the National Academies of Science, Engineering, and Medicine, the authors state," … if detrimental research practices are tolerated at the laboratory or department level, it can lead to a vicious circle where young researchers perpetuate these practices in the belief that they are behaving appropriately" (National Academies of Sciences, Engineering, and Medicine, Policy and Global Affairs, Committee on Science, Engineering, Medicine, and Public Policy, Committee on Responsible Science 2018).
3. While traditional RCR education has turned out to be of limited success, there is an ongoing search for more effective approaches (Watts et al. 2017). One promising approach is to better take the lab environment into account (Kalichman 2014; Plemmons et al. 2020).

For alternative approaches based in research environments, it is essential to know more about the research labs' situation and researchers' views and experiences concerning ethical issues in STEM labs. All of this is indicative of the ethical culture of research labs. Studies looking at the prevalence of research misconduct in federally funded research (Anderson 2007; Martinson, Anderson, and De Vries 2005; Titus, Wells, and Rhoades 2008), the views of experienced researchers on what ethics topics are most dangerous to the validity of the research (Bruton et al. 2020; Shaw and Satalkar 2018) and the effectiveness of RCR educational approaches (Mulhearn et al. 2017; Torrence et al. 2017; Watts et al. 2017) abound.

However, several key questions still exist. What are faculty and student views on what matters from an ethical point of view in research labs? What are the ethical issues they encounter in the lab? Knowing about what researchers consider ethical issues in STEM, what ethical issues they encounter in STEM labs, and what they consider central to the ethical culture of research environments provides important input for discussing the above three aspects.

To identify factors relevant to the ethical conduct of research in different STEM fields, the authors conducted a broad survey of faculty and students. The survey asked a series of questions that explored what ethical topics faculty and students considered most important, which of these ethical issues they have actually encountered in their research, and finally, how their research group sought to resolve these issues after they arose. The goal was to provide a snapshot of the faculty and students' experiences and views. The survey serves to shed some light on researchers' views on which factors are central for the ethical conduct of STEM research and allows us to think about important factors for building ethical research cultures.

II. Methods

In 2017, faculty, staff, and students at a private, technical university in the midwestern United States were surveyed about their experiences in STEM research labs. The study was approved by the institutional review board of the authors' university. A pilot of the questionnaire was sent out to 10 volunteer students and faculty, and revised based on their feedback. Responses to the final survey were kept confidential, and no personal information (such as names or e-mail addresses) was connected with the data. Participants were recruited through an e-mail sent by department administrators and on-campus, where they were offered snacks in exchange for their participation over a series of 4 weeks. Participants needed to be a member of the university community enrolled in a STEM program and have some research experience in a lab or a class to take the survey. Respondents were also given the opportunity to participate in a raffle, where three winners would receive a $25 gift card.

The survey included 72 items, some of which were open-ended questions, while the majority utilized a Likert-style scale. The survey collected demographic information about participants, including departmental affiliation, their current position at the university (undergraduate, masters, Ph.D. student, faculty, staff), their level of research experience, and asked participants about their views on and experiences with ethical issues in STEM research labs. A copy of the complete survey can be found in Appendix I.

A. Survey content

For the purposes of this research, questions on what the respondents consider ethical issues in STEM and on which ethical issues they have encountered in research labs at their current university have been analyzed to answer the above research questions. In this context, the survey asked both closed questions and open-ended questions. The closed questions offering Likert-scale response options included the following:

- "Please rate the importance of avoiding the following activities in your research group(s) [at your current university]. The Likert-scale response options for these questions were 1 = slightly important; 2 = moderately important; 3 = important; 4 = very important; and No basis for judgment;
- Please rate how often you have discussed the following activities in your research group(s) [at your current university]. The Likert-scale response options for these questions were 1 = never; 2 = rarely; 3 = sometimes; 4 = often; 5 = always; and No basis for judgment; and
- "Please rate how often you have actually seen or experienced the following activities in your research group(s) [at your current university]. "The Likert-scale response options for these questions were 1 = never; 2 = rarely; 3 = sometimes; 4 = often; 5 = always; and No basis for judgment.

For each of these three questions, 18 answering options/items were offered. The 18 items were taken in slightly modified form from the list of questionable behaviors developed by Anderson et al. (2007). In their survey, respondents were asked about a series of behaviors ranging from outright research misconduct to ethically questionable or "gray" practices. These researchers identified 27 different ethical violations and measured the number of scientists who reported having engaged in one or more of these activities. From their list of 27 items, the research team chose 18 that related most directly to the type of research being done at the university, including eliminating questions related to animal use and questions that only applied to supervisors or faculty.

- Falsifying or "cooking" research data
- Ignoring aspects of human-subject requirements
- Unauthorized use of confidential information
- Failing to present data that contradicts your own research

- Overlooking others' use of flawed data or questionable interpretation of data
- Changing the design, methodology, or results of a study in response to pressure from a funding source
- Publishing the same data or results in two or more publications
- Inappropriately assigning authorship credit
- Withholding details of methodology or results in papers or proposals
- Dropping observations or data points from analyses based on the gut feeling that they were inadequate
- Inadequate record-keeping related to research projects
- Using inadequate or inappropriate research designs
- Not being mentioned/considered adequately as an author
- Issues related to hierarchy
- Communication problems
- Not giving credit when using another's words or ideas
- Ignoring safety regulations
- Lack of team spirit

In addition to the Likert-scale questions, the following open-ended questions were asked to help shed light on respondents' individual experiences. These open-ended questions were asked in the first section of the survey before the Likert-scale questions to not prejudice the respondents when responding.

The open-ended questions included the following:

• "What ethics topics do you think are most important in the research group(s) you have worked in (at your university)?"

• "In a sentence or two, please describe ethical issues (if any) you have encountered in your current research group(s) (at your university)." and

• "How did your research group(s) deal with these issue(s) when they came up?"

In addition, the question "Where do you currently go to find advice on how to resolve ethical issues that may come up in your current research group(s)?" was asked. Respondents could only choose one answer or write in their own response in "other." Options were Colleagues/Coworkers; Research group supervisor/department chair; Existing ethical guidelines or policies from funding organization (NIH, NSF, etc.); Online resources; (Unnamed University) Administration (IRB Office, Office of Sponsored Research); and "Other."

B. Sample

Two hundred thirty-three individuals consented to participate in the study out of an overall population of 3,000 undergraduate students, 2,300 graduate students, and 400 faculty. After reviewing the initial survey data, the research team decided to eliminate the answers from individuals with less than three months of experience in a lab. This dropped the overall sample size down to 142 individuals. The justification for this change was to ensure that respondents had enough experience in the lab environment to make their responses valid.

III. Results

A. Likert-scale questions

Of the 233 responses we received, five cases were removed due to an unclear early version of the survey that rendered some of the responses uninterpretable. For this set of questions, the research team also chose to eliminate "no basis for judgment" responses to the questions on an item by item basis rather than eliminating all the responses from any participant who responded "no basis for judgment" to one or more questions, as this answer did not lend itself to interpretation. The total number of responses received for each question is indicated in the N column of the tables below. Due to an error found in the Likert scale for the question, "Please rate the importance of avoiding the following activities in your research group(s) [at your current university]" that omitted the "not important" option on a 5 point scale with 1 being "not important" and 5 being "very important"), the research team had to decide on a method to allow for the comparison between this question and the questions looking at the rate of discussion and rate of these activities being seen or experienced by the respondents. To do so, the team decided to take the 1–5 scale for question one, which equated 1 = "slightly important" and 5 as "very important," to 0–4, and to move the 1–5 scale used in the later questions to a 0–4 scale, with 0 being "never" and 4 being "always." Because of this error, the responses to the question, ""Please rate the importance of avoiding the following activities in your research group(s) [at your current university]." are slightly deflated than they might have been initially if the mistake in the Likert scale had not been made, and must be interpreted accordingly. The overall mean for each item is expressed in Table 1–3.

Table 1. Responses to the question, "Please rate the importance of avoiding the following activities in your research group(s) [at your university] (Table view)

Importance – How important, where 0- not important, and 4 – very important	All Responses			Faculty			Students		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Falsifying or "cooking" research data	141	**2.84**	0.525	39	3	0	102	2.78	0.607
Unauthorized use of confidential information	136	**2.83**	0.495	38	2.92	0.359	98	2.8	0.536
Failing to present data that contradicts your own research	141	**2.83**	0.506	40	2.93	0.35	101	2.79	0.553
Overlooking others' use of flawed data or questionable interpretation of data	143	**2.81**	0.503	39	2.9	0.384	104	2.78	0.539
Withholding details of methodology or results in papers or proposals	141	**2.81**	0.533	40	2.78	0.62	101	2.82	0.498
Using inadequate or inappropriate research designs	141	**2.81**	0.52	40	2.83	0.501	101	2.8	0.53
Ignoring aspects of human-subject requirements	123	**2.8**	0.538	31	2.94	0.359	92	2.76	0.581
Inappropriately assigning authorship credit	140	**2.79**	0.56	40	2.85	0.483	100	2.76	0.588
Dropping observations or data points from analyses based on the gut feeling that they were inadequate	140	**2.79**	0.487	40	2.85	0.362	100	2.77	0.529
Not giving credit when using another's words or ideas	138	**2.79**	0.546	39	2.85	0.489	99	2.77	0.568
Ignoring safety regulations	133	**2.78**	0.527	36	2.78	0.54	97	2.78	0.525
Inadequate record-keeping related to research projects	142	**2.77**	0.538	40	2.85	0.483	102	2.75	0.557
Not being mentioned/considered adequately as an author	140	**2.77**	0.541	40	2.78	0.53	100	2.77	0.548
Changing the design, methodology, or results of a study in response to pressure from a funding source.	138	**2.74**	0.583	38	2.71	0.611	100	2.75	0.575
Communication problems	140	**2.73**	0.561	39	2.74	0.549	101	2.72	0.568
Publishing the same data or results in two or more publications.	135	**2.59**	0.673	39	2.64	0.584	96	2.56	0.708

Importance – How important, where 0- not important, and 4 – very important	All Responses			Faculty			Students		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Issues related to hierarchy	129	**2.55**	0.696	35	2.46	0.741	94	2.59	0.679
Lack of team spirit	137	**2.5**	0.677	38	2.53	0.647	99	2.49	0.691

Table 2. Responses to the question, “Please rate how often you have actually seen or experienced the following activities in your research group(s) here at your university (Table view)

Experience – How often do you experience, where 0- Never and 4 – Always	All Responses			Faculty			Students		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Communication problems	140	1.16	1.16	38	1.47	0.98	102	1.04	1.21
Lack of team spirit	138	1.07	1.17	37	1.19	0.97	101	1.03	1.24
Ignoring safety regulations	139	0.78	0.98	38	1.18	0.98	101	0.63	0.95
Issues related to hierarchy	133	0.74	1.03	35	1.06	0.97	98	0.63	1.04
Not being mentioned/considered adequately as an author	138	0.70	0.95	38	1.03	0.94	100	0.57	0.92
Inadequate record-keeping related to research projects	138	0.69	0.97	38	1.05	1.01	100	0.55	0.93
Changing the design, methodology, or results of a study in response to pressure from a funding source.	131	0.66	1.06	34	0.71	0.80	97	0.65	1.15
Inappropriately assigning authorship credit	137	0.65	0.93	38	0.84	0.92	99	0.58	0.93
Ignoring aspects of human-subject requirements	136	0.65	0.98	37	0.78	1.00	99	0.60	0.97
Publishing the same data or results in two or more publications.	138	0.64	1.02	38	0.97	1.05	100	0.52	0.98
Overlooking others’ use of flawed data or questionable interpretation of data	139	0.60	0.89	39	0.69	0.89	100	0.56	0.89
Withholding details of methodology or results in papers or proposals	138	0.56	0.84	39	0.59	0.85	99	0.55	0.84
Dropping observations or data points from analyses based on the gut feeling that they were inadequate	138	0.55	0.90	38	0.61	0.86	100	0.53	0.93
Not giving credit when using another’s words or ideas	138	0.54	0.88	38	0.61	0.82	100	0.52	0.90
Using inadequate or inappropriate research designs	135	0.44	0.88	38	0.32	0.66	97	0.48	0.95
Unauthorized use of confidential information	123	0.42	0.85	34	0.29	0.58	89	0.47	0.93
Failing to present data that contradicts your own research	137	0.34	0.77	38	0.18	0.39	99	0.40	0.87
Falsifying or “cooking” research data	140	0.34	0.80	39	0.23	0.54	101	0.39	0.88

Table 3. Responses to “Please rate how often you have discussed the following activities in your research groups at your university.” (Table view)

Discuss – How often do you discuss, where 0 – Never and 4 – Always	All Responses			Faculty			Students		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Communication problems	142	1.84	1.25	40	2.15	1.14	102	1.72	1.27
Overlooking others’ use of flawed data or questionable interpretation of data	141	1.82	1.27	40	1.95	1.24	101	1.76	1.28
Withholding details of methodology or results in papers or proposals	139	1.81	1.28	40	2.05	1.26	99	1.71	1.28

Discuss – How often do you discuss, where 0 – Never and 4 – Always	All Responses			Faculty			Students		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Inadequate record keeping related to research projects	139	1.78	1.36	40	2.18	1.41	99	1.63	1.31
Issues related to hierarchy	136	1.70	1.44	35	2.09	1.50	101	1.56	1.40
Ignoring safety regulations	140	1.69	1.37	40	1.88	1.38	100	1.62	1.37
Publishing the same data or results in two or more publications.	140	1.67	1.40	40	1.98	1.46	100	1.55	1.37
Inappropriately assigning authorship credit	139	1.66	1.40	40	1.98	1.44	99	1.54	1.37
Failing to present data that contradicts your own research	137	1.66	1.35	39	1.85	1.39	98	1.58	1.34
Unauthorized use of confidential information	121	1.65	1.41	31	1.65	1.58	90	1.66	1.36
Not giving credit when using another's words or ideas	139	1.60	1.32	40	1.83	1.48	99	1.52	1.24
Falsifying or "cooking" research data	138	1.59	1.30	39	1.72	1.26	99	1.54	1.32
Ignoring aspects of human-subject requirements	137	1.53	1.31	38	1.87	1.34	99	1.40	1.28
Dropping observations or data points from analyses based on the gut feeling that they were inadequate	136	1.51	1.34	40	1.88	1.47	96	1.36	1.26
Not being mentioned/considered adequately as an author	139	1.49	1.32	39	1.67	1.32	100	1.42	1.31
Lack of team spirit	138	1.34	1.31	37	1.41	1.30	101	1.32	1.32
Using inadequate or inappropriate research designs	134	1.32	1.30	38	1.16	1.31	96	1.39	1.29
Changing the design, methodology, or results of a study in response to pressure from a funding source.	133	1.27	1.27	36	1.33	1.24	97	1.25	1.29

Respondents came from over 20 different departments: Mechanical, Materials, and Aerospace Engineering (24.6%), Biomedical Engineering (17.1%), Psychology (11.8%), Computer Science (9.2%), and Civil, Architectural, and Environmental Engineering (6.1%), among others. The majority of respondents were male (62.3%). In terms of their role at the university, 18.4% were faculty/staff (of the 40 in this group, 38 were faculty, 2 were staff), 20.6% were Ph.D. students, 20.2% were master's students, and 39.5% were undergraduate students. The researchers did not request race/ethnicity information, but 54.4% of the student sample identified themselves as domestic students, 32.9% identified themselves as international students, and 12.7% chose not to disclose this information. For this study's purpose, the researchers decided to group the undergraduate, masters, and Ph.D. students together and the faculty/staff together. Dividing the populations into smaller categories proved to be uninformative when analyzing the data due to the the small size of the sub-groups.

The data gathered through the Likert-scale questions was analyzed, and responses for individuals who did not complete the whole survey were removed. The research team applied a chi-square test of independence to compare results between students and faculty, but no statistically significant differences appeared. The authors then decided to look at the overall mean and standard deviation between the items to draw conclusions from the data gathered.

Regarding the statement, "Please rate the **importance** of avoiding the following activities in your research group(s) [at your university]," there was not a significant spread in how the participants ranked these issues (2.5–2.84, or moderately important to important), and the overall standard deviation between answers was relatively low (less than 1). Overall, respondents ranked activities that deal with data management as being the most important activities to avoid **(see** Table 1). This includes falsifying or "cooking" research data, the unauthorized use of confidential data, and failing to present data that

contradicts your work. Of the top ten activities to avoid, six of these activities involve data and research methodologies. The last three activities to avoid included publishing the same data in two or more publications, issues related to hierarchy, and lack of team spirit. Overall, the responses were very similar between faculty and students.

To compare the difference between the importance of avoiding certain behaviors and how prevalent these activities are, the survey asked how often lab workers have seen or experienced ethically problematic activities **(see** Table 2). The level of experiencing these issues ranked relatively low, ranging from 1.16–0.34, or between never and sometimes. The standard deviation between these answers, however, was a bit higher, with the top-ranked two issues having a standard deviation over 1.

Two items, "Communication problems" and "Lack of team spirit," were ranked considerably higher than the other issues. They were followed by "Ignoring safety regulations," "Issues related to hierarchy," "Not being mentioned/considered adequately as an author," and "Inadequate record-keeping related to research projects." Of the top five ranked issues, three relate to group dynamics: communication problems, lack of team spirit, and issues related to hierarchy. The four items that were seen or experienced the least often are "Using inadequate or inappropriate research designs, "Unauthorized use of confidential information", "Failing to present data that contradicts your own research", and "Falsifying or 'cooking' research data."

In general, faculty gave slightly higher ratings for all but the four lowest-ranked items, suggesting that they had seen or experienced the mentioned issues more often than students. The four lowest-ranked items were rated slightly higher by the students, however.

Regarding the statement, "Please rate how often you have discussed the following activities in your research groups at your university" **(see** Table 3), the overall discussion level of the 18 activities was relatively low and did not show a broad spread, ranging from 1.27–1.84, falling between rarely and sometimes. However, the standard deviation for all the items is well over 1, thereby indicating a wider spread of answers from both faculty and students on these issues. This likely indicates a fair degree of variation between labs in terms of how often these issues are discussed.

Communication problems, which ranked as less important in terms of ethical issues to avoid than 13 other activities, came up as the most discussed among lab groups. Faculty seemed to see this issue as slightly more important than students (2.15 vs. 1.72). Participants overall rated discussions of issues around data handling and research methodologies and issues that related to data quality as happening more regularly, including the issues of overlooking another's use of flawed or questionable data ranked as the second most often discussed and the withholding of methodology details as the third most often discussed.

Faculty were routinely higher in rating the level of discussion than students. The two items that broke this trend were about the activities of "Unauthorized use of confidential information" and "Using inadequate or inappropriate research designs."

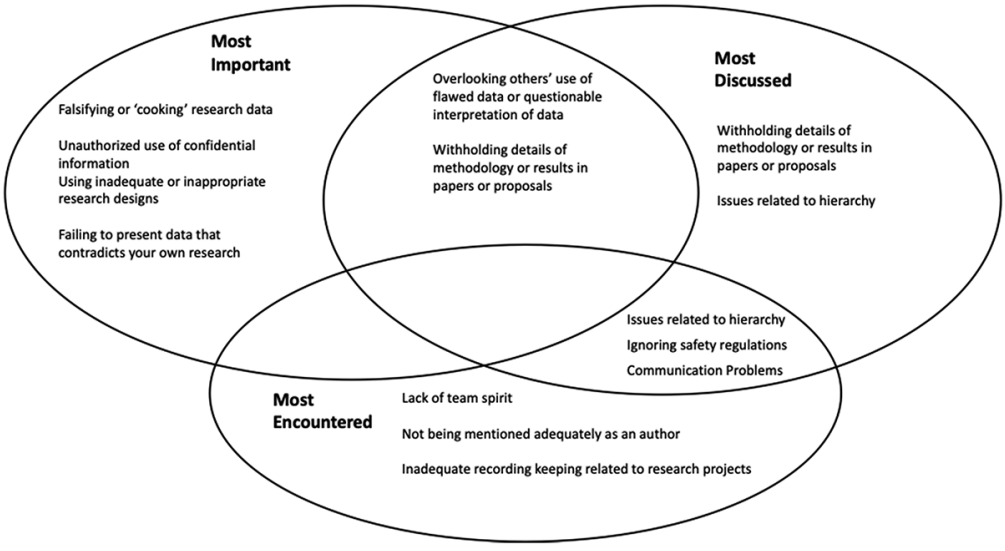
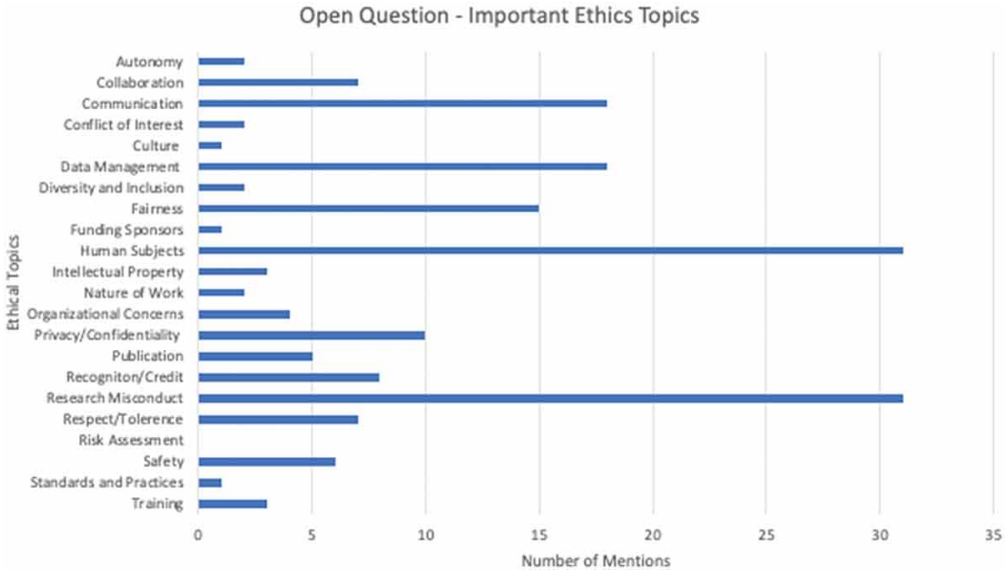


Figure 1. Venn diagram of total responses of ethical issues seen as the six highest ranked in importance, discussed and encountered items

Overall, there was little correlation between the sorts of ethical issues that were discussed versus the kinds of ethical issues actually encountered, other than "Communication problems" that came up as the 1st ranked item for each Likert-scale question, "Issues related to hierarchy," which ranked as the 5th most discussed issue and the 4th most encountered issue, "Ignoring safety regulations" which was the 6th most discussed issue and the 3rd most encountered, and "Inappropriately being mentioned/considered adequately as an author" which ranked 8th for both questions (see Figure 1).

Open-ended questions

Before completing the Likert-scale questions in this survey, respondents were asked a short series of open-ended questions to elicit individual reflections on ethical issues that can arise in research groups. Of the 233 respondents, a little less than half provided responses to these questions. This reduced response size could reflect a greater engagement in ethical issues among these respondents as compared to the overall sample size. The received comments were coded by three separate members of the research team using the RCR topics identified by the Office of Research Integrity (2000) as a starting point, and other codes were added by the team members as necessary. The team members then reconciled these codes through discussion of the individual comments. Several codes could be assigned to one answer. The total number of comments received for each question is noted below. Similar to the ranking questions, responses to the open-ended questions were further narrowed down to only include respondents who had at least three months of lab experience. Finally, the analysis excluded "not applicable" and unintelligible responses. This left 114 responses for open-ended question 1, 61 responses for question 2, and 70 responses for question 3.



Graph 1. Important ethical topics identified by respondents (open-ended questions) R = 114 responses

In response to the question, "What ethics topics do you think are most important in the research group(s) you have worked in (at your university)?" most responses were relatively short, just mentioning one or more key terms. However, some respondents paraphrased their answers more eloquently. For example, a faculty member in applied mathematics wrote, "Accurately communicating results, giving proper credit for contributions made," a Ph.D. candidate in computer science wrote, "Due diligence in ensuring that published results are not exaggerated, and not previously published." An undergraduate in biology wrote, "Honesty in reporting results, not withholding data that doesn't support a hypothesis."

Of the comments received, the most often ethics topics mentioned are “Research Misconduct” (31 times), “Human Subjects” (n = 31), “Data Management” (n = 18), “Communication” (n = 18), and “Fairness” (n = 15) (See Graph 1 for more details).

The ethics topics most frequently mentioned were further analyzed. Within the topic:” Research Misconduct”, several subtopics could be distinguished: Besides general comments (n = 7) such as “Ethics in research” or “Doing what is right instead of what is easy,” the most often mentioned subtopics were “Plagiarism” (n = 7), “Deception/Cheating/Fraud” (n = 7), “Academic Honesty/Dishonesty” (n = 4), and “Integrity” (n = 4). The most prominently mentioned subtopics in the topic “Human Subjects” were “Treatment – Harm/Risk” (n = 8), “Confidentiality/Privacy/Anonymity” (n = 7), “Informed consent,” (n = 6), and “Protection” (n = 4). In the category “Data Management,” the focus was on “Accurately Interpreting and Communicating Results” (n = 10) and “Data Integrity – Analysis, Appropriate Methodology, Accuracy” (n = 5). Under the topic “Communication,” respondents mentioned primarily “Honesty” (n = 10x) and “Transparency” (n = 5). Concerning “Fairness,” “Bias, Discrimination, Equality” (n = 8), and “Distribution of work” (n = 4) mattered most.

Graph 2. Ethical issues encountered by survey respondents (open-ended questions) N = 61 answers to question, “In a sentence or two, please describe ethical issues (if any) you have encountered in your current research group(s) (at your university).”

For the question of the ethical issues encountered, the most frequent ethical issues were “Human Subjects” (n = 21), “Data Management” (n = 13), “Organizational Concerns” (n = 10), and “Collaboration” (n = 9) (For details, see Graph 2). The most frequent human subject-related ethical issues mentioned were “Confidentiality, Privacy, Anonymity” (n = 7), “IRB Approval” (n = 3), “Treatment, Harm/Risk” (n = 2), “Informed Consent” (n = 2), and “Vulnerable Populations” (n = 2). With regard to “Data Management,” the ethical issues most frequently mentioned were “Data Integrity – Analysis, Appropriate Methodology, Accuracy” (n = 4), “Data Security” (n = 4), “Accurately Interpreting and Communicating Results” (n = 2), and “Data Acquisition” (n = 2). The responses that were coded as “Organizational concerns” referred to issues such as “Resources” (n = 5), “Hierarchy, Power Dynamics” (n = 2), “Quality of Research,” and “Financial Aspects” (n = 1).

Overall, responses to this question tended to be more explanatory than the responses to the first question. (For details, see Figure 2). While some comments dealt with issues that can clearly be seen as RCR topics,

others are more about collaboration or communication issues.

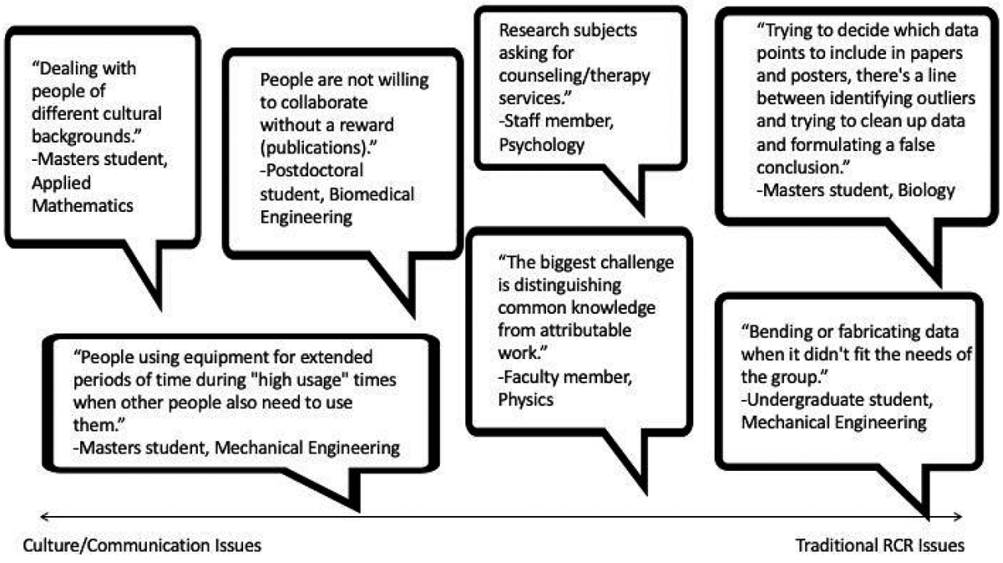


Figure 2. Responses regarding ethical issues encountered

In the third, open-ended question, respondents were asked, "How did your research group(s) deal with these issues when they came up? Answers within the category 'Communication' were most frequent (n = 28), followed by the category 'Collaboration' (n = 16), Human Subjects" (n = 14), "Organizational Aspects" (n = 12), "Standards and Practices" (n = 8) (See Graph 4 for details).

Graph 4. Solutions to ethical issues N = 70 Answers to question: How did your research group(s) deal with these issue(s) when they came up?

In the category "Communication," besides comments referring to general communication (n = 15) (for example, "Ca[l]mly asked everyone to settle down and talked through it,") communication with leadership was mentioned most frequently (n = 13). Some examples of this include, "There isn't a real method of handling this in our group. All we can do is report them directly to the supervisor", "We talked to our professor," and "talking with the supervisor." Some responses indicated that this resulted in the professor or PI solving the issue, "We consulted our professor, who eventually provided supplementary resources during the research." In contrast, others indicated a lack of response "We spoke to the professor, but there is not much that he did."

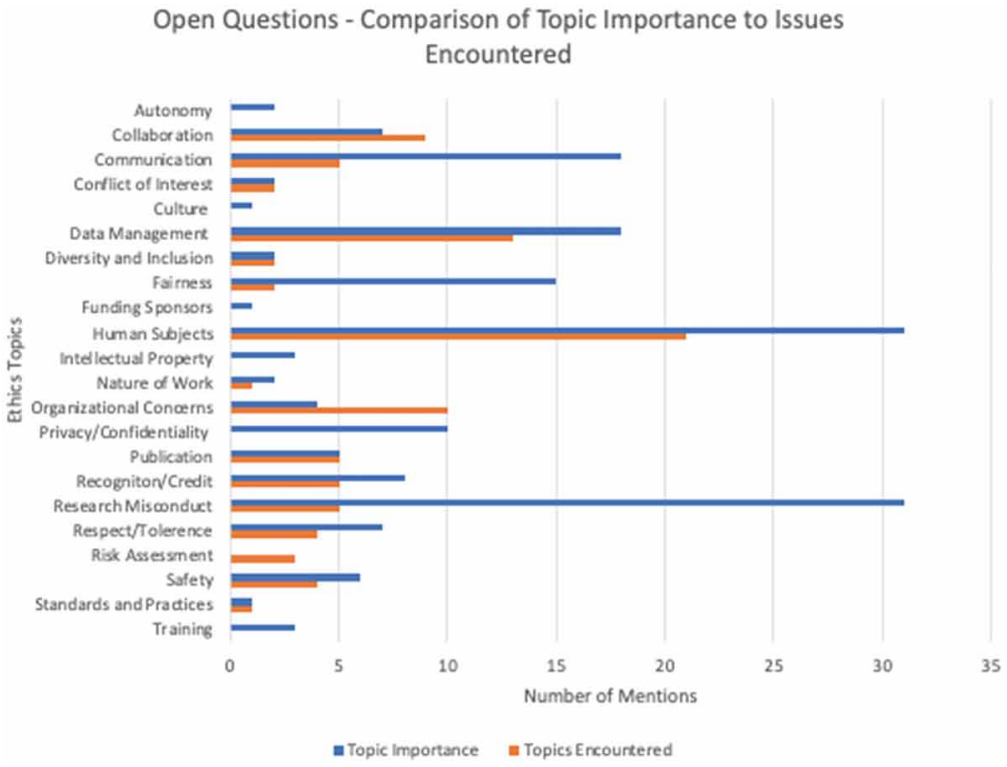
Answers categorized under "collaboration" often mentioned actions taken based on communication, such as "We try to solve it among us," "The member that wanted to fabricate/bend the data was outnumbered and told that we will not be fabricating data," or "List the possible solutions and pick the best one that would benefit all of us without putting anyone down." However, other responses indicated a failure to address the issue "They did not deal with them," or "Stay silen[t], does not want to rock the boat."

Responses in the category "Human Subjects" referred to how human subject research issues were resolved. Examples include the following quotes: "Deidentified data and kept data on online shared drives," "We have a debriefing session so the individual can talk about their feelings. We also have extra resources available if they feel emotional discomfort," or "Redoing surveys in which signatures weren't linked."

Among those responses that referred to organizational aspects or steps taken are, "To some degree, there are checkpoints put in place," "Created time limits on equipment during 'high usage' hours," and "Advisor is very strict about extreme assurance that all previous relevant work are mentioned and discussed in any publication."

Responses that referred to "Standards and Practices" included "We consulted ethical guidelines for the field as well as other researchers," "We undergo certification based on US federal research standards for human experimentation, and we make sure that our experimental protocols are approved by independent third party boards," and "They do try and follow the codes of conduct, but there are people who feel they are forced to follow them.".

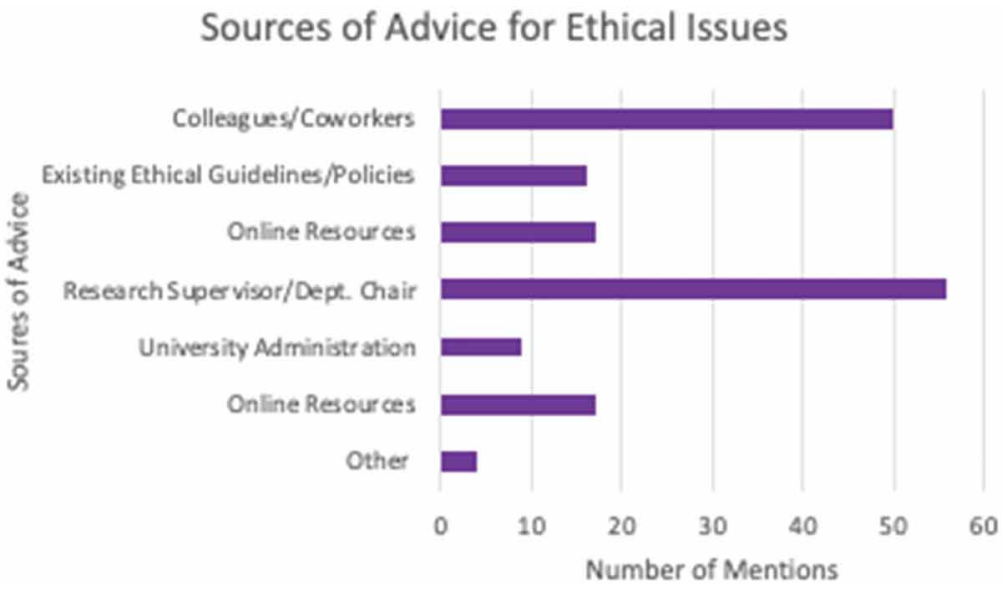
When comparing the extent to which respondents considered certain ethical topics important with the extent to which they encountered these issues in responses to the open-ended questions, the topic's importance is in general much higher than the actual incidence in the research groups. This difference is particularly striking for "Research Misconduct," "Fairness," "Communication," "Privacy/Confidentiality," and "Human Subjects," see Graph 5.



Graph 5. Comparison of topics considered important to topics encountered (open-ended questions)

However, there are a few exceptions. The number of respondents who indicated that they had experienced ethical issues related to "Collaboration," "Organizational Concerns," and "Risk Assessment" was higher than the number of respondents who said that they considered these topics ethically important.

This may point to a tendency to underestimate concerns related to these issues and be a reflection of the daily reality that communication and cultural issues loom larger and come up more frequently than research misconduct and questionable research practices, even though conclusions may be difficult to draw in view of the limited respondent number.



Graph 6. Sources of advice answers to question: Where do you currently go to find advice on how to resolve ethical issues that may come up in your current research group(s)? (Respondents could only choose 1 answer or write in their own answer in "Other") N = 155 responses

Finally, participants were asked to identify where they went to find advice on how to resolve ethical issues. Research supervisor/department chairs was mentioned most often (n = 54), followed by "Colleagues/Coworkers" (n = 50). Less than 20 participants responded, "Online Resources" (n = 17) or "Existing Ethical Guidelines/Policies (n = 16). The answer, "University Administration" was mentioned ten times. In the "other" category, respondents wrote in the following example responses: "Family," "Professor," "All of the Above," "Grant Funder," and "All except research group supervisor."

V. Discussion

A. What do students, faculty, and staff working in research labs consider the most important ethical issues in STEM research?

Our original hypothesis concerning this question was that we would find significant differences between ethical issues that students and faculty would see as important. Interestingly, the survey indicates that faculty, staff, and students share similar views on the closed question of how important it is to avoid certain activities or behaviors. Faculty and students generally agree on ranking the relevance of avoiding certain ethically problematic behaviors, with research misconduct and issues related to data management and research methodology ranked highest. This agreement may indicate that these two groups have similar ways in how they view the ethical culture of their joint research environment and share a culture of assessing ethical problematic activities and behaviors. This similarity may be a product of how RCR has been taught to students, as well as how they have been socialized into the lab environment. It also may indicate some form of response bias, showing that both students and faculty know which answers are more socially desirable.

On top of the list are "Falsifying or 'cooking' research data," "Unauthorized use of confidential information," and "Failing to present data that contradicts your own research" – all these activities are traditional RCR topics related to research misconduct. While the mean in the responses concerning the items

to avoid did not differ considerably, among the lowest-ranked items were “Communication problems,” “Issues related to hierarchy,” and “Lack of team spirit.” However, none of these issues were ranked below “moderately important.”

These findings are in line with the fact that current RCR education focuses more on “traditional” RCR topics rather than aspects that might be critical in building strong research cultures (National Academies of Sciences, Engineering, and Medicine, Policy and Global Affairs, Committee on Science, Engineering, Medicine, and Public Policy, Committee on Responsible Science 2018). The survey results also mirror other studies that found data mishandling as one of the most important activities to avoid. In a study by Bouter and colleagues (Bouter et al. 2016), respondents also ranked fabricating data as the activity most damaging to the truth and trustworthiness of science and damaging the trust that exists between lab members and the overall reputation of the lab group. A 2018 survey of 11,000 faculty members reported that 48% of respondents were concerned about data fabrication, falsification, and other kinds of research fraud (Blankstein and Wolff-Eisenberg 2019).

The fact that faculty tended to rate most of the mentioned items as slightly more important to avoid than students may indicate both a heightened awareness of these ethical issues and recognition of the relevance of these ethical issues for the integrity of the research process. The difference was highest for the item “Falsifying or ‘cooking’ research data”. While this heightened urgency among faculty to avoid ethically problematic activities may be due to past negative experiences, this may also indicate that, as faculty serve in a leadership role in the lab, they also have the most to lose in terms of reputation and scholarship, as well as potential sanctions that can be imposed on researchers found to be guilty of misconduct.

Notably, the closed question “How important is it to avoid x?” was responded to rather uniformly. There was not much of an overall difference between the responses obtained for the various items representing negative behaviors. This uniformity may indicate awareness of traditional RCR topics and the need to avoid problematic behaviors and to display socially expected behavior.

Concerning the open-ended question on the most important ethical issues in research groups, there is a relatively broad distribution of the frequency that these different ethics topics were mentioned. Some topics were mentioned more often, which indicates that they are considered more important than others. Overall, the answers to the open-ended questions draw more directly on the respondents’ immediate experience and are likely a more reliable indication of respondents’ immediate experience of their views on ethical issues in STEM labs and on what matters for ethical STEM research.

Similar to our findings from the closed, Likert-scale question on the most important ethical issues, “Research Misconduct’’ was one of the two most mentioned categories. The category “Data Management” was also frequently mentioned, indicating an awareness of ethical issues related to data management, such as accurately interpreting and communicating results and data integrity. Respondents also considered ethical issues related to human subjects research as central, as can be seen from the very frequent mentioning of the category “Human Subjects” and “Privacy/Confidentiality”.

Interestingly, a third broad theme was mentioned relatively often by the respondents, as can be seen from the relatively high frequencies of categories like “Communication,” “Fairness,” and “Respect/Tolerance.” While issues such as communication problems and issues related to fairness may not have been identified as key ethical issues by survey respondents when responding to the closed question, in the open-ended questions, communication and fairness did come up eighteen and fifteen times, respectively. Its prevalence in the open responses points to the important role communication, collaboration, fairness, and respect have from an ethical point of view when it comes to working in research labs or recognizing this importance from respondents who felt motivated to answer the optional open-ended questions. This may not be astonishing, as it reflects the role of communication, collaboration, and fairness for everyday interpersonal interaction in labs. The answers to both the closed and open-ended questions indicate that beyond the topics traditionally

stressed in RCR and RCR education, issues and skills related to communication and collaboration play an important role.

In line with this, in a 2018 article, Dubois and Antes identify five different dimensions of research ethics. The fifth dimension they identify, along with normative ethics, compliance with regulations, the rigor and reproducibility of science, and social value, is *workplace relationships*. They describe this as a newly identified aspect of research ethics, stating, "Although researchers may not have considered this dimension much previously, we believe it is integral to doing good research in a good manner" (DuBois and Antes 2018, 552). Students and faculty in this survey, while ranking issues of research misconduct and the proper handling of data as important, seem to recognize that building strong relationships with colleagues is a key ingredient to research's ethical practice. This can also be seen in responses to where individuals go for advice when dealing with ethical issues, which included coworkers and research supervisors as the highest ranked sources for this information (see Graph 5).

B. How widespread are these ethical issues?

In taking both the Likert-scale and open-ended questions together, we can explore how often participants have encountered ethical issues. Both sets of responses indicate that serious breaches of ethics are relatively low. Items that can be ranked as "Research Misconduct" were rarely mentioned in both groups of questions. This can be considered either as a promising finding that major ethical issues are not occurring or that these issues are happening but are not being recognized.

According to the open-ended question's answers, the most frequently encountered ethical issues are around "Human Subjects" research, followed by data management issues, organizational concerns, and issues related to collaboration. One might theorize that because of the need for research involving human subjects to be approved by an institutional review board and the substantial number of regulations surrounding this type of work, this issue often came up in the answers to open-ended questions regarding ethics.

Apart from the relatively high number of mentions in the "Human Subject" category, this is in line with the Likert-scale question's responses, whose top-ranked encountered issues also center around group dynamic issues. The most frequent issues mentioned as encountered in the closed question were "Communication problems" and "Lack of team spirit," followed by "Ignoring safety regulations" and "Issues relating to hierarchy." The ignoring of safety issues is an interesting break from this collection of issues and may reflect the fact that over 48% of our respondents came from an engineering-related field.

In general, faculty gave slightly higher scores in response to the question of ethical issues encountered, indicating that they had seen or experienced ethically problematic activities or behaviors more often than students. This is in line with faculty having spent more of their career in research labs than students. However, students ranked the four lowest-ranked items slightly higher: "Using inadequate or inappropriate research designs," "Unauthorized use of confidential information," "Failing to present data that contradicts your own research," and "Falsifying or 'cooking' research data." It may be speculated whether this could be due to the fact that faculty as supervisors may not be fully aware of these practices occurring (among students) or whether this could be interpreted as students implicitly criticizing the research methodologies utilized in their labs. While our sample did find that some problematic activities had occurred, the overall levels were extremely low.

C. How much of a topic are these ethical issues in research labs?

Overall, the response options to the Likert-scale question "How often have you discussed the following activities in your research groups at your university?" were rated relatively low. It is unclear, though, what these responses imply. If things are never or only rarely discussed – does this mean no news is good news, in the sense that these aspects do not really matter in the lab and for this reason are not brought up often? Or

does this mean that potential or real ethical issues are not often discussed in labs, in the sense of there is no explicit mention of them? Interestingly, communication problems were ranked highest in the Likert-scale question (Table 3), looking at how often the listed ethical issues were discussed in lab groups.

Faculty routinely rated the level of discussion of ethical issues higher than students. This may have something to do with differences in faculty-perception of how often they discuss issues of ethics with their students versus student-perceptions of the situation. Also, it may be assumed that faculty are more aware of the relevance of conversations about ethical issues than their students due to their leadership position in the lab. An alternative interpretation could be that reflections or discussions around the importance of ethical issues might be hidden from students, as faculty impart knowledge of ethical standards in research without actually labeling it as an ethical issue.

The importance of effective communication and discussion around ethical issues in research labs cannot be overstated. Even if these results can be interpreted as, "no news is good news," many of the activities participants were asked about involve key aspects of the research process, such as clearly describing one's research methodology, record keeping, the interpretation of data, and following safety regulations, all of which were discussed only "sometimes" by our participants. In teaching research ethics, four of the main learning goals should be knowledge of these issues, the ability to recognize issues when they arise, building the skills to begin to handle these issues effectively, and *improved attitudes toward open communication and respect of issues* (; Plemmons and Kalichman 2013:9, emphasis added by authors). If it is assumed that the validity and trustworthiness of science rely on students' knowledge and appreciation of these issues, then it is imperative for the level of discussions around these issues to be higher in the research environment.

D. What do we learn from our study about ethical research culture?

Faculty and students gave relatively similar responses in terms of what ethical issues are both the most important and what issues they have actually experienced (after we factor in respondents' amount of lab experience). This is indicative of a shared ethical culture that likely comes from everyday joint experiences in research environments, acculturation through shared RCR training, and the need to meet specific requirements and conform to regulations. As is to be expected, there is some variance regarding the current position and experience of the individual.

In most of the responses to the quantitative questions, the faculty routinely ranked items higher, indicating that they considered it more urgent to avoid the mentioned ethically problematic activities and behaviors than the students, had talked more often about those ethically problematic activities and behaviors, and had actually seen or experienced these ethically problematic activities and behaviors more often. The slight difference in the answers to the last two questions especially may be due to the fact that faculty have spent considerably more time in labs than students. During this time, they may have seen or experienced more ethically problematic activities and may also have talked more often about ethical issues in labs than students, who may have been working in labs for only several months or a few years. This is an unavoidable factor, though. (To avoid bias coming in through students with no or almost no lab experience, those that had less than three months of lab experience were excluded from the analysis.)

Overall, the rate of serious research misconduct found in this survey was low. The highest-ranked issues centered around lower-level questionable research practices, communication, and interpersonal issues in the labs. Specifically, communication problems ranked as the number one issue both in being the most discussed and experienced in research groups.

Responses to the question of where lab members go to find advice on how to resolve ethical issues in the lab revealed that by far, the two most important sources of advice are research supervisors/department chairs, followed by colleagues/coworkers. This clearly underlines the role of personal communication and the trust lab members put in their supervisors/chairs and colleagues/coworkers. These results can be seen as indicative of a process in which lab members "learn by observing" from senior researchers and

colleagues/peers, who may be perceived as ethical role models. Faculty and lab supervisors are the models by which students become socialized into the accepted norms and standards of their discipline, and ultimately how to build and maintain effective, ethical lab cultures (Gray and Jordan 2012; Wright, Titus, and Cornelison 2008). This kind of learning is likely both explicit and implicit, as students model their own future behavior on what they see as "effective" research conduct. Overall, this context points to the responsibility that senior researchers and colleagues/peers have in contributing to the building of ethical lab cultures.

Limitations

It is important to stress that the study represents a small sample at one university and cannot be generalized. Furthermore, the number of student respondents is considerably higher than the number of faculty/staff respondents. Given this, the results can only be indicative of a tendency among faculty and students. The responses to the closed questions do not allow any robust statistical conclusions comparing faculty and students beyond comparing the ranking, mean and standard deviation among the overall population and the individual groups. Due to an error found in the Likert scale of the first question as discussed in the results section, the responses to this question are slightly deflated and must be interpreted accordingly.

The survey covers only self-reported incidents and issues. There is certainly a chance that participants chose not to discuss more severe cases of research misconduct or questionable research practices, even though responses to the survey were anonymous. In addition, responses to the closed questions might be a product of response bias, showing that students and faculty know what are the "socially desirable" answers to give, especially in answer to what ethical issues are most important. The potential of bias due to socially expected answering tendencies also cannot be excluded.

The closed questions of this survey were based on the work done by Anderson et al. (2007) and in line with other, similar surveys (Martinson, Anderson, and De Vries 2005; Godecharle et al. 2018). We cannot exclude that there are additional ethical issues relevant to STEM research environments that this survey does not cover. However, as the open-ended questions in this survey did not provide any hints on additional ethical issues considered central that were not covered by the closed questions, the risk that this study has omitted central ethical issues in STEM seems limited.

VII. Conclusion

The study results provide detailed insight into the perceptions of students, faculty, and staff at one university regarding important ethical challenges. These results provide insight into the perception of those practicing research and the approach provides a framework for institutions seeking to better understand their research environments. Faculty and students ranked issues involving research misconduct and data management as some of the most important ethical issues in the research environment, potentially indicating that lab members do indeed have a set of shared norms and values around these issues. However, the results highlight that communication and collaboration skills are essential for everyday interpersonal interaction in research environments, particularly when addressing ethical issues in labs. These results indicate that issues outside of traditional RCR topics are considered central for ethical STEM by students and faculty. In view of this, we suggest that including training on communication, collaboration, and departmental culture are critical to ethics education, research ethics, and RCR training.

Data from this paper can be found at https://repository.iit.edu/islandora/object/islandora%3A1010272

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