BOARD # 316: A Digital Nudge: Assessing the Impact of an Immutable Records Data Management Platform on Student Researcher Ethics (ER2: the Ethical and Responsible Research Program)

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introduction

Research ethics and the lack of it have become an important issue more than ever both in the academia and the education sector, especially due to the advent of generative artificial intelligence. Hence, there is a pressing need for effective academic research ethics education at universities, particularly at STEM departments, so that we can help younger generations nurture their ethical thinking and responsible behavior in relation to STEM fields.

literature review and research gap

According to our scoping review in line with the PRISMA ScR 2020 guidelines, the current literature on academic research ethics education at universities broadly tends to apply one of the following approaches to inducing positive behavioral changes among students: speculative training, knowledge-focused training, and skill-focused training. Nevertheless, it does not sufficiently explore alternative approaches even though existing approaches appear to have both advantages and weaknesses. That is, the literature also argues that some faculty are reluctant to integrate research ethics into technical courses due to time constraints. Therefore, the most feasible option could be designing a highly effective program with relatively few additional resources, little coordination, and minimum training. Hence, it is relevant to explore alternative approaches to academic research ethics education at universities. Such alternative approaches may include a nudge-focused approach.

theory and research question

The nudge theory postulates that we can guide people's decision making and behavior in a particular direction by shaping the decision environment, *a.k.a*., the choice architecture [1]. Using this theory, we attempted to achieve high replicability and cost effectiveness as well as theoretical and methodological relevance. Thus, the present study investigated if the introduction of an online, immutable records data management platform would induce positive changes among graduate-level engineering students and/or science labs in terms of ethical understanding, ethical behavior in a research lab setting, and the choice architecture in which they were engaged in scientific research. Hence, we answered the following research questions:

1. To what extent does the introduction of immutable research records impact scientific ethics given that researchers are aware of such record keeping?
2. How does the efficacy of an intervention such as a mandatory Data Management Platform (DMP) for managing immutable research records influence individual- and group level research ethics in science labs?

methodology

This three-year study was based on a simple before-after design (*N =16*) that did not follow a randomized controlled trial, but rather a pre- and post-intervention assessment. We developed and introduced an online data management platform to five participating labs, recruited 16 participants, and carried out online surveys in Qualtrics before and after participants started managing research data with this platform in labs.

In this study, subjects in participating labs used our secure, online data management platform for research data storage as an integral part of the experimental routines in the labs. When a participating student collected data, she/he went to this platform and uploaded a data file onto it. When a new file was added to this platform, it automatically created a unique hash tag identifier and assigned it to the data file as an immutable stamp. As a result, this platform functioned as a database of data submissions that were immutable. The participating students became aware of such record keeping after they took a pre-survey explained below.

The online surveys in Qualtrics were based on iREDS Pre-Post Survey [2]. This pre-post survey is designed to evaluate the efficacy of scientific research ethics education and training. Drawing upon the literature in fields of research ethics, communication, and survey design as well as consultation with Principal Investigators, its survey questions aim to assess (a) student-level practices in labs (*i.e.,* ethical understanding and ethical behavior) and (b) general lab culture and climate (*i.e.,* choice architecture), such as faculty's behavior. In this study, we used 55 questions from iREDS Pre-Post Survey: five-point Likert scale questions (35 questions) and binary questions (6 questions) for general statistical data analysis, and "select all that apply" (6 of them) and open-ended questions (8 of them) for deeper contextual understanding of the results.

After having obtained answers from 16 students and deidentified the data, we statistically investigated its impact on their ethical understanding and behavior in addition to choice architecture, using Wilcoxon signed-rank test in Microsoft Excel (version 16.77.1). With this test, we assessed whether the differences between Time 1 (*i.e.,* "the pre-survey") and Time 2 (*i.e.,* "the post-survey") could have occurred merely by chance. Given the small sample size (N = 16), we rejected the null hypothesis (H_0: student responses are the same before and after the introduction of our online data management system) when the test statistic w_s is less than a relevant critical value (α = .05, two-tailed). To obtain a deeper contextual understanding of the results, we further analyzed qualitative data from the surveys by generating word clouds of their answers to open-ended questions with R packages (*i.e.,* NLP, tm, wordcloud, and RColorBrewer) and R Studio (version 2022.02.2).

results

The sample consists of 16 participants who completed both surveys, pre- and post-intervention, in English between October 2022 and August 2024. These students include 15 graduate students (2 female, 13 male) and one post-doctoral research associate (male). Additionally, this sample consists of 12 Asian students, two White students, one Hispanic student, and one student who preferred not to provide her/his racial/ethnic background. The answers to the above-mentioned research questions are summarized below:

1. To what extent does the introduction of immutable research records impact scientific ethics given that researchers are aware of such record keeping?

We did not obtain sufficient statistical evidence to say that student responses are positively different before and after the introduction of our online data management system in terms of students' ethical understanding. However, we did obtain statistical and qualitative evidence to say that student responses were positively different between two surveys in terms of general lab culture and climate (*i.e.*, choice architecture), students' views about ethical research practices, and individual-level ethical behavior.

First, we obtained statistical evidence that members of participating labs (*i.e.,* supervisors or colleagues) were significantly more likely to encourage participants to seek out education and training opportunities in ethical research best practices after the introduction of our data management platform (pre-test average: 3.44 out of 5.00, post-test average: 3.94 out of 5.00; α = .05, two-tailed). In a question "*To what extent does your supervisor or colleagues encourage you to seek out education and training in ethical research best practices?*", participants' average response significantly increased closer to "4: Encouraged a little" from "3: Neither encouraged nor discouraged."

Second, we obtained statistical evidence that after the introduction of this data management platform, participants were significantly more likely to change their views about research practices (*e.g.*, data management ethics) based on discussion within their respective labs (pre-test average: 2.13 out of 5.00, post-test average: 2.88 out of 5.00; α = .05, two-tailed). In a question "*Have you changed your views about research practices based on discussion within your lab?*", participants' average response significantly increased closer to "3: My views have changed a little" from "2: My views haven't changed too much."

Third, we obtained qualitative evidence that both participating students and other lab members changed their practices in terms of data recording, data storage, and data sharing after the introduction of our online data management platform. For example, a student, who originally used Dropbox and Google Drive for data storage, changed her/his data storage tools from both Dropbox and Google Drive to only Google Drive after the introduction of our online data management platform. Simultaneously, this student answered that other members in the lab also had changed their data storage tools from Dropbox, Google Drive, and public repositories (e.g., the Open Science Framework, GitHub) to only Google Drive.

In summary, the introduction of immutable research records might positively impact scientific research ethics in terms of general lab culture/climate, individual-level views about ethical research practices, and individual-level practices in labs when lab members are aware of such record keeping.

2. How does the efficacy of an intervention such as a mandatory Data Management Platform for managing immutable research records influence individual- and group level research ethics in science labs?

The results indicate that the introduction of immutable research records might have induced a

positive change in general lab culture and climate as they relate to data recording, data storage, and data sharing, which might have influenced individual-level views about ethical practices in labs, leading to lab members' behavioral change in a positive manner. First, the results of Wilcoxon signed rank test indicate that after the introduction of our online data management platform, supervisors and other lab members were significantly more likely to encourage participating students to seek out for research ethics training opportunities. Second, the results of Wilcoxon signed rank test indicate that participating students at least partially might have changed their views about research practices based on discussion within their respective labs. Third, qualitative data analysis with word clouds shows that participating students changed their practices in terms of data recording, data storage, and data sharing in labs after the introduction of our data management platform. Forth, qualitative data analysis with word clouds also shows that the patterns of participating students' behavioral change were the same as those of other lab members. In summary, these findings suggest that the introduction of our online data management platform first might have induced a positive change in general lab culture and climate, which might have influenced respective lab members' views about research practices, leading to better individual-level practices inside and outside labs.

Thus, the results suggest that collective research lab cultures might change when they receive a "digital nudge" to save immutable copies of their data records as part of the experimental routines in labs, which could result in more appropriate views about scientific research ethics and improved individual-level practices in labs.

discussion

The most recent scholarship has discussed that collective lab culture and climate would be the key to ethically relevant practices in labs [3][4]. However, current research has not necessarily provided sufficient evidence on how effectively we can change such lab culture and climate or if individual-level practices in labs will improve by altering lab culture and climate. As we have seen above, this study could provide some initial evidence that with a nudge-focused approach, we might be able to effectively change general lab culture and climate as they relate to scientific research ethics that could lead to improved individual-level practices in labs. In this sense, this study contributes to the body of knowledge on research ethics education in STEM programs at universities where the hesitation to integrate research ethics into technical research activities is often attributed to time constraints.

implications

These findings could be applied to undergraduate STEM programs that employ project-based learning (PBL). According to the most recent scholarship on biology education, the use of PBL in undergraduate STEM programs aims to encourage students to effectively acquire knowledge and skills pertinent to academic research ethics by working on a team research project in a lab setting [5]. Through this simulation approach, some studies argue that undergraduate students may be more likely to think and behave ethically in actual scientific research projects. Considering the results of this research, it could be relevant and useful to introduce a similar online data management platform to STEM courses based on PBL coupled with a relevant pre-post survey in order to strengthen its effectiveness. Though current engineering education

research has not necessarily sufficiently discussed the application of PBL to undergraduate programs for scientific ethics training, our study indicates that this teaching method could be promising when it is combined with a nudge-focused approach.

Nevertheless, this study had two major limitations on the research design. First, this study was not strictly designed to make a causal claim about the relationship between the introduction of our online data management platform and students' ethical understanding and ethical behavior in a research lab setting, using randomized controlled trial. Therefore, it did not have the control group to compare with the treatment group that participated in this project. Hence, group comparison was made only within participating students before and after the introduction of the online data management platform. Second, the sample size was relatively small due to difficulties in recruiting participants for this study although an *a priori* power analysis showed that the minimum sample size would be 15 (effect size: .80, power: .80).

To build on the results while addressing these weaknesses, the next step of this study will require a methodologically strengthened research design for better impact evaluation, such as the application of the mixed methods experimental (or intervention) design with a sufficient sample size. By applying this type of the research design, we will be able to gain more statistically robust evidence of causality with randomized controlled trial while obtaining a deeper contextual understanding of such evidence from direct observations of and interviews with students and faculty.

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