Transnational Science Publication Ethics Training Using Scenarios

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***Abstract* - This paper reports completed empirical studies of a larger, STEAM-driven endeavor that bridges two continents and several disciplines, highlighting the role of the technical communicator. The research questions revolve around whether, and to what degree, scenario-based ethics training is effective in helping chemists understand the expectations for responsible publication practice in chemistry, as defined by prestigious universities, professional organizations, and reputable journals. We build on previous studies of scenario-based ethics training. We identify possible next steps for research and training in global science ethics. Ultimately, by building empirical and theoretical knowledge about challenges to ethical behavior, we will be able to identify effective instructional methods for culturally-inclusive, validated ethics training.**

***Index Terms* - Ethics, pedagogy, China, global science, STEAM research**

Introduction

Our shared technological future is collaborative, trans-national, and trans-cultural in the broadest sense. As science becomes truly globalized, reconciling disparate ethical codes and underlying ideologies is a challenge for researchers, especially in our roles as authors and collaborators [1 -7]. However, most training in science ethics, including the relatively well-established and internationally accessible standards for chemistry publication ethics, is *ad hoc*, arbitrary, and incomplete; this was established over 20 years ago [2] and persists to the current day [8,9].

This paper reports completed empirical studies of a larger, STEAM-driven endeavor that bridges two continents and several disciplines. These studies build on previous studies of scenario-based ethics training [1-6]. The scenarios employed are well-known and widely available [10].

I. Context of the Study

The study examines Responsible Conduct of Research (RCR) practices and barriers within the field of chemistry, many of which practices are directly relevant to other professional fields ranging from humanities to engineering. Recent scholarship and expert analysis point to two priorities for promoting RCR in general and RCR education in particular: measuring the effectiveness of RCR education and extending the international reach of RCR training efforts.

First, after several decades of proliferating programs in RCR education, mechanisms for reliably assessing their effectiveness remain elusive. In a 2017 report on research integrity, the National Academies of Science call on research institutions to "continue to develop and assess more effective education and other programs that support the integrity of research" [7].

Second, the increasingly international nature of scientific collaboration demands that RCR programs evolve to reach participants in different countries. These circumstances in view, the National Academies recommends the development of RCR programs to "be widely adopted across disciplines and across national borders" [7]. To date, most RCR programs and most research on RCR education have focused on single-country populations. This project heeds the National Academies' call by extending this work to a comparative and international context. The study implements and assesses RCR training programs among chemists in two countries, promising insights into cross-national variation in the effectiveness of these measures and suggesting further research to extend their transnational reach.

II. The Team

The core RCR team implementing this study is interdis-ciplinary, including researchers whose home departments are chemistry, technical communication, and political

2158-1002/20/$31.00 ©2020 IEEE
DOI 10.1109/ProComm48883.2020.00008

science, and we collaborate with faculty and students in psychology, students from engineering and technical communication, and partners from industry and the private sector.

Technical communication is one of the three disciplines driving the current study. Technical communication expertise was useful in assisting the team to develop research questions, navigate human subjects' research compliance requirements, design and pilot research instruments, and disseminate results.

Our campus culture is beginning to recognize and facilitate trans-disciplinary research. Our new Center for Science, Technology, and Society (CSTS) brings together faculty across sciences, humanities, and social science, with some interest from the engineering faculty who comprise the vast majority on our campus. CSTS is located in the College of Arts, Science, and Business, which is the smaller of two colleges on campus, also home to the departments of English and Technical Communication, Chemistry, and Political Science.

Especially given the opportunities for extramural funding of trans-disciplinary research, our team seeks to capitalize on the affordances of more such work. Our team did not apply for or receive internal funding, but instead attracted gifts from the publishing arm of the American Chemical Society (ACS) and from a chemistry alumni donor. This funding formalized our partnerships and enabled us to support students, purchase resources, and travel for data collection and presentation.

III. Why chemistry?

Chemistry is an ideal test site for global science ethics knowledge and education [11,12]. Chemistry is truly internationalized, based on reported nationality of authors, professional society membership and submission data, and the sheer volume of collaborations. The American Chemical Society is the largest professional science society in the world at 140,000+ members. The ACS code of conduct is robust [13].

Few empirical studies recognize or articulate the transnational context in which ethics education is performed, and fewer yet attempt to place global research ethics in a dynamic socio-political context. Recent research demonstrates that ethical knowledge among chemists is uneven or incomplete [8,9]. Opportunities for networking, funding, and publication are robust in chemistry compared to other fields, although non-chemists cannot be full members of the American Chemical Society.

IV. Why the U.S. and China?

Within chemistry, the United States and China are two critical country cases for assessing the transnational effectiveness of RCR training [14]. Together, the American and Chinese research communities dwarf the rest of the world by their share of high-impact research in the discipline [15]. In 2018, China became the largest contributor of high-impact publications in chemistry, displacing the long-dominant United States [15]. Moreover, research collaborations between scientists from the two countries have been growing in pace with China's expanding participation in international research projects overall. These factors combine to make them perhaps the most important settings for assessing and comparing the impact of RCR training programs.

V. Methods

Pilot and beta testing were conducted over a period of several months at the University of Missouri, a STEM-centric mid-sized research university system in the U.S. Building on our team's previous studies of students' responses to scenario-based ethics education [6], we developed research instruments and collected data from a graduate-level chemistry course taught during the summer of 2019.

VI. Setting and logistics

For that last decade, Glaser has been working in China every summer as a guest lecturer at prestigious STEM-focused institution, delivering week-long courses to students on a variety of topics, often including science ethics. Yang has been a frequent graduate teaching assistant (GTA) on these occasions.

Two of us (Glaser and Yang) offered the course "Scientific Writing and Publication Ethics" during the summer of 2019 at the University of Chinese Academy of Science, Beijing, a prestigious research university (see Figure 1). Yang translated and administered the survey with 144 students participating. We received pre-tests from 139 students and post-tests from 118.

FIGURE 1. ACTIVE LEARNING IN A LARGE LECTURE CLASS AT UCAS, BEIJING.

Active learning is always key no matter the class size. Students worked at least one problem in class every day. The problem was introduced either by Dr. Glaser or by

GTA Yang. Students worked by themselves or in small groups. GTAs walked the lecture hall providing guidance as needed. Some discussion occurred on the board.

FIGURE 2. UCAS PROVIDES GENEROUS TEACHING ASSISTANT SUPPORT.

UCAS has been very generous with GTA support (see Figure 2). Three advanced UCAS graduate students served as teaching assistants and the UCAS TAs worked closely with American graduate student and NSF-supported GTA Ms. Kaidi "Kathy" Yang (from left): Ms. Xiaohui Xu, Ms. Yao Xiang, Ms. Kaidi Yang, and Mr. Xu Liu.

VII. Scenarios

Columbia University publishes oft-cited materials on its Responsible Conduct of Research site [10]. Those materials include three page-long written descriptions of common ethical concerns in science; they are not specific to chemistry. One of the scenarios is about the level of involvement that constitutes authorship; the second, about ethics of proper and improper uses of knowledge gained from peer reviewing in their field; and the third focuses on standards and justifications of research methodologies.

The study reported here features survey questions that focus on the subject matter in the first of the Columbia University scenarios. Best practices about listing authors were also gleaned from the ACS Style Guide [16]. A follow-up survey in the U.S. added additional questions about other scenarios.

INSTRUMENT

The survey was distributed in the primary language of instruction, and used numeric codes instead of participants' names. The pre-test was administered on the first day of class (Monday) and the post-test was administered on the final day (Friday). Four questions asked students about their background knowledge and attitudes toward chemistry research ethics, and 13 declarative knowledge questions related to publication ethics in chemistry. Finally, we asked students about their confidence in their knowledge of publication ethics.

The survey was translated into Chinese by a bilingual chemist (Yang), who participated in developing the instrument and collecting and analyzing the data. This conforms to best practices for international research.

TABLE 1. PRE- AND POST-TEST ITEMS.

Q#	Item Wording
Q1	How much do you know about chemistry research ethics?
Q2	How much do you care about chemistry research ethics?
Q3	How much instruction in chemistry research ethics have you received?
Q4	How much have you been taught about publication ethics in chemistry, on topics like writing, editing, manuscript preparation, submission to journals, and reviewing?
Q5	The order of the authors' names on a publication has no significance
Q6	Only those who do the actual chemistry research should be listed as authors
Q7	Everyone in a chemistry lab should be an author on a study that is published from that lab's work
Q8	We should list as many authors on a paper as we can
Q9	All people paid to work in a lab are the authors on every article
Q10	Laboratory staff technicians should never be listed as authors on publications
Q11	All students who work in a lab should be authors on every publication that is written while they work there
Q12	Only people on site at a lab should be authors of the papers from that lab
Q13	All authors on a paper need to have significantly contributed to the research or writing
Q14	The chemist who has contributed the most money to the lab decides who is listed as an author on publications
Q15	The chemist who has done the most work on a publication should decide who is listed as an author
Q16	The order of the names on a publication has significance
Q17	Laboratory staff technicians should be listed as authors on every publication
Q18	I am confident I know how to list authors for papers that I help write and publish
Q19*	My confidence about chemistry research ethics is stronger today than it was when this course began

*This item was asked in the post-test survey only.

The same questions were asked on the pre-test and post-test [see Table 1], although the post-test included a series of course- and self-evaluation questions that are not reported here.

RESULTS

All participants were from China, studied primarily (although not necessarily exclusively) in China, and were in their first year of graduate school.

Our analysis began by asking whether students acknowledged that the week of instruction counted. Specifically, question 4 (see Table 1) was meant to quantify students' relevant education, whether it came from mentoring, coursework, review of publication guidelines, or any other sources. Students could interpret "taught" however they wanted, but their week-long course should surely count as being taught, so their answers at the end of the week were predicted to reflect greater realizations of ethics education than the pre-test answer. As predicted, we saw strong results for question 4; mean scores went from 2.73 (on a 6-point scale) to 4.23, and the results were statistically significant (paired-samples t-test $= -10.40$, $p < 0.001$). This question sought to confirm that the students were crediting the course with having taught them about the listed topics.

Another key interest we had was to evaluate whether students felt more confident about specific aspects of publication ethics after the week of instruction. For example, question 18 asked students about listing authors on manuscripts. The instruction students received included discussion of the Columbia University case studies [10], one of which specifically described a conflict arising from disagreements about authorship. The discussion should have helped students understand more about how to make decisions with respect to listing authors on publications. Results indicated that students did improve in this area such that the mean for the pre-test responses (M = 2.88) was significantly lower than the post-test response mean (M = 3.28, paired-samples t-test $= -6.77$, $p < 0.001$).

Related to publication ethics is the knowledge students had, or gained, about expectations. We used the ACS Style Guide [16] as a primary reference because ACS is the most international and largest of the chemical societies. ACS is clear on certain points, such as the type of contribution that qualifies authorship.

Question 13 addressed requirements for authorship (see Table 1). No significant improvement was observed in correctness on Q13 from pre- (M = 4.59) to post-test (M = 4.47, paired-samples t-test $= 0.72$, $p = 0.476$). However, pre-test scores, on average, indicated agreement with this item, suggesting that overall students agreed that contribution was important in determining authorship. The answer to Q13 is unequivocally "yes," and again, although students tended to get the correct answers, their confidence in the answer does not appear to have risen after instruction. The absolute "never/all" language of the prompts may have also contributed to students' difficulty in improving strength of answers.

Question 8 addressed number of authors. A significant increase in agreement from pre- (M = 3.94) to post-test (M = 4.38, paired-samples t-test $= -2.85$, $p = 0.005$), suggested improvement in ethical decision-making after participating in the ethics course.

Performance on some questions was problematic, with most students selecting incorrect answers. For example, our team agreed that "only those who do the actual chemistry research should be listed as authors," (see question 6 in Table 1), but the students largely disagreed with this statement both before (M = 2.55) and after the instruction (M = 2.30, paired-samples t-test $= 1.52$, $p = 0.131$). Because "the actual chemistry research" may not necessarily include manuscript preparation, perhaps students were avoiding being tricked by too-restrictive a question here.

TABLE 2. DESCRIPTIVE STATISTICS FOR ALL PRE- AND POST-TEST ITEMS.

	Pre			Post		
	M*	SD*	%	M*	SD*	%
Q1	3.58	1.38	NA	4.72	1.18	NA
Q2	4.92	1.32	NA	5.27	1.00	NA
Q3	3.08	1.43	NA	4.35	1.21	NA
Q4	2.69	1.34	NA	4.22	1.27	NA
Q5	5.58	0.91	96%	5.41	1.29	90%
Q6	2.47	1.66	26%	2.30	1.56	23%
Q7	5.26	1.17	91%	5.30	1.17	92%
Q8	3.84	1.80	57%	4.38	1.78	71%
Q9	5.55	0.85	99%	5.43	1.09	93%
Q10	4.67	1.42	81%	4.56	1.52	80%
Q11	5.40	0.91	97%	5.33	1.11	93%
Q12	4.43	1.67	72%	5.04	1.37	86%
Q13	4.60	1.49	74%	4.47	1.66	72%
Q14	5.46	0.92	96%	5.33	1.12	92%
Q15	3.94	1.81	60%	4.25	1.85	63%
Q16	5.20	1.17	93%	5.39	1.04	94%
Q17	4.47	1.35	78%	4.71	1.39	84%
Q18	2.87	1.47	30%	3.82	1.38	59%
Q19	NA	NA	NA	5.49	.84	NA

*Means (M) and standard deviations (SD) for each item were calculated using the original 1 *strongly disagree* – 6 *strongly agree* scale. Frequencies were calculated using the incorrect (coded 1-3 on original scale)/correct (coded 4-6 on original scale) scores and show the percent of participants who answered the item correctly.
Note. Pre-test $N = 139$; Post-test $N = 118$.

In order to determine gains of ethics-related declarative knowledge, items 5 - 18 were also coded to reflect a correct/incorrect score, where any level of agreement with an item was coded into a "correct" response (1 point) and any level of disagreement with an item was coded into an "incorrect" response (0 p.). Percentages of participants who answered each item correctly are available in Table 2 (along with other descriptive statistics). Questions 7, 9, 11, and 14 all questioned who should receive authorship credit on publications. Using point-biserial correlations with these items in their correct/incorrect form correlated with overall post-test scores (i.e., the sum of correct/incorrect responses on the post-test items); students who answered these items correctly had better declarative knowledge scores overall (Q7: $r = 0.56$; Q9: $r = 0.69$; Q11: $r = 0.53$; Q14: $r = 0.53$, all significant at $p < 0.001$). Notably, in terms of declarative knowledge gained overall (as determined by comparing overall pre-test scores with overall post-test scores), results indicate no significant improvement between pre- (M = 10.21 correct answers on average) and post-test scores (M = 10.26 correct answers on average, paired-samples t-test = -0.32, $p = 0.751$). However, this non-significant increase may be due to ceiling effects in that students already scored fairly well on the pre-test.

Questions 5 ($r = 0.40$), 8 ($r = 0.46$), 15 ($r = 0.42$), 16 ($r = 0.32$), and 17 ($r = 0.33$) also demonstrated moderate relationships with overall test scores, meaning that correctly answering these items was moderately correlated to overall scores (all significant at $p < 0.001$).

Finally, questions 10 ($r = 0.28$, $p = 0.002$) and 13 ($r = 0.29$, $p = 0.001$) showed weak correlations to overall test scores; so although students' answers to Q10 tended to be correct, they did not reflect stronger correct answers after instruction.

We observed strong correlations between all four background questions (1-4) and the post-test confidence question (Q19). The strongest correlation was between question 2 (see Table 1) and confidence ($r = 0.50$, $p < 0.001$). We also correlated the students' overall post-test score (i.e., total number of items to which they correctly responded) to confidence; the correlation was positive at 0.44 ($p < 0.001$). That is, students who were more confident had higher overall post-test declarative knowledge scores, and students who had overall post-test scores were more confident. In fact, answers on the declarative knowledge test predict 50% of the variability in confidence measure. Although we may be observing a ceiling effect as the mode and median for post-test Q19 were both 6, with a mean of 5.49, our results provide some evidence that students' knowledge is related to their confidence. Increased agreement with questions 7, ($r = 0.42$), 9 ($r = 0.47$), 11 ($r = 0.45$), 14 ($r = 0.42$), and 16 ($r = 0.54$) had the strongest relationships with confidence (all significant at $p < 0.001$).

The scenario-based teaching method and the survey instrument were deployed in a revised form to a smaller group of chemistry graduate students studying in the U.S., as further proof of concept. Additional questions were asked. The size of that class (n = 11) precluded us from comparing the groups.

Discussion

From our results, we conclude that instruction affected performance on the test. Students resoundingly attributed the instruction with increasing their knowledge about specific areas of publication ethics in chemistry. Students' test scores improved for certain items (students appeared to already have high scores on the pre-test, making overall improvement on the post-test difficult to obtain). Additionally, doing well on the declarative knowledge items (i.e., overall post-test scores) was significantly related to students' confidence in understanding ethical decisions. Predictably, students who cared more about the topic also had more confidence in their knowledge of chemistry research publication ethics.

This test also yielded substantial information about possible improvements of the instruction and assessment. We know that phrasing of the questions is critical, and we recognized some potential ambiguities on our questions. We will follow up with focus group studies of specific prompts. We also have information about what this group of students already knew before they began the course, and what they learned.

Generally speaking, a week-long seminar in chemistry research ethics has a positive impact both on students' confidence and declarative knowledge, demonstrated by the rise in post-test scores for Q1. The clarity of questions in the assessment instrument, reinforcement of key topics during instruction, and presence or absence of detail in the scenarios may all affect performance on individual items.

The data indicate that the scenario-based approach is promising, with the participants in China both achieving higher scores on the knowledge questions and reporting satisfaction with the approach consistent with [6].

Conclusions

This study provides insight into a type of research that is rarely attempted: empirical testing of ethics knowledge. We modeled some of our work on the empirical study by Heitman et al. of RCR knowledge among graduate students in biomedical science, one of few to conduct empirical testing of explicit ethics-related topics within a discipline [17]. Heitman et al. found that many new biomedical science graduate students lacked knowledge about the ethics of their field and, importantly, their entire undergraduate experience apparently did not develop significant ethics knowledge. If the typical undergraduate experience in a discipline does not effectively impart ethics education, then our default apprenticeship model for behavioral training and enculturation clearly is not sufficient.

The lessons learned from this study included confirmation of the benefits of explicit instruction in chemistry publication ethics for first-year graduate students. This study demonstrates how teams comprised of faculty from disparate disciplines can coordinate ethics-instruction research effectively. We argue that technical communication researchers have much to offer to the enhancement of STEM ethics education efforts, as the expansion of the RCR team beyond chemistry infused expertise in methods, compliance, and policy.

Finally, our experience exemplifies how small-scale, modestly funded classroom studies can expand to more ambitious, larger projects. We have two examples. The first study of chemistry ethics instruction by Glaser and Yang evaluated student satisfaction rather than ethics knowledge [3], and the initial pilot study measuring of ACS publication rules began as a class project in one of Northcut's courses.

I. Team composition

Technical communicators are useful in global science ethics research because the technical communicator contributes a robust understanding of how ethical codes differ, helping to localize ethics instruction for intra-disciplinary contexts. That is, because some of the guidelines in chemistry differ from those in other fields, it is important that chemists receive chemistry-specific training.

Technical communicators with a research emphasis are useful as methodologists in implementing best practices for research instrument development, and in revising research instruments to more appropriately measure knowledge and perceptions about science ethics with greater validity and reliability.

The combination of technical communicator working in concert with experts in chemistry and in global science policy promises increasingly robust, globally-validated technical education and assessment materials. Ultimately, by building on empirical knowledge about challenges to ethical behavior, we will identify best practices for culturally-inclusive, validated approaches to global publication ethics instruction whether it occurs within a single discipline (e.g., chemistry) or a broader disciplinary realm (STEAM).

II. Next steps for research

The NAS report and other research acknowledge that while efforts at fostering the institutional adoption of RCR training tools have been successful, the effectiveness and impact of these tools has only been sporadically assessed [18]. Moreover, when the effects of these tools have been assessed, the results have often been mixed or negligible [18]. This project addresses this priority by developing and testing an instrument to assess key dimensions of the effectiveness of scenario-based training programs widely used in RCR education. When a validated instrument is available for broad usage, then ethics education can increasingly become a data-driven and consistent endeavor, part of an integrated education and assessment process for aspiring professionals.

Acknowledgements

The authors acknowledge contributions by Matthew Dew, psychology undergraduate at Missouri S&T, and Dr. Kenneth Bansah, graduate student in Technical Communication at Missouri S&T. We thank Dr. Cun-Yue Guo of UCAS for his continuous support. This research was supported by Carey Bottom's Science Ethics Support Initiative.

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