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Connecting Past with Present: A Mixed-Methods Science Ethics Course and its Evaluation

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Abstract We present a graduate science ethics course that connects cases from the historical record to present realities and practices in the areas of social responsibility, authorship, and human/animal experimentation. This content is delivered with mixed methods, including films, debates, blogging, and practicum; even the instructional team is mixed, including a historian of science and a research scientist. What really unites all of the course's components is the experiential aspect: from acting in historical debates to participating in the current scientific enterprise. The course aims to change the students' culture into one deeply devoted to the science ethics cause. To measure the sought after cultural change, we developed and validated a relevant questionnaire. Results of this questionnaire from students who took the course, demonstrate that the course had the intended effect on them. Furthermore, results of this questionnaire from controls indicate the need for cultural change in that cohort. All these quantitative results are reinforced by qualitative outcomes.

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Introduction

In recent years, there has been a proliferation of science ethics courses. The *Collaborative Institutional Training Initiative* (CITI)—a standardized online course (Braunschweiger and Goodman 2007)—is the most popular ethics training platform across academic institutions. CITI falls under an educational design known as *Responsible Conduct of Research* (RCR). RCR also includes graduate courses that cover current practices and regulations, much like CITI, but in more depth and in the context of classroom instruction. Several studies indicate that RCR courses have some positive effects, but the same studies also bring to the fore areas in need of improvement or nuanced consideration (Powell et al. 2007; Funk et al. 2007; Antes et al. 2010). Specifically, RCR instruction yields knowledge gains but appears to fall short in cultivating empathy and moral attitudes. This is a potential problem because being well informed about science ethics is not the same thing as having internalized science ethics.

A quite different educational design features undergraduate courses with emphasis on scholarly treatment rather than practical matters. This design cluster includes science ethics courses rooted in history that use case-based pedagogy [e.g., (Foley Fall 2007)]. Historical cases can humanize science ethics issues and connect them to personal and cultural concerns, thus engaging the student in ways that RCR courses may be difficult to do. There is also literature support about the effectiveness of this design's basic components, that is, the value of history in science education (Matthews 1994) and the value of case-based learning in ethics education (Shulman 1992).

In the present article we describe a graduate science[1] ethics course that fuses and enhances these two complementary designs. Specifically, the course blends historical with contemporary treatment, using delivery mechanisms with experiential and emotional components. Such delivery mechanisms are distinct from standard instruction, where the focus is on lecturing and rationality.

Teaching students about the seriousness of ethics in science during their graduate school years is ideal timing. It is there, in the peak of their ambitions and passion for research, that students should be reminded about ethical values.

Course Themes

Through our research and teaching experiences, we came to realize that graduate students often hold views of scientific absolutism, which prevents them from embracing the science ethics message. These views are being cultivated by an entrenched culture in science departments and labs. The belief system that supports this attitude considers science to be value free, it subscribes to the pursuit of

[1] Please note that we use the term science broadly, covering all the STEM fields.

knowledge at nearly any cost, it sees no place for feelings in scientific pursuits, and limits the obligations of scientists to their fields; everything else is somebody's else responsibility (e.g., the supervisor who took the project decision).

We find this belief system highly problematic. Not only are these notions wrong but they can also undermine morality in insidious ways, because they desensitize the scientists and relegate any humanistic considerations to a low priority. We are afraid that any gains achieved through an RCR module are on perilous ground, as long as this set of ideas is held dear by the young scientists.

Our *Mixed Methods Science Ethics* course that connects *Past with Present* (MEPP) aims not only to convey usable knowledge but also to dispel these ideas. The latter is a challenging objective, tantamount to cultural transformation. To facilitate this objective, the course aims to raise the moral sensitivity and moral motivation of young scientists, two elements of moral behavior (Bebeau et al. 1999) that are suppressed by scientific absolutism views.

The MEPP course employs a 360° educational approach targeting hearts and minds; it includes historical tracing, emotional documentaries on landmark cases, role playing in past debates, and current practicum experiences. Winning the heart of the graduate student is key to motivate and sensitize her/him, paving the way for the transformation sought after. This is not only supported in the literature (McCuen and Shah 2007; Sunderland 2014; Thiel et al. 2013), but also is embedded in the wisdom of our language—motivation and emotion have the common latin root 'motus'.

The course delivery by a mixed instructional team is a deliberate choice. Specifically, the lead instructor is Dr. I. Semendeferi (Teaching/Research Associate Professor—History of Science) who collaborates with Dr. I. Pavlidis (Professor—Computational Physiology). Young scientists may find easier to embrace the moral message from a historian of science if it is supported by one of their own (i.e., a research scientist), and if it is embellished with some language they understand (i.e., practicum). Mutual understanding and empathy between humanities and sciences play key role in the course's delivery.

The MEPP course carries 3 semester credits and is offered in its present form since 2011 at the University of Houston (Semendeferi and Pavlidis 2011–2014). Specifically, the class meets twice per week (1.5 h each time) for the entire fall semester (14 weeks); the grade scheme is A–F. The class's enrollment ranges between 20 and 30 students.

The themes covered in the course are: (a) professional and social responsibility; (b) authorship and peer review; and (c) human and animal experiments. These themes constitute the core ethical issues of contemporary science. Scientific results inform policies, products, and services. This part of the science operation has the most immediate impact on people's lives. Prior to this stage stands article authorship, the fundamental production mode of science, with peer review as its quality control mechanism. Further up the operational chain, humans and animals, which are both moral agents, are the subjects upon which scientific research is carried out, prior to its publication.

Within each thematic unit, treatment starts with landmark cases that shaped our current views and regulatory framework, and ends with the present state of affairs. Students therefore acquire historical perspective and understanding. History is fundamental in imparting the science ethics message (Rollin 2006). Analyzing science through the lenses of the past helps young scientists understand that scientific endeavors and outcomes are shaped in part by cultural values. The students also experience that conflict of interest, ambition, scientific excitement and passion may create bias. And, bias in the making of science can be dangerous. Thus, the students realize that the search for the ‘absolute’ truth in science has limitations. This realization evokes their emotions and sensitizes them (Semendeferi 2014).

It is also worth noting that contemporary ethics cases are often unsettled, arousing contrasting responses among the students. What is ethical and what is unethical is not always clear. The more recent the case, the stronger the biases. Landmark ethics cases from the past, however, are mostly settled and convey messages that can be more easily understood and accepted. Visiting the historical record draws students on the ethics cause in unison. Then, they approach current ethics issues with a less combative and more deliberative attitude.

Next, we describe the specific ways that history connects with the three science ethics themes in the course.

Professional and Social Responsibility

First, we visit the relationship of history with the professional and social responsibility theme, where we study the insidious role of unchecked government-industry relationships and the industry’s unprincipled manipulation of science for profit. By nature, science is democratic and is based on open communication. It honors skepticism and debate. There are scientists, however, who use this very fact in unethical ways. Experiencing that in historical cases, arouses the students’ emotions and sensitises them to their responsibility as experts.

As examples of questionable government-industry relationships we visit the cases of the AEC/NRC[2]—nuclear power industry and the NASA—aerospace industry, which contributed to the Three-Mile Island (Walker 2004; Semendeferi 2008; Sturgis 2009; Shrader-Frechette 2011) and Challenger technological disasters (Boisjoly et al. 1989; Vaughan 2009), respectively. Inherent in these cases is the underestimation of risk, which is not only unethical but also shortsighted. The demise of the nuclear power industry and the undoing of the space shuttle program are partly due to these disasters.

As examples of the industry’s manipulation of science we visit the cases of the tobacco industry (Brandt 2007; Proctor 2011; Oreskes and Conway 2010) and the lead industry (Markowitz and Rosner 2003, 2013), which led to public health disasters. The underlying pattern is the warnings of courageous scientists or engineers of the danger of a practice or product. These warnings are either ignored or attacked by powerful interests and their endorsing scientists, and valuable time is lost in legal and publicity battles. As a result, millions of lives that could have been saved from morbidity, are not. This human cost is an addition to the financial burden to society, which is innate in public health cases.

[2] Atomic Energy Commission/Nuclear Regulatory Commission.

By this time the students realize the biases, conflicting interests, ethical dilemmas, and the long-term implications in critical techno-scientific endeavors. Not a moment too soon, they are ready to play their role as caring experts in the grand-challenges of our times.

Authorship and Peer-Review

Next, we visit the relationship of history with the authorship theme, where the timeless human passion for recognition is brought into focus against the backdrop of an evolving social context. Such a social context sometimes makes little difference in people's behaviors, creating the sense of deja vu, while at some other times makes a significant difference. This realization can help the students to overcome contextual constraints, standing ahead of their time, should they ever face consequential moral dilemmas during their careers.

The point is brought to life in two landmark authorship disputes, the Darwin-Wallace case (Shermer 2002) on natural selection versus the Gallo–Montagnier case on AIDS (Gallo 1991). In both events, we have the story of two scientists working on the same problem and arriving at a solution nearly simultaneously. The issue of credit was resolved between Darwin and Wallace in a famously collegial manner through the mediation of a common friend. In contrast, the combative manner of the infamous credit dispute between Gallo and Montagnier was only settled via the mediation of sovereign governments.

Independent gentlemen in the pursuit of pure science gave way to publicly funded professionals in the pursuit of the next grant and the paper in the journal with the highest impact factor. Deliberative and slow filtering of research results that lasted for years gave way to hasty treatment, with all the characteristics of a panic race. Mediation by colleagues gave way to mediation by sovereign states, the patrons of the new science system.

These two contrasting cases from the historical record, introduce an insightful treatment of the current scholarly landscape, where team science rules. There is analysis of the ethics issues that arise in the context of team science, for some of which the Gallo–Montagnier incident serves as an excellent case study. In a team science setting, the fair assignment of author credit and blame becomes a complicated problem. Furthermore, due to interdependencies in a team science network, conflict of interest and the balancing of collaboration versus competition becomes a riddle, with consequences for the peer-review process. The analysis of all these team science issues informs a discussion about ethical norms of behavior to resolve them (Petersen et al. 2014; Pavlidis et al. 2014).

Human and Animal Experiments

Next, we visit the relationship of history with the human experiments sub-theme, where the course's coverage includes the PHS Syphilis Study at Tuskegee (Jones 1993), the radiation experiments (Buchanan 1996; Welsome 2010), and the Stanford experiment (Zimbardo et al. 2000). In all these cases the ethical issues are clear and the flaws in the experimental designs widely recognized. The common thread is that the scientists' passion for knowledge may be pure and aiming to serve humanity at large, but sometimes a part of humanity is mistreated in the process. The actors' justification for this mistreatment varies widely and is culturally constructed. In the Tuskegee study, the investigators did not assign to the black subjects full human moral status in accordance with entrenched racial notions at the time. In the radiation experiments, the investigators viewed the subjects as worth sacrificing in the pursuit of a cold war victory. In the case of the Stanford experiment, the investigators were neither racist nor serving any national purpose. They simply had a bad experimental design, which they thought was innovative science. Thus, they got into the dynamics of the situation becoming the emblematic example of the very phenomenon they attempted to study.

The human experiments sub-theme closes with an examination of recently approved studies by the university's *Institutional Review Board* (IRB) committee. In addition to teaching the mechanics of composing IRB applications, we connect specific elements in these studies with the principles established in the historical cases.

For the animal experiments sub-theme we trace the evolution of moral attitudes and experimental practices all the way form vivisections to the recent ban of chimpanzees by the National Institutes of Health (NIH). The coverage is informed by the teachings of Singer (2011) and culminates with the examination of recently approved studies from the university's *Institutional Animal Care and Use Committee* (IACUC).

Course Delivery and Participatory Modes

The key to internalizing the messages conveyed by the course's themes lies in the ways these themes are delivered and the opportunities given for creative student participation. The modes of delivery and participation for the MEPP course include: lecturing; documentary films; debates; practicum; submission of web links; blogging; and a seminar series with speakers from both the humanities and the sciences (Semendeferi et al. 2011–2014).

The core delivery mechanism is centered on a three-stage approach for each historical case included in the course's themes. The first session (stage) is devoted to lecturing, the second session to documentary films, and the third session to a debate. A concluding lecture per theme makes the connection of past lessons with present realities and practices. This connection is also reinforced by the other participatory modes of the course, such as the hunting of web links and the practicum.

Lecturing and Documentary Films

The lecture introduces the students to key facts and issues related to the case. It also includes strong and colorful statements that are presented in a passionate manner provoking the students. The documentary films elaborate on the case and engage the students by forcing them to live the drama. As we have already stressed, emotions play a fundamental role in constructing moral behavior according to neuroscientific findings (McCuen and Shah 2007). To this end, the emotional power of visual media and their effect on behavioral changes is well-known (LaMarre and Landreville 2009; Fox et al. 2001). History of science is blessed both in terms of narratives and visuals, thus, serving as an ideal generator of emotionally rich cases (Semendeferi 2014).

In selecting the films for the course, we paid attention to their quality and dramatic effect. For example, for the Challenger case, we show the National Geographic documentary, *Challenger: The Untold Story* (Everett et al. 2006), while for the danger of nuclear waste to current and future generations, we show the award winning documentary, *Into Eternity: A Film for the Future* (Madsen and Director 2010). "Appendix" gives a select list of the documentaries and the lecture readings per case.

A concluding lecture for each theme presents the current state of affairs and regulatory framework.

Debates

Students prepare intensely for the debate sessions, where they are arranged in small groups. Each group has its representative, who rotates throughout the semester in a round robin fashion. By design, the debates are lively and emotionally engaging. Half of the groups argue in favor of the unethical scientists involved in the case, and the other half argue against them. The groups switch sides from debate to debate. This way the students experience how to confront ethics rivals. If necessary, the instructor intervenes provoking the groups to strengthen their arguments. Asking the graduate student to put her/his feet into the protagonists' shoes and act in a historical case, like in a theater setting, is highly evocative (Brown 1994).

Sometimes, finding arguments to support the unethical scientists in each landmark case is an awkward task for the students. When this happens, the instructor intervenes by encouraging and inspiring the groups on the unethical side to strengthen their arguments. For example, taking the role of a pronuclear scientist arguing against an antinuclear one in the period before the Three Mile Island disaster (TMI), is a difficult task but one that provides a strong experience for the students. This experience is shaped by the retrospective knowledge that TMI not only endangered public health but also contributed to the demise of the nuclear power industry in the United States (Morone 1989). This is where the value of history, when combined with an appropriate delivery method, really shines in science ethics (Semendeferi 2014).

Practicum

During the semester and parallel to the class schedule, the students take a practicum that lasts one to 2 months, taking one to 2 h per week. The practicum brings the students in contact with the current world, reconciling instruction with contemporary reality. Students are matched to labs and mentors for their practicum through an online bulletin board system we developed for this purpose (Dcosta 2014). Practicums are available for two of the three course's themes: the students either intern in labs performing human and animal experiments or perform reviews for journal and conference manuscripts under the supervision of a senior investigator.

In the practicum on animal research at the Methodist Institute for Technology, Innovation, and Education (MITIE^{SM}) (MIT 2014), the students are exposed to a multitude of experiences. For example, they visit the center's vivarium and learn how the animals are cared for; they attend the IACUC meetings where applications for animal research are discussed; then, they attend the ensuing animal experiments, which gives them the opportunity to experience how the recently discussed protocols are exercised. All these create a contrasting picture with past practices (e.g., vivisections), making the students appreciate how the historical process led to a more ethical experimental culture. Sometimes, however, the students witness the IACUC committee hotly debating specific protocol provisions—a reminder that ethics is a continuous battle.

For the peer-review practicum, the class collaborates with senior researchers who regularly review manuscripts, and their expertise covers the disciplines of the students who typically join the MEPP class. These researchers act as peer-review mentors. Some venues, such as the *IEEE Computer Vision and Pattern Recognition Conference* allows Ph.D. students to be involved as reviewers in training, provided that they are registered under the supervision of a senior reviewer. In other cases, we obtain special permission by the journal or conference that happened to send a manuscript for review to a mentor during the period of the class.

The standard process is for the mentor to have a tutorial session with the student, where s/he stresses important issues for a competent and ethical review, including the thorough study of the manuscript, lack of bias, the use of professional language, and timeliness. Then, the mentor gives the student a confidential copy of the manuscript and a reviewer form. The student is given 2 weeks to perform the review and during this period there may be another mentoring meeting. At the end of the 2 week period the mentor meets the student again and comments on the strengths and weaknesses of the student's review, offering specific suggestions on how to improve it. Then, the student is given one more week to compose the final review. Upon submission of this final review to the mentor, the student also returns the confidential copy of the manuscript. Shortly thereafter, the mentor shares her/his own review with the student and sends a mentorship report to the class instructors for their information. In several instances, the students raise excellent review points that complement the mentor's thoughts, to the delight of everyone involved in this process.

Web Links

The students need to submit two web links related to the course's themes. The web links need to be from a reputable news source or a well-known academic journal. The search and selection of web links cultivates initiative and raises the students' alertness about science ethics issues. Web links that are deemed of acceptable quality are posted to the university's science ethics web site (Web 2014). A few examples can give an idea about what draws the students' attention. In the fall 2012 class a student suggested a commentary in the *Nature* magazine (Corbyn 2012), which references a *PNAS* study documenting that most of the retractions in life-sciences journals are due to fraud and not errors (Fang et al. 2012). Another student in the same class suggested a policy forum in the *Science* magazine, tackling the misalignment of regulations with ethical considerations in human research (Dressler 2012). A third student suggested a CNN article about lessons drawn for U.S. nuclear safety from the Fukushima meltdown (Aldrich 2012).

Blogging

The students also need to compose a blog piece about a science ethics topic of their choice. Blogs that are deemed of acceptable quality are posted on the university's science ethics web site (UHB 2014). Blogging turns analysis into composition, further cultivating ethical initiative and blending judgment with emotions and experiences. It is a culmination element where the cumulative effect of the course's methods manifest. The topics that preoccupy the students' blogs are drawn from the course's three themes. Characteristic examples include a blog about how empathy needs to guide a scientist's behavior (Gulley 2013), a blog on authorship dilemmas in biomedicine (Panthi 2013), and a blog devoted to the unethical study on stuttering children by Prof. Johnson in the 1930s (Goel 2013).

Seminar Series

Finally, the mixed humanities-sciences seminar series (Semendeferi et al. 2011–2014) is a reflection of the course's mixed design, aiming to bring together what we believe are complementary views on science ethics issues.

The seminar series features celebrated historians who situate science in time, bringing a potent message: The current scientists are the past of the future. The historians' narratives and visuals reveal connections between past and present, as well as certain timeless patterns of unethical behavior in the making of science. Some of the invited historians are the writers of the cases studied in the course. Examples include Prof. James Jones, the author of the Tuskegee case study (Jones 1993), and Prof. David Rosner, the author of the lead poisoning case study (Markowitz and Rosner 2003). Prof. Jones lectured about his research on a new case study, that of the 'bubble boy' (Jones 2014), while Prof. Rosner (Rosner 2013) lectured about his new research on ethically questionable research for the health effects of lead exposure. Other historians analyze science ethics cases with developing implications to our society (Pfatteicher 2012).

The seminar series also features a track of philosophical talks, as ethics is inherently linked to philosophical considerations. Some of the talks in this track bring together philosophy and neuroscience to address open questions in human behavior [for example, see the seminar by Sinnott-Armstrong (Sinnott-Armstrong 2013)]. Some other talks in this track are directly related to ethics education and research (Hollander 2014; Klugman 2013).

Finally, the seminar series features scientists who provide experiential accounts or quantitative analyses of the current issues in scientific authorship and the peer-review operation. A characteristic example is the organization of a panel event devoted to the discussion of issues in the peer-review process in journals and funding agencies (Wheeler et al. 2012). The panel included chairs of standing panels from the National Institutes of Health (NIH), editors of major technical journals, and well-known scientists, holders of the presidential and other awards.

In addition to the MEPP class students, the seminar draws attendees from the faculty and student body of various departments (science and humanities), giving the sense of a broad community with common purpose. These seminars have been turned into complete educational products, with web pages featuring the speakers' presentations, webcasts, and the audience's feedback (Semendeferi et al. 2011–2014).

Qualitative Results

The course's themes and methods aim to change the students' attitude towards science ethics issues from that of benign neglect or reservation to one of active participation. By definition, such an attitude change can be facilitated by raising the students' moral sensitivity and moral motivation (Bebeau et al. 1999). Moral sensitivity is the awareness of how our actions affect other people; it involves empathy and role-taking skills. Moral motivation is about prioritizing moral values over other personal values. Our working hypothesis is that the various course's elements, especially when catalyzed by emotional engagement, can raise the students' moral sensitivity and moral motivation.

In addition to developing and validating a questionnaire to measure the sought after cultural change (see "Quantitative Results" section), we were also looking for qualitative data in the instructional record that support our hypothesis. We noticed that several of the students who graduated from the class kept sending us web links related to science ethics issues, and they also kept coming to the seminars. This is a clear mark of moral sensitization and prioritization.

We were also paying attention to what inspired students in blog composition and the selection of web links. An incident from the fall 2012 instructional record is illuminating, as it points to the emotionally catalytic role of the course's documentaries. A student had misty eyes while watching the National Geographic documentary about the Challenger disaster (Everett et al. 2006). Later we learnt that her father was one of the engineers in the Challenger's NASA team. In a blog that she wrote shortly thereafter (Kunz 2012), she brilliantly connected the first-account stories she heard from her father as a child, the emotions evoked by the documentary's visuals, and the accident data analyses included in the official reports.

In another important qualitative indicator—the course's free form evaluation reports—the students were unanimous in their praise for the experience gained through role playing in past debates and the value of the documentary films. For the debates, a few representative comments bring the collective sentiment to life: 'The debates were one of the most crucial parts of this class.'—student in fall 2012. 'I thought the debates were entertaining and also important. I think they helped to bring forward arguments/perspectives I may not have considered otherwise. They helped me becoming engaged in the topic.'—student in fall 2012. 'I loved the debates because they allowed us to communicate, discuss, and defend a certain position'—student in fall 2013. 'Very good experience!' [the debates]—student in fall 2013. For the films, two representative student comments sum it up: 'Wonderful films!'—student in fall 2012. 'I learned a lot from the films because of how the material was presented.'—student in fall 2013.

Students also expressed positive opinions for the practicum. Two comments are telling: 'I am grateful for all I experienced during the practicum …I was seeing all the protocols and ethical practices employed in the labs.'—student in fall 2012. 'Highly improved my reviewing skills!'—student in fall 2013.

Several other free form comments praised the connection between past and present as well as the course's mixed methods. Here are two representative quotes: 'Pretty enlightening! I have learnt a lot about …science in the past. I can apply this knowledge to my present and future.'—student in fall 2012. 'I thought the course showed a variety of teaching techniques, which kept things interesting. '—student in fall 2013.

Quantitative Results

To the best of our knowledge there is no method to measure cultural transformation in scientists, such as the one sought by the MEPP course. For this reason we developed a relevant questionnaire (Table 1). Per an approved protocol form the Institutional Review Board (IRB) of the University of Houston, we formally administered this questionnaire to the MEPP class at the end of the fall 2012 semester (group S^E_{12}). We also administered it to the MEPP class at the beginning and at the end of the fall 2013 semester (groups S^B_{13} and S^E_{13}, respectively). Finally, we administered the questionnaire to two control groups: the Computational Physiology class in the 2012–2013 academic year and the Ubiquitous Computing class in the 2013–2014 academic year (C_{12} and C_{13}, respectively). These two classes were chosen as control pools because they enroll mixed demographics of mostly graduate students from the science, engineering, and health science departments. Hence, they mirror to some degree the mixed demographics of the Science Ethics class. Conveniently, none of the students in the Computational Physiology and the Ubiquitous Computing classes received any science ethics education prior to taking the questionnaire.

Nearly all the students in the MEPP classes and the majority of the students in the control classes turned in the questionnaires: $n = 25$ for S^E_{12}; $n = 22$ for S^B_{13} and S^E_{13}; $n = 24$ for C_{12}; and, $n = 27$ for C_{13}. Hence, this study was powered by 47 interventional subjects and 51 control subjects. A research assistant, not involved in course instruction, was the person administering the questionnaires.

Questionnaire Design

Per the argumentation in "Course Themes" section, the aim of the questionnaire was to capture elements of the scientist's culture in association with her/his levels of moral sensitivity and moral priorities (motivation). Developing the initial form of a questionnaire is imprecise science. As it is demonstrated later in "Questionnaire Validation and Potential Instrument" section, this particular questionnaire proved to be successful. Hence, it is instructive to shed light on the process through which it came about.

The questionnaire was developed by the lead instructor of the MEPP course—Dr. Ioanna Semendeferi; her undergraduate degree is in Physics, while her Ph.D. degree is in History of Science and Technology. Hence, she lived the cultural climate in science departments before moving to humanities. Following her Ph.D. graduation, she started teaching humanities to scientists, thus reconnecting with the scientists' culture. This back and forth gave her the opportunity to experience and deliberate on the different viewpoints of the two academic cultures. All the questions that test cultural convictions stem from this personal journey. Examples include how objective is science (Q1) and if it is value free (Q3). Scientists and humanists who study the sciences tend to have opposite views on these matters. This difference is

Table 1 Original Science Ethics Questionnaire (O-SEQ). The scales are bold, bold italics, and normal; they are shown at the bottom of the table. The first scale has unique content and optimal response $\boldsymbol{R_o} = \mathbf{3}$. The second and third scales have the same content but different optimal responses; for the second scale $\boldsymbol{R_o} = \mathbf{5}$, while for the third scale $\boldsymbol{R_o} = \mathbf{1}$

Q#	Question
Q1	Science is objective
Q2	It is important to consider ethics issues when pursuing scientific research
Q3	Science is value free
Q4	In order to pursue scientific knowledge everything is worth risking
Q5	Emotions have no place in a scientific pursuit
Q6	A scientist's job is simply the production of knowledge
Q7	Moral judgment should always be a part of any human endeavor. Since science is a human endeavor, moral judgment should be part of science
Q8	When engaging in research, scientists reflect the values and attitudes of their society
Q9	In scientific studies, people may be reduced to objects, symbols on paper, or numerals in a mathematical formula, thus creating the possibility that they will be treated unethically
Q10	Scientific excitement and passion, a natural part of the research process, may cause a scientist to act in an unethical manner
Q11	In our society science is the main mechanism of progress
Q12	Scientists have enormous power to make things better
Q13	Science honors skepticism and debate. This very fact, however, may cause a scientist to act unethically
Q14	Conflict of interest may cause scientists to engage in unethical behavior when pursuing research
Q15	A scientist's emotions play a role in whether or not s/he makes ethical or unethical decisions
Q16	If a scientist claims that s/he is following government protocol or the orders of a superior, then s/he is not responsible for any ethical violation that occurs during the course of conducting research
Q17	A strong belief in a particular science theory, research method, or set of data may make a scientist biased and, thus, possibly engaged in unethical behavior
Q18	Science is a career. Thus it involves making many ethical decisions

1-Almost Never. 2-Rarely. 3-Sometimes. 4-Often. 5-Almost Always

1-Strongly Disagree. 2-Disagree. 3-Not Sure. 4-Agree. 5-Strongly Agree

1-Strongly Disagree. 2-Disagree. 3-Not Sure. 4-Agree. 5-Strongly Agree also noted by Rollin (Rollin 2006) and was evident in interactions with science students in formative versions of this course (2008–2011 period).

Actually, a pattern of student statements in the course's formative period provided qualitative support for most of the cultural conviction questions. An example is the notion that a scientist's job is the mere production of knowledge, related to Q6, with Q16 as its corollary.

The question subset aiming to test sensitivity (or lack thereof) targeted perceptions about bias (e.g., Q10), conflict of interest (e.g., Q14), and detachment (e.g., Q9). Scientists do not fully grasp the numbing effect of these mechanisms, because they live within the action space. In fact, Q9 was inspired by a quote from the editor of the *Atlanta Constitution* on p. 14 in James Jones' classic *Bad Blood: The Tuskegee Syphilis Experiment* (Jones 1993): "Sometimes, with the best intentions, scientists and public officials …forget that people are people …They concentrate totally on plans and programs, experiments, statistics—on abstractions—that people become objects, symbols in paper, figures in a mathematical formula, or impersonal subjects in a scientific study".

The question subset aiming to test priorities, targeted views on the career character of science (e.g., Q18) and the ubiquitous necessity of moral judgment (e.g., Q7). In fact, Q7 was inspired again by a quote from the editor of the *Atlanta Constitution* on p. 14 in (Jones 1993): "Scientific investigators had to learn that moral judgment should always be part of any human endeavor …including the dispassionate scientific search for knowledge".

Questionnaire Validation and Potential Instrument

In order to validate the questionnaire we performed factor analysis, a standard process that is well understood and widely used in instrument development (Pett et al. 2003). We pooled together the response data from the $S_{12}^{E}, C_{12}, S_{13}^{E}$, and C_{13} groups ($n = 98$ subjects). We found the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy to be $0.68 > 0.60$ and the Bartlett's test of sphericity to be significant (<0.05). Hence, we concluded that factor analysis is feasible for this data set.

Using the Kaiser criterion (components with eigenvalues >1) we computed that there are 5 components, explaining 61.17 % of the total variability. Looking, however, at the Scree plot we observed an 'elbow' at Component 3 and hence, we determined that we can reduce the components down to 3, explaining 47.40 % of the total variability. Next, we composed the Pattern Matrix using Principal Component Analysis (PCA) (Table 2A).

For Component 1 the questions Q3–Q6, and Q16 have loadings exceeding 0.6; for Component 2 the questions Q9, Q10, and Q14 have loadings exceeding 0.6; for Component 3 the questions Q2, Q7, and Q18 have loadings exceeding 0.6. Therefore, from the initial set of 18 questions the subset with differentiating power between groups (treated vs. controls) includes the following 11 questions: {Q2–Q7, Q9, Q10, Q14, Q16, Q18}.

For this reduced question set we re-ran factor analysis on the same pooled data: $S_{12}^{E} \cup C_{12} \cup S_{13}^{E} \cup C_{13}$. We found the Kaiser–Meyer–Olkin (KMO) measure of

Table 2 **A.** Pattern Matrix for initial factor analysis. **B.** Pattern Matrix for factor analysis on the reduced question set; the last column lists the Cronbach's alpha coefficients when the corresponding questions are removed from consideration

	A: Component				B: Component			
Q#	1	2	3	Q#	1	2	3	Cronbach's Alpha if Q# removed
Q3	−0.84			Q4	0.81			0.72
Q4	−0.83			Q3	0.80			0.76
Q5	−0.68			Q5	0.71			0.78
Q16	−0.68			Q6	0.68			0.78
Q6	−0.61			Q16	0.68			0.76
Q1	−0.35			Q9		0.81		0.57
Q11				Q10		0.80		0.61
Q14		0.76		Q14		0.76		0.65
Q9		0.76		Q2			0.88	0.69
Q10		0.73		Q7			0.82	0.70
Q12		−0.36		Q18			0.80	0.73
Q7			0.85					
Q2			0.81					
Q18			0.78					
Q13		0.32	0.57					
Q15		0.36	0.50					
Q17		0.38	0.41					
Q8		0.30	0.34					

sampling adequacy to be 0.72 > 0.60 and the Bartlett's test of sphericity to be significant (<0.05). Hence, we concluded that factor analysis is feasible for this data set.

Using the Kaiser criterion (components with eigenvalues >1) we computed that there are 3 components, explaining 62.55 % of the total variability. From the Scree plot we confirmed that the 'elbow' appears after Component 3. Next, we composed the Pattern Matrix using Principal Component Analysis (PCA) (Table 2B). The same grouping that emerged in the initial factor analysis, is also emerging in this second pass, but only stronger. There is no question with loading <0.6 and each question is strongly loaded in one component only. This result suggests that the reduced set of questions (Table 3) is a potential instrument.

The Cronbach's alpha coefficient for questions belonging to Component 1 {Q3–Q6, Q16} is 0.80 > 0.60. The Cronbach's alpha coefficient for questions belonging to Component 2 {Q2, Q7, Q18} is 0.79 > 0.60. The Cronbach's alpha coefficient for questions belonging to Component 3 {Q9, Q10, Q14} is 0.70 > 0.60. Therefore, the Cronbach's alpha coefficients for all three components are strong. Remarkably, in each of the three components, when a question is removed, the Cronbach's alpha coefficient in the reduced component never exceeds the Cronbach's alpha

Table 3 Validated Science Ethics Questionnaire (V-SEQ). The questions are arranged per thematic component (Cultural–Moral Sensitivity–Moral Motivation). The scales are normal and bold italics; they are shown at the bottom of the table. The scales have the same content but different optimal responses: $\boldsymbol{R_o}$ **= 1** and $\boldsymbol{R_o}$ **= 5**, respectively

	Q#	Question
Component 1—Cultural	Q3	Science is value free
	Q4	In order to pursue scientific knowledge everything is worth risking
	Q5	Emotions have no place in a scientific pursuit
	Q6	A scientist's job is simply the production of knowledge
	Q16	If a scientist claims that s/he is following government protocol or the orders of a superior, then s/he is not responsible for any ethical violation that occurs during the course of conducting research
Component 2—Sensitivity	***Q9***	In scientific studies, people may be reduced to objects, symbols on paper, or numerals in a mathematical formula, thus creating the possibility that they will be treated unethically
	Q10	Scientific excitement and passion, a natural part of the research process, may cause a scientist to act in an unethical manner
	Q14	Conflict of interest may cause scientists to engage in unethical behavior when pursuing research
Component 3—Motivation	***Q2***	It is important to consider ethics issues when pursuing scientific research
	Q7	Moral judgment should always be a part of any human endeavor. Since science is a human endeavor, moral judgment should be part of science
	Q18	Science is a career. Thus it involves making many ethical decisions

1-Strongly Disagree. 2-Disagree. 3-Not Sure. 4-Agree. 5-Strongly Agree

1-Strongly Disagree. 2-Disagree. 3-Not Sure. 4-Agree. 5-Strongly Agree

coefficient in the original component, indicating that there is no need for further reduction (Table 2B—last column). Component 1, Component 2, and Component 3 that emerged out of this validation process, correspond to the cultural, sensitivity, and motivation aspects targeted by the questionnaire's design (Table 3).

Comparison Within the Treated Group: Course Effect

We are interested to understand what was the effect of the MEPP course to the student responses. We have paired data for the fall 2013 offering of the course, and thus our effect analysis will focus on this subset. According to the instructors, the optimal responses are as follows: $R_o = 3$ for {Q1}, $R_o = 5$ for {Q2, Q7–Q15, Q17, Q18}, and $R_o = 1$ for {Q3–Q6, Q16} (Table 1). There are three possible effects:

- *No Effect* This is when the pre- and post-course responses to a question are identical. In this case, it is important to know whether the unaltered response was the optimal or not.
- *Positive Effect* This is when the post-course response to a question is closer to the optimal response, compared to the pre-course response.

- *Negative Effect* This is when the post-course response to a question is further away from the optimal response, compared to the pre-course response.

To quantify the effect we need to take the appropriate difference between post- and pre-course responses. We define three difference scorings, one for each possible optimal response:

- *Scoring Function for Questions with Optimal Response* $\boldsymbol{R_o} = \mathbf{3}$: $D_3 = |\text{pre-course score} - 3| - |\text{post-course score} - 3|$, Table 4A.
- *Scoring Function for Questions with Optimal Response* $\boldsymbol{R_o} = \mathbf{5}$: $D_5 = (\text{post-course score}) - (\text{pre-course score})$, Table 4B.
- *Scoring Function for Questions with Optimal Response* $\boldsymbol{R_o} = \mathbf{1}$: $D_1 = (\text{pre-course score}) - (\text{post-course score})$, Table 4C.

We tally the D scores in each question, for the student population in the MEPP'13 class. This produces a 5-tuple for the question scored with D_3 and a 9-tuple for any question scored with D_5 or D_1; these tuples are depicted in bar graph form in Fig. 1. Then, we collapse the 5-tuple and 9-tuples into 3-tuples, capturing the Negative, No, and Positive Effect in each question. Please note that the collapsed No Effect category does not include the responses that are equal to the optimal response (green sub-bars in Fig. 1). Based on these 3-tuples, we compute for each question the posterior point estimates of the Negative, No, and Positive effect, using a non-

Table 4 Scoring tables for questions, per optimal response category

Pre-course response	Post-course response				
	1	2	3	4	5
A: Optimal response $R_o = 3$					
1	0	**1**	**2**	**1**	0
2	*−1*	0	**1**	0	*−1*
3	*−2*	*−1*	0	*−1*	*−2*
4	*−1*	0	**1**	0	*−1*
5	0	**1**	**2**	**1**	0
B: Optimal response $R_o = 5$					
1	0	**1**	**2**	**3**	**4**
2	*−1*	0	**1**	**2**	**3**
3	*−2*	*1*	0	**1**	**2**
4	*−3*	*−2*	*−1*	0	**1**
5	*−4*	*−3*	*−2*	*−1*	0
C: Optimal response $R_o = 1$					
1	0	*−1*	*−2*	*−3*	*−4*
2	**1**	0	*−1*	*−2*	*−3*
3	**2**	**1**	0	*−1*	*−2*
4	**3**	**2**	**1**	0	*−1*
5	**4**	**3**	**2**	**1**	0

Zeros indicate no effect, bold numbers indicate positive effect, and italics numbers indicate negative effect for the respective responses

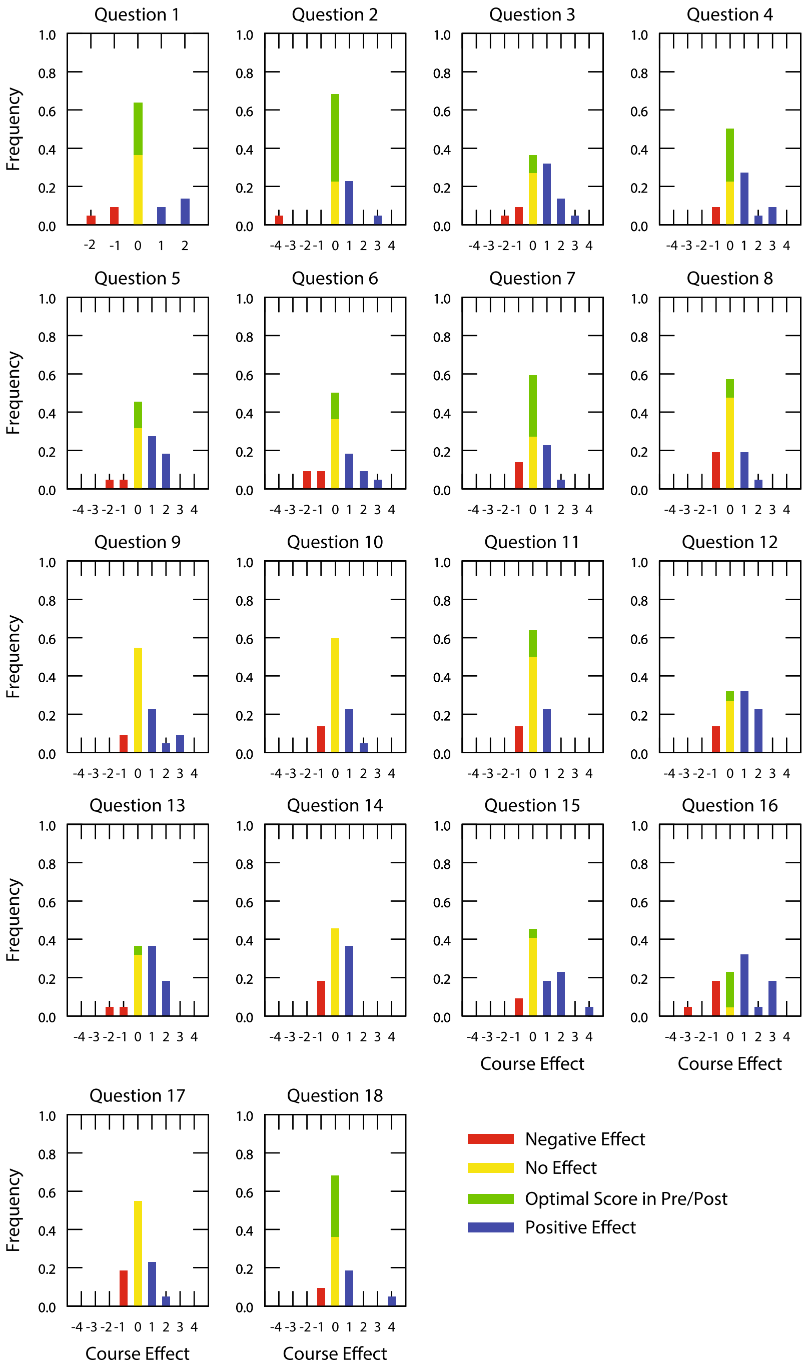

Fig. 1 Comparison within the MEPP'13 class ($n = 22$ subjects). The raw course effects for each question, as computed by the D formulas

Table 5 Posterior effects for the MEPP'13 class ($n = 22$ subjects). The p value of the Wilcoxon (W) test for each question is shown in the last column; italics denote significant values ($p < 0.05$)

	MEPP'13 class			
	Estimate of effect			W test
	Negative (%)	No (%)	Positive (%)	p value
Q1	21.0	47.4	31.6	*0.01*
Q2	13.3	40.00	46.7	0.25
Q3	17.4	30.4	52.2	*0.04*
Q4	15.8	31.6	52.6	*0.02*
Q5	13.6	36.4	50.0	*0.04*
Q6	22.7	40.9	36.4	0.43
Q7	22.2	38.9	38.9	0.27
Q8	22.7	50.0	27.3	0.60
Q9	12.0	52.0	36.0	*0.04*
Q10	16.0	56.0	28.0	0.27
Q11	18.2	54.5	27.3	0.53
Q12	16.6	29.2	54.2	*0.01*
Q13	12.5	33.3	54.2	*0.02*
Q14	20.0	44.0	36.0	0.26
Q15	12.5	41.7	45.8	*0.01*
Q16	28.6	9.5	61.9	0.07
Q17	20.0	52.0	28.0	0.43
Q18	16.7	50.0	33.3	0.24

informative Dirichlet(1,1,1) prior. We tabulate these posterior point estimates in Table 5. We observe that in all the questions, the Positive effect outweighs the Negative effect. Furthermore, in the last column of Table 5 we observe that these favorable mean rank differences are statistically significant ($p<0.05$) for many of the questions [paired Wilcoxon (W) test].

Comparison of Treated Versus Controls

We pool the subjects exposed to the Science Ethics course in 2012 and 2013 into a combined treat group $\mathbf{S}^{\mathbf{E}} = S^E_{12} \cup S^E_{13}$. We also pool the control subjects in 2012 and 2013 into a combined control group $\mathbf{C} = C_{12} \cup C_{13}$. Figure 2 visualizes the results and Table 6 provides the statistics. Based on the Mann−Whitney test, we observe that for 11 out of the 18 questions (Q2–Q8, Q13, Q16–Q18) the p value is less than $\alpha = 0.05$, indicating that for these questions there are significant mean rank differences. Indeed, in Fig. 2 we observe that for these questions the optimal response has higher frequency in the combined treated group $\mathbf{S}^{\mathbf{E}}$ with respect to the combined control group $\mathbf{C}$. Not surprisingly, the majority of these 11 questions belong to the subset that emerged as a potential instrument through the validation process. The within group comparisons for the fall 2013 course offering in combination with this result, indicate that the educational method: (a) has a positive

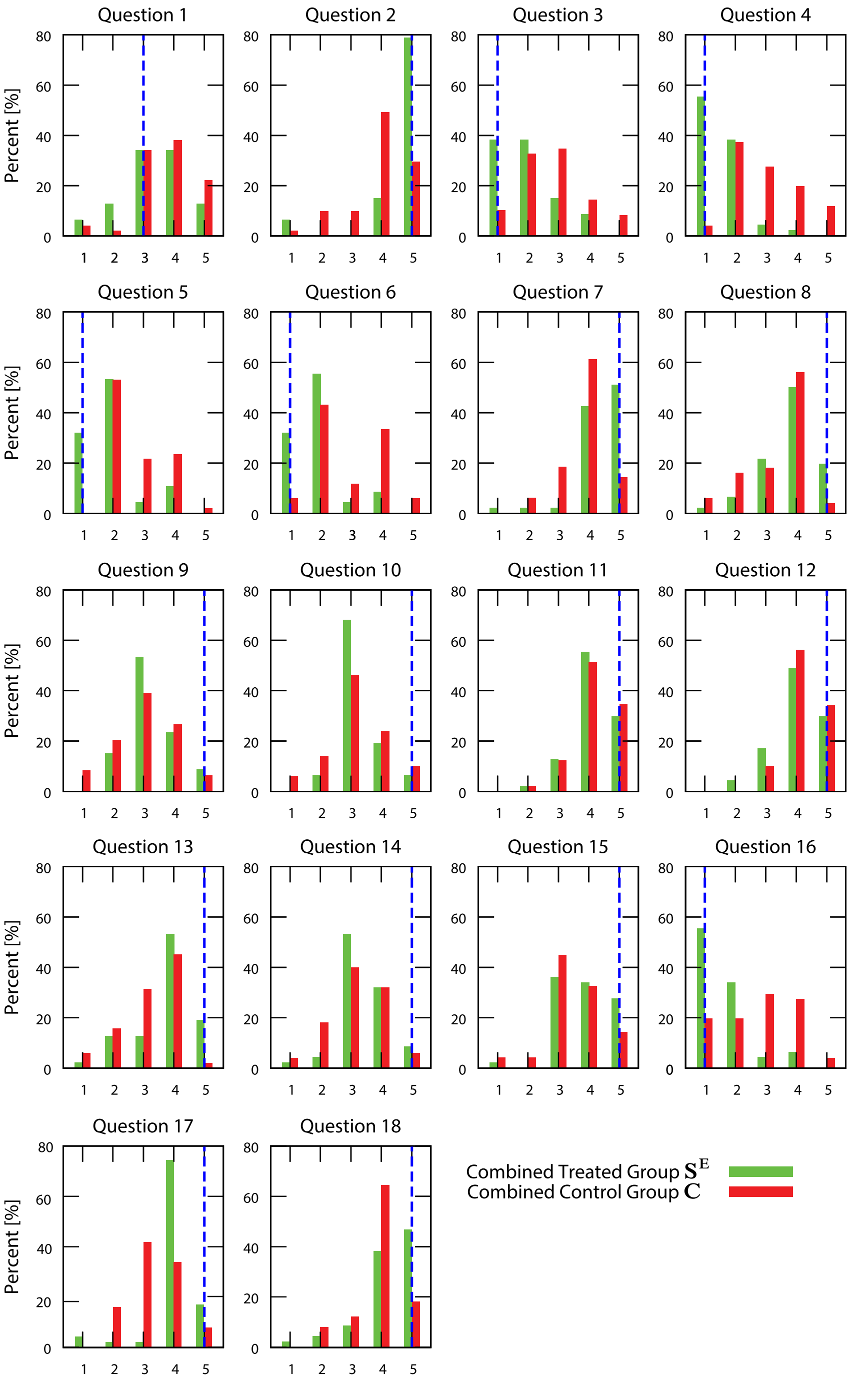

Fig. 2 Bargraphs of student responses in the combined treated group S^E ($n = 47$ subjects) and the combined control group **C** ($n = 51$ subjects) per question. The dotted line in each graph denotes the optimal response

Table 6 Frequency distribution of each possible response per question for the combined treated S^E ($n = 47$ subjects) versus the combined control group **C** ($n = 51$ subjects)

		Response (%)						M–W *p* value
		1	2	3	4	5	Optimal	
Q1	$\mathbf{S^E}$	6.38	12.77	34.04	34.04	12.77	3	0.08
	C	4.00	2.00	34.00	38.00	22.00		
Q2	$\mathbf{S^E}$	6.38	0.00	0.00	14.89	78.72	5	*0.00*
	C	1.96	9.80	9.80	49.02	29.41		
Q3	$\mathbf{S^E}$	38.30	38.30	14.89	8.51	0.00	1	*0.00*
	C	10.20	32.65	34.69	14.29	8.16		
Q4	$\mathbf{S^E}$	55.32	38.30	4.26	2.13	0.00	1	*0.00*
	C	3.92	37.25	27.45	19.61	11.76		
Q5	$\mathbf{S^E}$	31.91	53.19	4.26	10.64	0.00	1	*0.00*
	C	0.00	52.94	21.57	23.53	1.96		
Q6	$\mathbf{S^E}$	31.91	55.32	4.26	8.51	0.00	1	*0.00*
	C	5.88	43.14	11.76	33.33	5.88		
Q7	$\mathbf{S^E}$	2.13	2.13	2.13	42.55	51.06	5	*0.00*
	C	0.00	6.12	18.37	61.22	14.29		
Q8	$\mathbf{S^E}$	2.17	6.52	21.74	50.00	19.57	5	*0.04*
	C	6.00	16.00	18.00	56.00	4.00		
Q9	$\mathbf{S^E}$	0.00	14.89	53.19	23.40	8.51	5	0.34
	C	8.16	20.41	38.78	26.53	6.12		
Q10	$\mathbf{S^E}$	0.00	6.38	68.09	19.15	6.38	5	0.84
	C	6.00	14.00	46.00	24.00	10.00		
Q11	$\mathbf{S^E}$	0.00	2.13	12.77	55.32	29.79	5	0.67
	C	0.00	2.04	12.24	51.02	34.69		
Q12	$\mathbf{S^E}$	0.00	4.26	17.02	48.94	29.79	5	0.28
	C	0.00	0.00	10.00	56.00	34.00		
Q13	$\mathbf{S^E}$	2.13	12.77	12.77	53.19	19.15	5	*0.00*
	C	5.88	15.69	31.37	45.10	1.96		
Q14	$\mathbf{S^E}$	2.13	4.26	53.19	31.91	8.51	5	0.27
	C	4.00	18.00	40.00	32.00	6.00		
Q15	$\mathbf{S^E}$	2.13	0.00	36.17	34.04	27.66	5	0.06
	C	4.08	4.08	44.90	32.65	14.29		
Q16	$\mathbf{S^E}$	55.32	34.04	4.26	6.38	0.00	1	*0.00*
	C	19.61	19.61	29.41	27.45	3.92		
Q17	$\mathbf{S^E}$	4.26	2.13	2.13	74.47	17.02	5	*0.00*
	C	0.00	16.00	42.00	34.00	8.00		
Q18	$\mathbf{S^E}$	2.13	4.26	8.51	38.30	46.81	5	*0.01*
	C	0.00	8.00	12.00	62.00	18.00		

The *p* value of the Mann−Whitney (M–W) test for each question is shown in the last column; italics denote significant values ($p < 0.05$). The optimal response to each question is provided for easy reference effect on the students, and (b) this effect makes the treated students to differ significantly from their untreated counterparts.

Conclusion

As we outlined in "Questionnaire Design" section, the original questionnaire was targeting the young scientists' belief system in connection with their moral sensitivity and moral motivation. The three components that survived the questionnaire validation process contain the questions that can serve as potential instrument (Table 3). Component 1 has the 5 surviving questions from the cultural subset; Component 2 has the 3 surviving questions from the moral sensitivity subset; and, Component 3 has the 3 surviving questions from the moral motivation subset. Although these three components can be further augmented with additional questions in future retesting processes, they can be used in their present form to good effect, as it has been demonstrated in our analysis. Moreover, this validated questionnaire may find applications beyond the science ethics classroom, in cultural studies of science communities.

Based on the results of the qualitative and quantitative evaluation, it appears that the MEPP course design achieves what we set out to do, that is, it changes the scientists' value system into a more ethical one, while increasing their moral sensitivity and moral motivation. By looking closer at the MEPP course design, it is evident that the historical element permeates the majority of its content. From the qualitative feedback, we also know that the students loved the charged debates and documentaries. Hence, it appears that emotionally appealing historical treatment is an indispensable element of this design. By definition, however, the MEPP design has many other elements, too. What really unites all of the course's components is the experiential aspect: from acting in historical debates to participating in the current scientific enterprise. In short, connecting past with present seems highly promising in the moral training of young scientists.

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Appendix

See the Table 7.

Table 7 List of cases per theme, with select films and readings for the MEPP course

Themes	Cases	Films	Readings
Introduction	N/A	Dear Scientists; Silent Spring	Rollin, 06
Professional/social responsibility	Nuclear power	Meltdown at Three Mile Island; Into Eternity	Walker, 04; Semendeferi, 08; Price, 82
	Challenger space shuttle	Challenger: The Untold Story	Vaughan, 09; Feynman, 88
	Tobacco	The Tobacco Wars	Brandt, 07
	Lead	Trade Secrets	Markowitz, 03
Authorship and peer-review	Darwin/Wallace	The Forgotten Voyage	Petersen, 14; Shermer, 02; Gallo, 91
Human/animal experiments	Syphilis experiments	The Deadly Deception	Jones, 93
	Human radiation experiments	The Atom and You	Welsome, 10
	Stanford prisoner experiment	The Milgram Experiment	Zimbardo, 00

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