Integration of Ethics across the Curriculum: From First Year through Senior Seminar †

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The Fisher College of Science and Mathematics (FCSM) at Towson University (TU) has integrated authentic research experiences throughout the curriculum from first year STEM courses through advanced upper-level classes and independent research. Our observation is that training in both responsible conduct of research (RCR) and bioethics throughout the curriculum was an effective strategy to advance the cognitive and psychosocial development of the students. As students enter TU they generally lack the experience and tools to assess their own competence, to apply ethical debates, to investigate scientific topics from an ethical perspective, or to integrate ethics into final conclusions. Student behavior and development follow cognitive models such as described in the theories put forth by Piaget, Kohlberg, and Erikson, both for initial learning and for how concepts are understood and adopted. Three examples of this ethics training integration are described, including a cohort-based course for first year students in the STEM Residential Learning Community, a cohort-based course for community college students that are involved in an NIH-funded Bridges to the Baccalaureate program, and a senior seminar in Bioethics in the Molecular Biology, Biochemistry and Bioinformatics Program. All three focus on different aspects of RCR and bioethics training, providing opportunities for students to learn about the principles of effective decision-making, critical and analytical thinking, problem solving, and communication with increasing degrees of complexity as they move through the curriculum.

INTRODUCTION

Historically, ethical training has been isolated as a separate subject of study within medical-school and health-care curricula without a presence in biology programs. A study conducted by Marocco (9) surveyed the core biology course requirements in 104 undergraduate biology programs (including Ph.D.-granting and non-Ph.D.-granting public and private institutions) and found none included ethics as a component of their required curriculum. With the advance of technology and the integration of authentic research experiences early in the undergraduate curriculum, however, the inclusion of ethical training is increasingly relevant. Although first-year students may not be as cognitively or psychosocially advanced as seniors, the introduction to RCR and ethics training creates a foundation for growth. Technology has advanced faster than laws and social norms have been able to adapt, by, for example adopting standards for how science may be applied; students entering the STEM workforce therefore need the skills to respond to ethical issues as they arise.

These recent advances have led both the National Science Foundation and the National Institutes of Health to mandate the integration of ethics training into grant-funded projects that include student research (e.g., NSF Research Experiences for Undergraduates and NIH Bridges to the Baccalaureate Program). Additionally, lessons learned from medical-school ethics training are being used to develop undergraduate training (4). In 2004, Zaikowski and Garrett (12) called for a multi-tiered approach for the integration of bioethics education into the undergraduate curriculum, including courses for non-majors and majors and a culminating capstone or senior seminar experience. A study from Columbia University (7) discussed the design of bioethics courses for students majoring in biosciences and pre-health studies; the major suggestions were to use a variety of active-learning, discussion-based pedagogical strategies to develop creative problem-solving skills through the use of case studies and to include topics from real-world scenarios. These approaches all provide multiple points of contact throughout the curriculum to reach a broad spectrum of students.

Ethical training can be very broad in scope, ranging from the more general and broader discussions of biotechnology (e.g., human cloning) to the more specific and defined discussion of scientific integrity and RCR (e.g., how to report
data). At Towson University, ethics training is seen as an important part of a science education. The broad objectives are to increase science literacy, to introduce aspects of RCR to undergraduate researchers as well as future research scientists, and to increase awareness for future STEM K–12 educators. The STEM K–12 educators can then introduce the concepts in their classrooms to increase scientific literacy for the general public. As a critical component of a STEM undergraduate education, ethics has been integrated at multiple points during the curriculum. First-year students living in the STEM Residential Learning Community (STEM-RLC) take a one-credit course. During the second semester, the topics of scientific integrity and bioethical discussions are covered using case studies and a common book. Transfer students involved in an NIH Bridges to the Baccalaureate program take a course that also integrates scientific integrity and bioethics through discussion, case studies, and a common book. Finally, a Bioethics Seminar is required for all upper-level majors in the Molecular Biology, Biochemistry and Bioinformatics (MB3) program. The integration of bioethics training develops higher-order thinking skills in students, including critical thinking, analytic skills, and communication skills. Additionally, these discussions prepare students for involvement in authentic research experiences.

The learning objectives overlap for the three courses described and levels of complexity increase as the students move toward the upper-level Bioethics seminar. As a result of their participation in the classes described students will be able to:

1. Articulate their ideas and opinions both orally and in written format (all three courses). This includes the ability to identify ethical issues, separate content knowledge from opinion, and summarize and analyze arguments for and against a specific bioethical scenario. Students are expected to demonstrate good critical thinking and to write and speak clearly and logically.

2. Work cooperatively and collaboratively with others to develop written group statements accurately reflecting the potentially diverse opinions of the group members (all three courses).

3. Identify and apply various ethical decision-making tools (MBBB 493). Students will formulate and defend a well-supported position on issues in bioethics.

The development model from Bloom’s taxonomy was applied to organize the progression of learning objectives. The objectives increase in complexity and category from the first learning objective to the third. The first learning objective is focused on the Application and Analysis categories, while the second is primarily Synthesis, and the third is a combination of Synthesis and Evaluation (I). This progression reflects the increased level of thought one would expect as students advance in their academic careers, gaining content knowledge and improving their critical-thinking and communication skills.

### STEM residential learning community for first-year students

Starting in the 2013–2014 academic year, first-year students majoring in one of the programs within the FCSM made up the first STEM-RLC. These students lived in the same residence hall and participated in programming to enhance retention and decrease time to graduation. One aspect of this program was a course called Introduction to Careers in Science, Technology, and Mathematics (IDNM 200). This one-credit course provides students with information about programs on campus to assist with success and addresses STEM-specific topics, including bioethics. Grading for the course is S(successful) or U(unsucessful). The bioethics-related class activities included a discussion of bioethics case studies and a discussion of The Immortal Life of Henrietta Lacks (II). Two case studies were used to provide opportunities for students to start thinking about how to look at bioethical issues. One case study, from the National Bioethics Institute at Oregon State University, focused on the issue of extinction caused by humans, but had a bit of a twist as it dealt with the intentional destruction of the smallpox virus (http://www.biotech.iastate.edu/wp_single/wp-content/uploads/2012/11/extinction.pdf). The first part of the case study set the ethical dilemma, followed by a fictional case-study scenario to discuss perspectives and implications. The second case study, from The Biotechnology Outreach Center at Iowa State University (http://www.biotech.iastate.edu/wp_single/wp-content/uploads/2012/11/goldenrice.pdf), provided readings both in support of and in opposition to funding golden rice research. Students once again were divided into groups to compile arguments to either support or oppose the research, adding aspects not specifically presented in the papers. The class then discussed the case study as a group. It is important to make sure that all voices are heard in the small group and class discussion. The small class size compelled each student to participate and to become comfortable with expressing their individual perspective in front of a diverse group.

For the discussion about The Immortal Life of Henrietta Lacks, a Teacher’s Guide developed for the book and available online (http://rebeccaskloot.com/wp-content/uploads/2011/03/RHSklootTeachersGuideLORES.pdf) provides excellent discussion questions for each chapter. Groups of students were responsible for leading the discussion on specific chapters. Discussions often led to well-researched and prepared comments and further discussion based on students’ personal experiences. A potential pitfall for this activity is incomplete advance preparation for the discussion as a result of not having read the book; this occurred in a few instances and those students were asked to leave class and were not given credit for participation that day. To add to the discussion about the use of HeLa cells in research, students were asked to find a peer-reviewed journal article that used HeLa cells and discuss it with the class. A final assignment
had students write one question to be used during a campus event (hosted by the FCSM) that involved a conversation with two members of the Lacks Family. The students were excited to have the opportunity to talk to family members, ask their questions, and have their books signed.

Assessment for the class involved a Likert-scale survey to indicate how valuable the activities were and open-ended questions. For the ethics case studies, over 58% of the class found the activity very valuable or moderately valuable. Comments included: “All of us are going into fields that require us to have good ethics and morals. Also, this lesson was the most interesting” and “There are many ethical dilemmas in the science and medical fields so this information was valuable. It is important to discuss this information now as opposed to later when those ethical issues might arise in our careers.”

Evaluation for the Henrietta Lacks activities indicated 70% of students found the activities very valuable or moderately valuable. Comments included the following: “As previously stated, it is all ethics. This book was amazing, meeting the family made it even realer [sic] and made us feel truly sympathetic for what the Lacks family has gone through” and “It is important to learn about the ethical issues involved with Henrietta Lacks’s treatment and the handling of her cells. It is important for us to know how laws, such as patient confidentiality and ownership and informed consent, came to exist.”

NIH Bridges cohort of transfer students

The NIH-funded Bridges to the Baccalaureate program annually includes local community-college students. This multi-year program encourages students to pursue a B.S. in some area of biomedical science after earning their A.A.S. degree. Students are required to take a four-credit course in the spring semester before starting a summer research internship. The course (IDNM 101, Using Information Effectively in the Sciences) is designed to provide students with an introduction to information processing, problem-solving techniques, critical thinking skills, communication skills, team building, and professional ethics in the sciences. Two main areas of focus for ethical training in this course are addressed using two different resources: The Immortal Life of Henrietta Lacks (11) and On Being a Scientist: A Guide to Responsible Conduct in Research (10).

The Immortal Life of Henrietta Lacks (11) is required reading. The students all come from the Baltimore area and many grew up in the area where Mrs. Lacks lived. This book provides a poignant portrayal of the interface between human subjects and research scientists. The discrepancy between the monetary benefits and scientific acclaim that came to a number of research scientists and the unfortunate life changes of the Lacks family is clearly conveyed. Disregard of the family by the scientific community is evident.

In class, students are encouraged to use the story of Henrietta Lacks and the HeLa cells to explore potential ethical questions. A number of scenarios are used by the students as the discussion progresses. The methods are used to help students improve necessary skills, such as critical reading and thinking (students connect and critique various human behaviors and societal norms recorded in the story); clear, effective writing (students write brief summaries of portions of the book—with peer review, editing, and re-write opportunities); collaboration (students work in teams to summarize chapters); discussion and argument (student teams lead discussions about the book that include supporting statements and personal opinion); ethical behavior (students recognize and discuss situations that have ethical ramifications); analysis (involves “compare and contrast” method to look at societal expectations of researchers toward various socioeconomic groups in the past and present); and presentation skills (students give talks on topics from the book). The need for ethical consideration and regulation is demonstrated. The potential jeopardy to individual privacy is highlighted in a way that is evident to students.

Since these students are still at early stages of their undergraduate careers and have not had any research experience beyond class laboratories, it is critical to integrate a RCR component into the class. These students will be working with faculty mentors in the summer following the class and it is vital that they are exposed to the topics covered in On Being a Scientist: A Guide to Responsible Conduct in Research (10). Particular attention is given to the treatment of data, authorship, the mentor relationship, and research misconduct. The prior discussion of the Henrietta Lacks story provides meaningful context for the students for the discussion of research misconduct. The Tuskegee Syphilis project is also discussed using the case study Bad Blood from the National Center for Case Study Teaching in Science (http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case_id=371&id=371). Sample assignments are provided in supplemental materials.

MB3 bioethics seminar

Bioethics and RCR are integral components of the curriculum in the Molecular Biology, Biochemistry and Bioinformatics (MB3) program. The MB3 program is an interdepartmental major with concentrations in the subjects indicated by the program name. MB3 graduates pursue many career paths, including professional programs, masters and doctorate graduate programs, and employment in biomedical research.

Bioethics and the RCR in the MB3 curriculum are addressed primarily through a required one-credit Bioethics Seminar (MBBB 493). The Bioethics Seminar is taken by students in their junior or senior year after completing Genetics, Organic Chemistry, and either Molecular Biology or Biochemistry. Approximately half the students taking the seminar class are currently involved in a research experience. Over 80% of MB3 graduates complete at least one semester of research with a faculty mentor.
The Bioethics Seminar utilizes a combination of traditional lecture, open-ended discussions, case-study discussions, written case studies, student oral presentations, and a term paper based on the oral-presentation subject. Approximately the first third of the course is dedicated to discussions concerning RCR. The last two-thirds of the class covers bioethics, concentrating on the ethical issues associated with the application of recent and potential biotechnological advances.

Each semester, the class begins with a student-driven identification of bioethics issues. That open-ended discussion allows the instructor to roughly divide the issues between RCR topics and the ethical application of technology. Because the classroom is student-centered, the specific issues vary somewhat from one semester to the next and generally concentrate on issues that are relevant to the students’ own research experiences or have been raised recently in other classes or the popular press. For example, the initial issues raised that are related to RCR tend to include misconduct (data manipulation, fraud, and plagiarism), the use of animal and human research subjects, authorship, and conflicts of interest. Students rarely identify responsible mentoring as an issue. Student-identified issues related to the application of biotechnological advances usually include the use of stem cells, gene therapy, and genetic engineering.

Once the basic division between RCR and the ethical application of biotechnology has been established, the class discusses several case studies to practice decision making that includes ethical issues. One case study frequently used is the Tuskegee Syphilis study. Basic facts of the study are reviewed using resources from the Centers for Disease Control and Prevention (http://www.cdc.gov/tuskegee/timeline.htm) and Tuskegee University (http://www.tuskegee.edu/about_us/centers_of_excellence/bioethics_center/about_the_usphs_syphilis_study.aspx). The response of students to this case is universally negative, but they are challenged to explain how they reached their decision. That relatively “black and white” example is usually followed by case studies that result in less of a consensus from the class, such as vaccination requirements for children to attend public schools. For this example, students are encouraged to find their own on-line summaries so they see examples of misinformation available through the Internet. These classic case studies are followed by the interactive RCR training tool “The Lab” developed by the Office of Research Integrity in the US Department of Health and Human Services (http://ori.hhs.gov/thelab). In this video, students face the issue of scientific misconduct while taking on the role of one of several key players (graduate student, post-doctoral research associate, principal investigator, and research integrity officer) at a major research university. Students have the opportunity to make choices at various points in the progression of a case of scientific fraud. The result of these brief exercises is that students usually conclude that they do not know how they make ethical decisions. In fact they are frequently utilizing the basics of one or more commonly employed ethical approaches without knowing it. It is perhaps not surprising that realizing that they do not know how they have reached a particular decision does not lessen their conviction that the decision is correct.

Those initial case studies are followed by semi-traditional coverage of various ethical decision-making strategies with an emphasis on Utilitarianism and Deontology. The classroom presentation is supplemented by more case studies in which the students use one or more of the approaches covered to reach a decision. The class then returns to the original case studies and re-examines their original decisions to see how their decision-making process compares to established approaches and to re-evaluate those decisions. It is common at this point for several students to change their minds about vaccination requirements (in both directions).

The majority of the semester consists of a series of two-week modules during which students are introduced to key issues and explore the details of those issues through a combination of in-class case study discussions, limited mini-lectures, and written case studies. Many of the case studies were developed by the instructor (Dr. Larry Wimmers) and are based on those available in On Being a Scientist: A Guide to Responsible Conduct in Research (10) and Scientific Integrity (8). Each module begins with in-class discussions of case studies intended to introduce an issue and demonstrate some of the complications commonly encountered in the real world. For example, when dealing with the issue of authorship, an initial case study detailing a fairly straightforward case initiates a discussion of why authorship is important and what the base expectations should be to qualify as an author. That discussion is usually accompanied by a mini-lecture covering the widely accepted guidelines for authorship and key resources for those guidelines, the responsibilities of authorship, and how disagreements about authorship are dealt with. Subsequent case studies deal with complications, such as different expectations for undergraduate vs. graduate authors, recalcitrant or missing authors, whether funding a project qualifies for authorship, and authors who want to decline authorship.

At the end of the two-week module, students prepare a written case-study report. The case studies used for the written reports address complications of an issue not explicitly covered during the previous two weeks. Each case study is associated with five or six specific questions that must be answered in the report. One of those is to analyze the issue using a utilitarian approach, detailing all the stakeholders, how they would be affected, how likely that effect is, and how “severe” that effect would be for the stakeholder. Students are encouraged to think beyond the immediate stakeholders and look at potential effects when policies are implemented across the population. For example, when discussing stem cell therapies, students are expected to consider potential effects on lifespan, population growth, and resource limitations. The use of published resources to justify arguments is required.

During approximately the final three weeks of the semester, teams of students give formal oral presentations...
on a range of subjects related to the ethical application of recent biotechnological advances. Each team explains the techniques involved, presents a thorough utilitarian analysis and presents an argument for or against the specific application of the technique being presented. That argument must include reference to the utilitarian analysis but is not required to reach the same conclusion. The formal presentation is always followed by a group discussion about the position advocated by the presenters.

Within one week of the formal oral presentation, the students review the presentation in detail with the instructor. This meeting helps the students prepare their final term paper, which is on the same subject as the oral presentation. A significant portion of the grade for that term paper is based on whether or not the students have addressed faults identified with the content in their oral presentation.

Students complete course evaluations at the end of each semester consisting of both Likert-scale quantitative questions and open-response qualitative questions. While the quantitative questions do not apply well to a seminar class, the responses to the open-ended qualitative questions have been telling. Each semester, the majority of students indicate that they learned about issues that they had never considered. Most semesters, several students indicate that they were surprised by the diversity of positions expressed by their classmates. Informal discussions with the class at the end of the semester about what the students could immediately apply from the class show further support. The students actively engaged in research indicate their desire to discuss with their research mentors the expectations for authorship.

**DISCUSSION**

The integration of ethics into the undergraduate science curriculum is appropriate based on the cognitive and moral development of young adults as described in the theories of Piaget (2), Kohlberg (2, 5) and Erikson (3). As young adults enter Piaget's Formal Operational Stage, they gain hypothetic-deductive reasoning that is critical for an understanding of the scientific method (6). Students in this stage have the ability to think abstractly, to engage in meta-cognition about their own thought processes, and to demonstrate logical problem-solving ability as a result of both brain maturation and cognitive development. At the same time, they are entering a stage Piaget labeled as Autonomous morality, where they understand the concept that rules are made by people for the good of society. In this phase, young adults begin to understand the concept of empathy and take into account the perspectives of others. Rules develop from discussion among peers in a cooperative manner (2). This leads to understanding other points of view on ethical topics, learning how to communicate and support one's position, and ultimately discussing how one's view fits into a more formal bioethics schema. Kohlberg took Piaget's ideas to another level in his Stages of Moral Reasoning (4). Kohlberg further differentiated the stages of development into additional subcategories and into later stages of adolescence and adulthood. According to Kohlberg, college students may start in the conventional level of moral reasoning, where morality is based on society's views and expectations of what is right and wrong. These rules are not questioned. They can then transition to the post-conventional stage where they develop their own views of what is right and wrong based on their own perspectives and experiences, which may be different from the views of society. At this stage, rules may be challenged. Post-conventional development is divided into two stages (stages 5 and 6). In stage 5, students focus on what are designated as basic human rights. Decision making for societal rules occurs in a democratic manner for the good of the majority (5). In stage 6, rules must be based on what is just, while unjust laws may be disobeyed.

Erik Erikson's Theory of Psychosocial Development focused on eight stages of social development. The stage most relevant to college-aged students is the Identity vs. Role Confusion stage, in which students develop their own identity (3). This includes their own views on ethics and morality. The role confusion stems from unresolved issues about themselves and their role in the world ("What will I do when I grow up" type of scenario).

The three examples of formal ethics training presented target different populations ranging from freshman, to transfer students at the rising sophomore level, to students mostly at the junior or senior level, all at slightly different stages of psychosocial development. In each case, the approach relies heavily on case studies and student discussions to illustrate both socially important issues and professional aspects of scientific inquiry. The students enter the sessions with an intuitive sense of what is “right and wrong” in terms of the application of science. They have not thought about how they have reached those conclusions, however, and thus are not initially prepared to challenge their own preconceptions or critically evaluate new situations. They also enter uninformed about most issues relative to RCR with the exception of fraud and plagiarism. They leave with a working toolset for analyzing their own beliefs and new situations. They also gain a functional knowledge of relevant RCR issues and an appreciation for the diversity of opinions on critical social issues.

**SUPPLEMENTAL MATERIALS**

Appendix 1: Syllabus for IDNM 200: Introduction to Careers in Science, Technology and Mathematics
Appendix 2: Syllabus for IDNM 101: Using Information Effectively in the Sciences
Appendix 3: Syllabus for MBBB 493: Bioethics Seminar
Appendix 4: Assessment rubric
Appendix 5: Additional teaching resources (including websites, case study resources, and potential films for discussion)
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