

Ethical Reasoning for Quantitative Scientists: A Mastery Rubric for Developmental Trajectories and Professionalism, and Portfolios that Document Both

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Abstract

PURPOSE: Training in the responsible conduct of research (RCR) is necessary, but RCR training typically targets those conceptualizing the experiments, and is not prioritized for those who *analyze* the data. This approach and bias cannot encourage development in ethical reasoning for quantitative scientists, and it does not support the identification of quantitative students with a professional code of ethics.

METHOD: A published model for lifelong learning of RCR, based on ethical reasoning skills that underpin research integrity generally, was combined with the ASA ethical guidelines. The model is based on a Mastery Rubric, a tool for curriculum development and evaluation. A Mastery Rubric is created to describe the knowledge, skills and abilities that the curriculum is intended to target (the ASA guidelines and ethical reasoning in this example), as well as concrete but flexible descriptions of performance across a continuum of developmental levels from more novice to more expert exhibition of the curricular goals. Here, a new approach to teaching the ASA Ethical Guidelines for Statistical Practice, and documentation of their performance with portfolios, is described.

RESULTS: A semester course combining ethical reasoning that supports the responsible conduct of research (in quantitative as well as other sciences) with the ASA Ethical Guidelines is outlined. It promotes sustainable learning with a developmental trajectory for reasoning and a sense of professionalism for quantitative scientists. The model also has implications for training and certification of mentors for statistical practice.

CONCLUSIONS: Synthesizing the ASA Guidelines with a published developmental trajectory can support instruction in the Guidelines and also accomplish the RCR training that federally-funded students must have. Together, these can lead to stronger professional identity for our students and (future) ASA members. The use of a portfolio, like the ASA PStat® accreditation application, can be used to document a wide variety of experiences and skills, including growth in reasoning, responsibility in the conduct of research, and professional identity.

Key Words: portfolio assessment; responsible conduct of research; Ethical Guidelines for Statistical Practice

1. Introduction: training in the responsible conduct of research for quantitative scientists

While not universal, the typical conceptualization of training in the responsible conduct of research (RCR) in graduate science instruction is to complete one module or course. Some institutions may have a single RCR training module or course for all scientists; the National Institutes of Health (NIH) and Collaborative Institutional Training Initiative (CITI, <https://www.citiprogram.org/Default.asp?>) have online modules for ethics training – which are the same for every student, staff or faculty member in an institution. This training tends to be general, and focused on the key historical milestones, rules, and regulations governing human and animal subject protections. Not all sciences and scientists will benefit from the same RCR training materials (e.g., Bulger & Heitman, 2007), and many disciplines do not even require it. Its relevance to quantitative science students in departments such as mathematics and statistics is questionable – as is the benefit accruing to those quantitative students who might elect to enroll in such courses.

In addition to being general and appearing tangential to some disciplines, the NIH and CITI module content also suggests that the responsible conduct of research is separate from a sense of professionalism. In their review of the literature on ethics education in science and engineering, Keefer et al. (2013) note that, while many new resources for ethics instruction have recently been developed and/or made available, scientists who are not trained in ethics themselves have difficulty creating meaningful, assessable learning opportunities around ethics and the responsible conduct of research. Thus, the dominant RCR training paradigm promotes a delimited, static, “universal” approach to ethics education that might be outsourced to the NIH or CITI, or to a central ethics, regulatory or compliance group on a given campus – or, might be taught in a potentially inefficient and unassessable way (Keefer et al. 2013; see also May & Luth, 2012) within programs.

A recent attempt to address this challenge for statistics students in particular is the 2011 Handbook of Ethics in Quantitative Methodology (AT Panter & SK Sterba, Eds.). This handbook includes a chapter summarizing key ethical principles relevant to the analysis of data (Rosnow & Rosenthal, 2011). The table is recapitulated below, including the features that represent competent data analysis and reporting (columns) and ethical standards in the Western biomedical tradition (rows; Beauchamp & Childress, 1983).

Table 1: Four general ethical standards (rows) crossed with five data analytic and reporting standards (columns)

Ethical standards	Data analytic and reporting standards				
	Transparent	Informative	Precise	Accurate	Grounded
Beneficence					
Nonmaleficence					
Justice					
Respect for persons					
“Integrity” is included as an ethical standard by Rosnow & Rosenthal but is not a traditional ethical standard; rows are from Beauchamp and Childress (1983).					

Although the columns and rows of Table 1 are important objectives for the training of statisticians and quantitative scientists, the *cells* – the intersections of these two sets of

objectives – are not coherent targets for teaching or learning. That is, the data analysis and reporting standards (columns) have very little bearing on the ethical standards (rows), which are fully focused on treatment of humans – and vice versa. In fact, only one of the eight ASA Guidelines (ASA, 1999), “Responsibilities to Research Subjects,” bears any relation to the ethical standards in the rows of Table 1, and the columns, while representing competent execution of data analysis and reporting, do not capture the professional standards of the American Statistical Association in any meaningful way. The ASA Guidelines describe these Responsibilities to Research Subjects as involving “...requirements for protecting the interests of human and animal subjects of research-not only during data collection but also in the analysis, interpretation, and publication of the resulting findings.” Thus, the foundational ethical standards in this table are essentially subsumed by this single ASA Guidelines topic.

These foundational ethical standards are widely known to be important, but the responsible conduct of research is NOT limited to correctly and ethically dealing with the humans from which data is taken (e.g., Tractenberg, 2011). The guidance for teaching and learning around the responsible conduct of research and professional ethics for practicing statisticians should not be limited to these ethical principles, particularly since they together comprise only *one* of the eight topical areas outlined by the ASA 1999 report. Therefore, Table 1 cannot effectively be used to structure or evaluate the success of RCR training objectives (or programs) for quantitative scientists. The cells in Table 1 do not support instruction in general, and the ethical components are not consistent with the ASA Ethical Guidelines for Statistical Practice (the “ASA Guidelines”).

As an alternative to Table 1, Table 2 shows how the eight topics of the ASA Guidelines (rows) can be aligned with the data analytic reporting standards (columns), to capture the key features of competency (columns) and also to represent the ASA Guidelines.

Table 2. Eight ASA Ethical Guidelines for Statistical Practice topics (rows) crossed with five data analytic and reporting standards (columns; from Rosnow & Rosenthal, 2011).

ASA Ethical Guidelines	Data analytic and reporting standards				
	Transparent	Informative	Precise	Accurate	Grounded
Professionalism competence, judgment, diligence					
Responsibilities to funders, clients & employers assuring that statistical work is suitable					
Responsibilities in Publications and Testimony					
Responsibilities to Research Subjects					
Responsibilities to Research Team Colleagues					
Responsibilities to Other Statisticians or Statistical Practitioners					
Responsibilities Regarding Allegations of Misconduct					
Responsibilities of Employers					

Table 2 is oversimplified for clarity in presentation; the ASA Guidelines topic names are shown in Table 2 for simplicity, while the Guidelines themselves actually specify many ethical considerations that are components of each of these topics (<http://www.amstat.org/committees/ethics/index.html>). Even in its simplified form, Table 2 can provide some support for the development of teaching and learning objectives around the responsible conduct of research and competent statistical work. However, Table 2 is incomplete in the sense that the characteristics of competent statistical work (columns), i.e., transparency, informativeness, precision, accuracy, and groundedness (in theory/method) do not constitute, or support, many or even most of the Guidelines. In fact, these data analytic and reporting standards (columns) are captured by the “professionalism” and/or the “responsibilities to research team colleagues” Guideline topical areas. Neither Table 1 nor Table 2 supports the development or evaluation of teaching or learning in the responsible and professional conduct of research by quantitative scientists; nor do they support the development of teaching and learning objectives around the ASA Guidelines. Based on the foregoing, a focus on the ASA Guidelines will capture *both* the foundational ethical principles and the elements of competent analysis and reporting that are shown as the rows of Table 1, and will also incorporate the standards of competent work shown in the columns of Tables 1 and 2.

1.1 The ASA Guidelines can be made more teachable/learnable using a published curriculum building and evaluation tool, the Mastery Rubric

What is proposed is to integrate the eight topical areas of the ASA Guidelines with a curriculum building and evaluation tool published in 2010 and 2012, called a Mastery Rubric (Tractenberg, et al. 2010; Tractenberg & FitzGerald, 2012). In a Mastery Rubric, the desired knowledge, skills and abilities (KSAs) for a curriculum are outlined together with performance levels that characterize the respondent, but instead of describing performance from worst to best (e.g., Stevens & Levi, 2005, Ch. 1), the descriptions reflect what is expected in the performance of each KSA as the individual moves from novice towards expertise (Tractenberg et al. 2010). It also describes all relevant dimensions of performance – in the case of the ASA Guidelines, all eight topic areas.

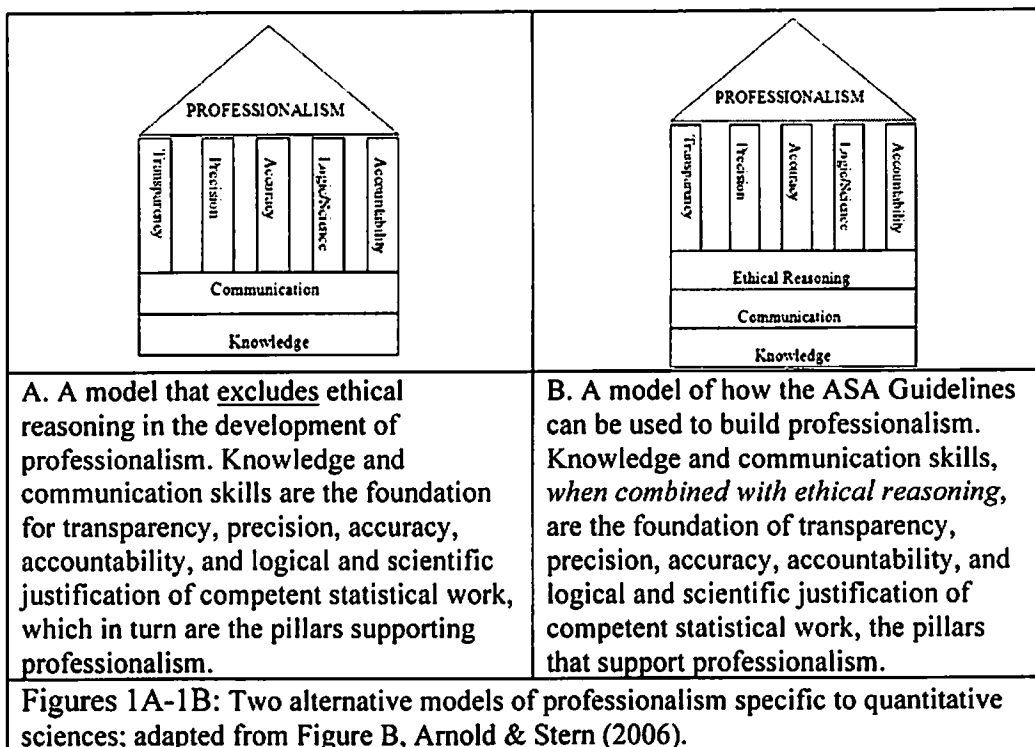
The mastery of information is not the same as the development of more expert-level habits of mind; a Mastery Rubric formalizes this and the performance levels highlight what “more expert-level” looks like for each of the target KSAs. Flexibility comes from the variety of ways a respondent can convey their possession of each skill at a target performance level; that is, each individual need not say the same things in the same ways about the same experiences or material to document their functioning at a given performance level. A Mastery Rubric shows whether and how a curriculum supports the targeted development (e.g., Tractenberg et al. 2010); it can help identify opportunities for students, as well as instructors, with respect to the desired performance, and activities/instruction necessary to support, and elicit, that performance (see Messick, 1994). The Mastery Rubric construct is ideally suited to the purpose of this project: to present a model that can be used to integrate the ASA Guidelines into the training of future practitioners.

2. Method and Results

In 2010, the Mastery Rubric (MR) construct was applied to the problem of developing a flexible, *career-spanning curriculum* for training in the responsible conduct of research (RCR). The resulting MR was published in 2012 (Tractenberg & FitzGerald, 2012). The

2012 Mastery Rubric for the responsible conduct of research (MR-RCR) conceptualizes “ethics education” or “RCR training” as a set of six learnable, improvable types of knowledge, skills or abilities (KSAs). These KSAs are: Prerequisite knowledge; recognizing an ethical issue; identification of decision-making frameworks; identification and evaluation of alternative actions; making and justifying decisions; and reflecting on the decision. This KSA list is focused on decisionmaking and reasoning skills that are widely (nationally and internationally) considered to represent “ethical reasoning” (see, e.g., <http://www.scu.edu/ethics/practicing/decision/framework.html>). In the present project, the MR-RCR was integrated with the ASA Guidelines.

Figures 1A and 1B show two alternative models of professionalism specific to quantitative sciences. The figures are adapted from one for professionalism in the health professions (Figure B, Arnold & Stern, 2006). In the figure, the five key elements of competent work by statisticians (Rosnow & Rosenthal, 2011) are shown as pillars supporting “professionalism”: transparency, precision, accuracy, accountability, and logical and scientific justification <for work>. There is no mention of ethical knowledge or reasoning in any discussion of professionalism – outside of those describing health sciences or practice, and medicine. However, the ASA Guidelines implicitly blend these two constructs – ethics and professionalism, which is why the Mastery Rubric for the Responsible Conduct of Research is a useful model for training quantitative scientists.



The models shown in Figures 1A and 1B support the conceptualization of ethical reasoning as integral for both effective work (e.g., Rosnow & Rosenthal, 2011) and the development of a sense of professionalism (e.g., Stern, 2006). This contrasts with Parker (2012), whose plan for training PhD biologists does not mention RCR or ethical professional conduct *once*, while for mathematics education, Ferrini-Mundy (2008) mentions “ethics” as an element of the core knowledge that PhD students in mathematics

need, but does not discuss whether this can or should be integrated into this doctoral training as integral to the formation of the mathematician's professional identity.

Integrating the MR-RCR framework with the ASA Guidelines has two motivating factors. Firstly, the MR-RCR framework developmental trajectory has a level for "Master" level achievement. That is, this framework describes the development of knowledge, skills and abilities beyond the "journeyman" level to include and describe the performance that is expected of those who would mentor others in the development of the specific KSAs. Therefore, by combining the MR-RCR with the ASA Guidelines, individuals who would be designated as mentors for professional conduct can document their ability and experience doing exactly this. Time in position, number of publications, and professional competence alone cannot suffice as justification for the "mentor" label, because these characterize journeyman-level performance and say nothing about an individual's abilities to diagnose, remediate, and tailor training opportunities for mentees. The documented ability to mentor others – to have and successfully guide apprentices to the journeyman level themselves – is described for the master level in the MR-RCR, and this is desirable for the ASA Ethical Guidelines as well.

The second motivation for synthesizing these together is to link "professionalism" and the sense of professional identity that the ASA Guidelines were developed, in part, to guide the sense of professional identity that many professions have and encourage in their trainees. A Mastery Rubric lists instructional targets (KSAs) with performance levels, so that performance for each target can show proficiency increasing. Self-monitoring is encouraged – and with this framework, it can be focused on, "how well do I do/know this <target>, what do I need to do to become more proficient?" This focus, emphasizing personal development and self-reflection, is not widely or explicitly targeted in higher education, but is highly relevant to consistently following the Ethical Guidelines for Statistical Practice. The addition of professional identity development as a functional element in doctoral, not just RCR, training is to promote the PhD student's perception that they do NEED to become more proficient, or more responsible in their conduct of research, in order to become more like a professional. Thus, this forges the link between training in ethics and responsibility (supported by the MR-RCR) and the development of professional identity in quantitative scientists.

Many professional associations and societies for quantitative sciences have codes of ethics or conduct, but there are few, if any, methods for inculcating new professionals into these ways of being. Table 3 shows an excerpt of a table demonstrating a method for doing so with the ASA guidelines (three are shown) with the six learnable, improvable ethical reasoning skills. Also embedded in Table 3 are items from the NIH "responsible conduct of research" (RCR) topic list that is also used by NSF and DoD, in addition to other funders who use the NIH grant structure and review models (see NIH, 2009).

The alignment of the NIH topics with the KSAs (columns) and the ASA Guidelines (rows) is loose and can be re-done as desired/appropriate. Table 3, and the full table (Table A1) in the Appendix (with all eight ASA Guidelines and all of the NIH RCR topics), illustrate a way to integrate the ASA guidelines into a semester-long course that can use existing materials (case studies, vignettes, role plays, etc.) and also meets or exceeds NIH and NSF training requirements in RCR. Tables 3 and A1 represent the level of performance that novice or beginners could be expected to exhibit in both ethical reasoning KSAs (columns) and the ASA Guidelines areas, after one course.

Table 3. Three of eight ASA ethical professional areas crossed with six KSAs of ethical reasoning –EXCERPT from full ASA Guidelines table.

Ethical Reasoning KSAs:	Knowledge, skills and abilities (KSAs) of Ethical Reasoning					
	Prerequisite knowledge: Instruction on ethical domain (NIH topic area) and its relevance to the ASA ethical area	Recognize a Moral issue: what are the implicit and explicit options I am considering when I choose to act any given way? What are my responsibilities?	Identify decision-making frameworks: Focus on Stewardship, virtue ethics, "accepted practice", and utilitarianism frameworks.	Identify and evaluate alternative actions: My actions must support both my profession and the scientific domain under study.	Make & justify decision: Articulating how and why my actions represent my professionalism and my competence.	Reflect on decision: Internalizing decisionmaking and considering how to promote greater reasoning and justification in future actions.
ASA Ethical Guideline Areas: Professionalism competence, judgment, diligence	peer review	What are my responsibilities with respect to peer review of my work, or reviewing others' work? Should I submit my work to peer review? Should I provide a peer review? Can I justify not exercising all my competence and judgment in my peer review?	How is "peer review" treated under each of these frameworks? Do the frameworks treat transparency, informativeness, precision, accuracy, and groundedness differently as objectives?	Considering my time and effort as resources (and optimizing transparency, informativeness, precision, accuracy, and groundedness), what do my choices imply?	How can I best justify my decisions about peer review? What other justifications are there? By what authority does that justification apply?	What do my choices with respect to peer review (proposals, posters, manuscripts, dissertations, IRB submissions) say about my professionalism?
Responsibilities to funders, clients & employers assuring that statistical work is suitable	data acquisition and laboratory tools; management, sharing and ownership	Do my actions with respect to data (acquisition, management, sharing) treat one 'client' as more important than another? Can I justify prioritizing these responsibilities? Can I justify choices made by employers (e.g., to NOT share data) and still maintain professionalism and suitability of my work?	How are my responsibilities to funders, clients and employers with respect to data issues (transparency, informativeness, precision, accuracy, and groundedness) treated under each framework?	Considering my responsibilities to these entities, (transparency, informativeness, precision, accuracy, and groundedness), what do my choices about data, its management and sharing necessarily imply?	Are there formal mechanisms to justify my decisions about data, its management and sharing? What are my justifications? By what authority does that justification apply?	What do my choices with respect to data acquisition, management and sharing say about my commitment to funders, clients and employers? What do they say about my professionalism?
Responsibilities to Research Team Colleagues	conflict of interest – personal, professional, and financial; collaborative research including collaborations with industry	What is a conflict of interest? Do my responsibilities change, or are they prioritized differently, when my colleagues are on an academic team vs. in or with industry? Are there different elements of professionalism that pertain when the research team colleagues are with me (in academia, in industry) or in another domain (industry/academia)? Are my responsibilities to government partners different or prioritized differently than those to industry/academic partners?	How is/are the quantitative scientists' role(s) with respect to research colleagues and/or conflicts of interest viewed under each of these frameworks? Are different frameworks more applicable to academic, industry or government colleagues?	Considering my responsibilities (transparency, informativeness, precision, accuracy, and groundedness) to the research colleagues, (representing my professional competence and judgment), what do my choices about the conflicts of interest and their declaration/management necessarily imply?	Is there a formal mechanism by which I can justify my decisions about conflicts of interest and their declaration/management? If not, what other justification can I come up with? If so, by what authority does that justification apply to my situation?	What do my choices with respect to conflicts of interest and their declaration/management say about my professionalism?

2.1 Adding a developmental trajectory, and its assessment with a portfolio

Table 3 (and Table A1) achieves what neither Table 1 nor Table 2 can: it synthesizes the ASA Guidelines with a set of learnable, improvable skills. It also has meaningful – flexible – intersections of each row and column (cell), such that virtually any material can be used to support teaching and assessable learning representing key features in ethical reasoning as well as any one of the ASA ethical guideline topical areas. In our semester course (on ethical reasoning, not for quantitative scientists), the first eight meetings are focused on orienting students to the knowledge, skills, and abilities (KSAs) in the MR-RCR, utilizing one topic from the NIH topics list (NIH, 2009) as content on which to practice each KSA. After the eighth week, we shift from exploring and initiating development in, and practice of, the KSAs to refining individual confidence with -and evidence of - each. For the remaining meetings, case analyses are focused on the KSAs that each student believes they need more practice with, or, whichever is most salient for analyzing the case.

At the end of a semester, novices or “apprentices” compile a portfolio that documents how they perceive that their own abilities have changed over the term. Students use their own case analyses from earlier and later in the course as evidence that they do have the KSAs that were taught and practiced, and to support claims (in 500 word essays) that they have changed from less- to more- expert (from beginner to novice for a one-semester graduate level course targeting KSAs and ethical reasoning). Performance levels they would target are roughly what are described in Tables 3 and A1 – the novice level.

However, one of the most important features of the Mastery Rubric is that it conveys a *developmental trajectory* for how the learnable and improvable skills that are to be delivered through the curriculum, or developed across a career, should look as they change in qualitative ways (Tractenberg et al. 2010; Tractenberg & FitzGerald, 2012; Tractenberg, 2011). One way to address this missing element is to utilize the Mastery Rubric for RCR (Tractenberg & FitzGerald, 2012) for designing teaching and learning goals that separately address (explicitly) each of the ASA Guideline Topical areas. Table 4 is an excerpt of the MR-RCR (Tractenberg & FitzGerald, Table 1). While not outlined in this paper due to space constraints, the developmental trajectories that are (partly) articulated in Table 4 can be used to create and evaluate teaching and learning objectives around *each* of the eight ASA Guidelines. For example, for a case study or published article (or role play) where the teaching and learning objectives are centered on “Responsibilities to Research Team Colleagues”, whether or not an NIH topic area is also included or represented in the case study (or materials), students would be asked to demonstrate each of the ethical reasoning KSAs -i.e., describe the prerequisite knowledge required to begin to analyze the case; then they would identify/recognize the ethical issue(s); identify at least two decision-making frameworks; identify and evaluate alternative actions; make and justify a decision relevant to the case, and then reflect on the decision. These same ethical reasoning KSAs would be taught, students would be given the opportunity to practice with feedback, and then ultimately, demonstrate their possession of, these KSAs *for each of the ASA Guideline topics*.

Individuals who wish to be classified as “Masters” or mentors with respect to the ASA Guidelines compile a portfolio of evidence that supports their claims of having these KSAs, for each of the Guideline topics, at the level of the Master (i.e., one who has documented experience successfully guiding apprentices to the Journeyman level).

Table 4. Excerpt of the Mastery Rubric for Responsible Conduct of Research (Tractenberg & FitzGerald, 2012 Table 1)

	novice <i>Limited opportunity to exhibit any of the RCR KSAs; lack of awareness of many or all of the dimensions and also of his/her own development or place in the continuum.</i>	beginner <i>Increasing opportunities to exhibit RCR KSAs. Requires oversight as awareness of KSAs grows.</i>	competent <i>Inconsistent exemplification of all RCR KSAs, but clearly emerging proficiency in RCR; reflective participation in RCR training activities –seeking new opportunities to reinforce less-well developed skills.</i>	proficient <i>Consistent exemplification of all RCR dimensions; proficient mentoring of less senior/proficient scientists; active and proficient participation in RCR training activities, including their development and evaluation.</i>
Performance levels:				
KSAs:	Uninitiated	Apprentice	Journeyman	Master
Prerequisite knowledge	CITI and NIH online training modules completed satisfactorily.	Participation in discussion over time on fundamental (foundational) ethical issues.		
Identify and evaluate alternative actions	Incomplete list of the most clear-cut options – from few frameworks. Cannot evaluate or rank well; unaware of nuances within or between alternatives.	List of clear cut options –from limited number of frameworks, articulation of alternative actions possibly recognizing conflicts between alternatives and/or for various interests, but uncertain how/unable to reconcile these conflicts well. Incomplete evaluations of alternatives.	Evaluative list and ranking of alternative actions, from most frameworks; evaluation of stakeholders for whom each alternative might be most relevant and/or compelling, and why. Incomplete explication.	Create and evaluate a relatively comprehensive list of alternative actions from the perspectives of those moral points of view that are specifically relevant to the problem. Capacity to create vignettes for eliciting lists or evaluations from less-proficient RCR trainees.
Make & justify decision	Unable to consistently justify any one decision over another adequately.	Justify at least two decisions, even if they are at odds, and predict what the outcomes would be if all (justified) decisions were taken – furthering the decision-making process but not exactly completing it.	Identify “best” alternative actions, justify the rankings. Synthesize the evidence composed for first three KSAs for a thorough analysis of what can and should be done – by whom, and why.	Identify the “best” alternatives from the perspective of each stakeholder as well as overall. Critique these classifications from the perspectives of experts in the field. Capacity to create vignettes for assisting less-proficient RCR trainees in perceiving these perspectives, alternatives, and justifications.
Reflect on decision	Reflection is a very abstract, high level cognitive activity and would not be expected for the novice or beginner; novice or beginner might make an acceptable or “correct” decision and simply be aware that they cannot justify it well.		Considers ramifications of earlier decisions to improve future decisions on problems that do not necessarily have a “right” answer.	Facilitating reflection of others on ethical decisionmaking; leadership roles in pursuit of contextual changes to avoid, adapt, or facilitate, similar decision-making in the future.

Any evidence that represents the KSAs at the proficient or Master level, as shown in Table 4 and described in Tractenberg & FitzGerald (2012), can be utilized to compose the essays that are included in the portfolio for certification of the Master level status. The process by which this portfolio for RCR training mentorship is assembled and evaluated has been completed by a team of three experts in RCR training mentorship (to date), and a manuscript describing the process is in preparation (Tractenberg, et al. in prep). In the interim, interested individuals can utilize and adapt the portfolio approach outlined by the American Statistical Association for its Professional Statistician (PStat@) accreditation (see http://www.amstat.org/accreditation/pdfs/Guidelines_for_ASAVoluntary_Professional_Accreditation.pdf).

3. Discussion

This paper describes a method to develop flexible, assessable teaching and learning objectives that both emphasize the responsibilities of the quantitative science in conducting research (RCR) and the ASA Ethical Guidelines for Statistical Practice. This approach challenges the current model for using the ASA Guidelines in the development of "professional conduct" - i.e., post the guidelines and hope people read, and learn to embody, them. Instead, using a Mastery Rubric construct (and even adapting the Mastery Rubric for the Responsible Conduct of Research), is a much more dynamic - but practical - approach to formally integrating the Guidelines into training for statistical practice. The approach: a) represents ongoing development across the quantitative scientist's career, encouraging individual self-regulation by making developmental objectives and performance criteria explicit; b) promotes certification of performance levels of both the responsible conduct of research and ethical statistical practice in that conduct of research; and c) provides for concrete evaluation and improvement of training opportunities and their utility for/consistency with learning objectives at the institutional level.

The alignment of the ASA Guidelines and ethical reasoning KSAs together with the NIH RCR topics shown in Table 4 suggests how *any* available materials, even those that were *not* originally designed for use with quantitative scientists, can be adapted or adopted in a formal training program that both meets federal/funder RCR training requirements and also gives an introduction to/instruction in the ASA Guidelines. It also shows that ethical challenges and issues represent decisionmaking opportunities, wherein ethical statistical practice can be supported by these well-known, but not widely taught, reasoning skills.

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Appendix. The Novice level version of Table 3, sufficient to support a full semester or quarter long course on the responsible conduct of research (compliant with NSF/NIH/DoD requirements) that also introduces the eight ASA Ethical Guideline Topical Areas.

Table A1. Eight ASA ethical professional areas (rows) crossed with six *learnable, improvable KSAs of ethical reasoning*
 From: <http://www.amstat.org/committees/ethics/index.html> after Tractenberg & FitzGerald (2012, tables 1-2)

Ethical Reasoning KSAs:	Knowledge, skills and abilities (KSAs) of Ethical Reasoning					
	<i>Prerequisite knowledge:</i> Instruction on NIH domain and its relevance to the ASA ethical area	<i>Recognize a Moral issue:</i> what are the implicit and explicit options I am considering when I choose to act any given way? What are my responsibilities?	<i>Identify decision-making frameworks:</i> Focus on Stewardship, virtue ethics, "accepted practice", and utilitarianism frameworks.	<i>Identify and evaluate alternative actions:</i> My actions must support both my profession and the scientific domain under study.	<i>Make & justify decision:</i> Articulating how and why my actions represent my professionalism and my competence.	<i>Reflect on decision:</i> Internalizing decisionmaking and considering how to promote greater reasoning and justification in future actions.
ASA Ethical Guideline Areas:						
Professionalism competence, judgment, diligence	peer review	<i>What are my responsibilities with respect to peer review of my work, or reviewing others' work?</i> <i>Should I submit my work to peer review? Should I provide a peer review?</i> <i>Can I justify not exercising every bit of my competence and judgment in my peer review?</i>	How is "peer review" treated under each of these frameworks? Do the frameworks treat transparency, informativeness, precision, accuracy, and groundedness differently as objectives?	Considering my time and effort as resources, and optimizing transparency, informativeness, precision, accuracy, and groundedness), what do my choices (moral issues) necessarily imply?	Is there a mechanism by which I can justify my decisions about peer review? If not, what other justification can I come up with? If so, by what authority does that justification apply to my situation?	What do my choices with respect to peer review (proposals, posters, manuscripts, dissertations, IRB submissions) say about my professionalism?
Responsibilities to funders, clients & employers assuring that statistical work is suitable	data acquisition and laboratory tools; management, sharing and ownership	Do my actions with respect to data (acquisition, management, sharing) treat one 'client' as more important than another? Can I justify prioritizing these responsibilities? Can I rationalize choices made by employers (e.g., to NOT share data) and still maintain professionalism	How are my responsibilities to funders, clients and employers with respect to data issues (transparency, informativeness, precision, accuracy, and groundedness),	Considering my responsibilities to these entities (transparency, informativeness, precision, accuracy, and groundedness), what do my choices about data, its management and sharing necessarily	Are there formal mechanisms by which I can justify my decisions about data, its management and sharing? If not, what other justification can I come up with? If so, by what authority does that justification apply to my situation?	What do my choices with respect to data acquisition, management and sharing say about my commitment to funders, clients and employers? What do they say about my professionalism?

		and suitability of my work to the task at hand?	treated under each framework?	imply?		
<u>Responsibilities in Publications and Testimony</u>	responsible authorship and publication	Can I take full responsibility for what I have written, published, or testified? Is the entirety of my written or testified work fully professional? Have I done everything I can to ensure that my responsibilities to reviewers, readers/hearers, and decisionmakers have been met? Or, Are their situations I have seen/can imagine where these responsibilities might need to be prioritized?	How is "responsible authorship" treated under each of these frameworks? Do they differ in their requirements for transparency, informativeness, precision, accuracy, and groundedness?	Considering my responsibilities to reviewers and readers (or hearers) – and decisionmakers, (transparency, informativeness, precision, accuracy, and groundedness), what do my choices about publications and/or testimony necessarily imply?	Are there established mechanisms by which I can justify my decisions about publishing or testifying? If not, what other justification can I come up with? If so, by what authority does that justification apply to my situation?	What do my choices with respect to publishing (posters, manuscripts, dissertations) or testifying say about my professionalism?
<u>Responsibilities to Research Subjects</u>	policies regarding human subjects, live vertebrate animal subjects in research, and safe laboratory practices	What is my role as a quantitative scientist in the alignment of the research with the governing policies? Is the sample size and proposed analytic plan the correct balance of risk and knowledge-value? Have I prioritized power over interpretability of results? Does the analysis plan support theory testing and/or knowledge building, or the NHST methodology?	How is/are the quantitative scientists' role(s) with respect to research subjects viewed under each of these frameworks?	Considering my responsibilities to the research participants, (professional competence and judgment), what do my choices about the analyses necessarily imply?	Is there a formal mechanism by which I can justify my decisions about sample size, experimental design and/or analytic method? If not, what other justification can I come up with? If so, by what authority does that justification apply to my situation?	What do my choices with respect to experimental design, sample size and analysis planning (in proposals, posters, manuscripts, dissertations, and/or IRB submissions) say about my professionalism?
<u>Responsibilities to Research Team Colleagues</u>	conflict of interest – personal, professional, and financial collaborative research	What is a conflict of interest? Do my responsibilities change, or are they prioritized differently, when my	How is/are the quantitative scientists' role(s) with respect to research colleagues	Considering my responsibilities to the research colleagues (transparency, informativeness,	Is there a formal mechanism by which I can justify my decisions about conflicts of interest and	What do my choices with respect to conflicts of interest and their declaration/manageme

	including collaborations with industry	colleagues are on an academic team vs. in or with industry? Are there different elements of professionalism that pertain when the research team colleagues are with me (in academia, in industry) or in another domain (industry/academia)? Are my responsibilities to government partners different or prioritized differently than those to industry/academic partners?	and/or conflicts of interest viewed under each of these frameworks? Are different frameworks more applicable to academic, industry or government colleagues?	precision, accuracy, and groundedness), what do my choices about the conflicts of interest and their declaration/management necessarily imply?	their declaration/management? If not, what other justification can I come up with? If so, by what authority does that justification apply to my situation?	nt say about my professionalism?
Responsibilities to Other Statisticians or Statistical Practitioners	the quantitative scientist as a responsible member of society, contemporary ethical issues in scientific &/or quantitative research, and the environmental and societal impacts of quantitative sciences in scientific research – whether this affects academic or lay consumers. Helping scientists be responsible;	Can I take full responsibility for what I have written, published, or taught? Is the entirety of my written or spoken work fully professional? Are my responsibilities generally primarily to reviewers, readers/hearers, and decisionmakers –or are they more to other statistical practitioners? Are their situations I have seen/can imagine where the responsibilities might need to be prioritized differently for "lay" vs. professional statistical consumption?	How is/are the quantitative scientists' role(s) with respect to other quantitative scientists treated under each of these frameworks? Do the frameworks apply differently when other quantitative scientists are actually also research collaborators <or vice versa>?	Considering my responsibilities other statistical practitioners (professional judgment), what do my choices about publications and/or testimony, and how these publications or testimonies may be viewed by the public/society, necessarily imply?	Are there established mechanisms by which I can justify my decisions about what I contribute to "society"? If not, what other justification can I come up with? If so, by what authority does that justification apply to my situation? Are the justifications different if the "society" is a professional (quantitative or scientific) one vs. the general (lay) one?	What do my choices with respect to how I portray myself to other statistical practitioners say about my professionalism? Does this depend on whether other quantitative scientists are perceiving my interactions with nonquantitative scientists vs. my interactions with other statistical practitioners?

<p>Responsibilities Regarding Allegations of Misconduct</p>	<p>Definitions of research misconduct and policies for handling misconduct</p>	<p>Do I rely on the letter of the definition to identify misconduct (or the spirit)? Do I prioritize definitions when there are different bodies/regulations to consider? Can I rely on government agency (e.g., NSF, NIH), institutional, or professional society definitions with greater confidence? Can I marginally avoid a label or charge of "misconduct" and maintain my professionalism?</p>	<p>How is/are the quantitative scientists' role(s) with respect to misconduct by nonquantitative scientist colleagues treated under each of these frameworks? Do the frameworks apply differently when I or my colleagues are quantitative scientists?</p>	<p>Considering definitions of, and policies for handling, misconduct, do these different frameworks lead to different decisions?</p>	<p>Is there a formal mechanism by which I can justify my decisions about misconduct? If not, what other justification can I come up with? If so, by what authority does that justification apply to my situation?</p>	<p>What do my choices with respect to misconduct, its identification and my actions about it say about my professionalism?</p>
<p>Responsibilities of Employers,</p>	<p>mentor/mentee responsibilities and relationships</p>	<p>If your employer (client or funder) does not understand specifically what you do/how you do it, does that alter or affect their responsibilities with respect to your mentorship and professional development? Does the independent quantitative scientist have different responsibilities to mentor/be mentored than collaborative or "supportive" quantitative scientists?</p>	<p>How is mentorship for quantitative scientists specifically treated under each framework?</p>	<p>Do your responsibilities to have or provide mentorship vary throughout your career, across different contexts (academia, industry, government)? What distinguishes the different alternatives you identify? Is it primarily the extent of the obligation or some other aspect?</p>	<p>Are there established mechanisms by which I can justify my decisions about mentoring/seeking a mentor? If not, what other justification can I come up with? If so, by what authority does that justification apply to my situation?</p>	<p>What do my choices with respect to mentorship (seeking/providing) say about my professionalism?</p>