ARTICLE
Active Learning in a Neuroethics Course Positively Impacts Moral Judgment Development in Undergraduates

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The growing neuroscientific understanding of the biological basis of behaviors has profound social and ethical implications. To address the need for public awareness of the consequences of these advances, we developed an undergraduate neuroethics course, Neuroscience and Society, at the University of Minnesota. Course evolution, objectives, content, and impact are described here. To engage all students and facilitate undergraduate ethics education, this course employed daily reading, writing, and student discussion, case analysis, and team presentations with goals of fostering development of moral reasoning and judgment and introducing application of bioethical frameworks to topics raised by neuroscience. Pre- and post-course Defining Issues Test (DIT) scores and student end-of-course reflections demonstrated that course objectives for student application of bioethical frameworks to neuroethical issues were met. The active-learning, student-centered pedagogical approaches used to achieve these goals serve as a model for how to effectively teach neuroethics at the undergraduate level.

Key words: neuroethics; active learning pedagogy; undergraduate education; bioethics education; moral judgment development

In its call for the bioethics education for neuroscientists at all levels, the recent report of the Presidential Commission for the Study of Bioethical Issues emphasizes the role of undergraduate curricula in integrating ethics education into developing understandings of basic scientific concepts (Presidential commission for the study of bioethical issues, 2014). This recognition of the impending challenges from neuroscience research in many areas of widely held public beliefs and policies aligns with the growing focus within neuroscience circles of the need to consider the ethical implications of our collectively generated new knowledge (Marcus, 2002; Sahakian and Morein-Zamir, 2009; Hauser, 2014). Neuroethics education should not only raise awareness of the ethical implications of the research itself, but should also facilitate cognitive learning, improve critical analysis, and create habits of mind and attitudes that probe the fundamental question of how emerging neuroscience knowledge impacts our understanding of what it means to be human (The Hastings Center, 2013).

Many universities do not consider neuroethics appropriate for undergraduates; in a recent international survey, only four of thirteen undergraduate neuroscience programs reported providing neuroethics training (Walther, 2013). Among 201 neuroscience programs in Canada responding to a 2010 survey, 35% offered undergraduate neuroethics training (Lombera et al., 2010). Motivation for offering such courses may be lacking (Lombera et al., 2010) since no professional regulatory bodies mandate undergraduate ethics training. Arguments have been made both for and against mixing ethics and science teaching (Mahowald and Mahowald, 1982; McInerney et al., 1983; Presidential commission for the study of bioethical issues, 2014). McInerney and colleagues (McInerney et al., 1983) argue that citizens need a background and perspective that combines the teaching of both ethics in science classes and science in ethics classes to be able to navigate personal and societal issues at the interface of science and public policy.

One way to answer the calls for increased public awareness of neuroscience and the potential ethical issues arising from advances in this field (Sahakian and Morein-Zamir, 2009; Illes et al., 2010) is to place neuroethics education within an undergraduate liberal arts educational framework. This paper reports on a third-year undergraduate level course at the University of Minnesota titled Neuroscience and Society that integrates ethical thinking into discussions about contemporary topics in neuroscience. Developed in 2011, this course has given approximately 200 students the opportunity to learn about and apply bioethical frameworks to neuroethical issues and to develop skills in critical thinking and analysis, writing, oral communication, and teamwork. In the following, we will discuss the evolution and context of the course, course objectives and content, and an analysis of course impact on students. While we have both formative and summative student evaluations for the course, this analysis focuses on direct measures and student self-evaluations of learning. In the discussion, we argue that an undergraduate-level neuroethics course is an excellent way to institutionalize educating citizenry to appreciate the dilemmas posed by our increasingly mechanistic understanding of the biological basis of behaviors.

EVOLUTION AND CONTEXT OF COURSE

The course was developed and implemented by DAO and JMD, whose shared goal was to create a course that

addressed how experimental neuroscience influences contemporary social issues. We believe that a deep understanding of both ethical reasoning and neurobiology are necessary to grapple with the policy implications emerging from an understanding of mental abilities and responsibilities. Our intent was to design an experience that would give students the resources to adopt multiple points of view, solve problems, and communicate ideas from the field of neuroethics. These skill sets should transfer to other domains and prepare them for life-long learning.

Discussions throughout the spring and summer of 2011 produced a course structure that took advantage of active learning pedagogy and the newly constructed interactive classrooms in the University of Minnesota's Student Teaching and Student Services building (Cotner et al., 2013). These classrooms contain from five to fourteen round tables for nine people, promoting face-to-face student discussions within the context of large class sizes. Computer hookups, wireless access, and a large shared computer screen and white board per table support pooling of student ideas and resources. Multiple microphones per table facilitate sharing of information and arguments with the whole class. The central podium can cede control of the screens, and hence the class, to any table. Student groupings would also maximize diversity in backgrounds, majors and self-assessed teamwork skills. This design empowers students and promotes interaction, discussions, and decentralized learning (Beichner et al., 2007; Cotner et al., 2013).

The course was targeted at an audience of third-year undergraduates who might take a minor in Neuroscience or who just wanted to understand how neuroscience would impact their future lives as citizens. The course was open to students from across campus to promote cross-disciplinary discussions.

The resulting plan (UMN 2011) met the University's Civic Life and Ethics Liberal Education requirement. Courses that meet this requirement prepare students for future encounters with professional, civic, or personal problems by helping them develop skill sets needed to come up with creative solutions (UMN, 2014). The class also satisfied the Writing Intensive undergraduate requirement (Center for Writing, 2010). Course learning and developmental outcomes were guided by five of the seven Student Learning Outcomes (Provost's Council for Enhancing Student Learning, 2010). These included i) Can identify, define, and solve problems, ii) Can locate and critically evaluate information, iii) Understand diverse philosophies and cultures within and across societies, iv) Can communicate effectively, and v) Have acquired skills for effective citizenship and life-long learning.

The Neuroscience and Society course was structured to include the six components of bioethical education recommended by Thornton, Callahan, and Nelson (Thornton et al., 1993); 1) a brief *history of biomedical ethics* through consideration of Dax's case and subsequent shifts in medical ethics, 2) *theoretical foundations and methods of analysis* through introduction to various frameworks and case analysis, 3) *comparative analysis of the scope of the field* through discussion of multiple neuroethical controversies, 4) moral *issues of professionalism* through case studies involving health care providers and bench scientists, 5) *cultural contexts* through examining writings and approaches from across the globe and case studies with cross-cultural conflicts, and 6) *resources in the field* through in-class and individual searches of contemporary academic and popular literature.

Neuroscience and Society was taught for the first time by DAO and JMD to 30 students in spring of 2012. In spring of 2013, the course expanded to 90 students. The class met for 90 min twice a week for a total of 45 contact hours. Data from these two years form the basis of this report. With each iteration, the content shifted slightly to reflect the expertise of the current teaching assistants and the interests of the students. As with any teaching enterprise, the pedagogy improved each year.

OBJECTIVES AND CONTENT

Neuroscience and Society learning and developmental outcomes included moral judgment development, development of the skills necessary for effective communication and teamwork, foundations of bioethics, and introduction to ethical issues raised by neuroscience. The formal course objectives stated that students will:

1. acquire a more sophisticated sense of moral judgment and reasoning.
2. develop skills to work within a team to compile, interpret, discuss, and present information with nuanced and controversial interpretations.
3. acquire an understanding of frameworks for bioethical thought.
4. learn to identify and become informed on emerging ethical issues that accompany our increased understanding of brain function.

To meet specific course objectives, we adopted a format that placed student synthesis of ideas as the central activity. Ideas were examined through readings, personal reflections, class discussions, debates, and formal writing. Students wrote two paragraphs summarizing and analyzing the assigned reading on a daily basis prior to class. In the first half of the course, students brought these reading responses to class for peer writing evaluations as the opening class activity. Thus, before any classroom discussion or presentation of content occurred, students had interacted with the material two or three times. This ensured that students were prepared for the ensuing discussions.

To compile an initial list of topics, we sought inspiration from a compilation of publically available neuroethics course syllabi (Center for Neuroscience & Society, 2013). Our content was a combination of topics initially introduced by instructors and topics presented by student groups during the last six weeks of class (Table 1). Topics chosen by instructors include "What is thinking?", "How do you know right from wrong?", foundations of bioethics, Dax's case, Terry Shiavo's case, moral development, psychiatric disorders, and neurological diseases. Student-chosen topics have included free will and agency, criminal

Chosen by Instructors	Chosen by Students, 2012	Chosen by Students, 2013
Somatic markers; the role of emotions in decision-making	Free-will and agency: does neuroscience change the discussion?	Free-will and agency: does neuroscience change the discussion?
What is thinking?	Are our brains wired for religion?	Over-diagnosing mental illness and overprescribing medications
How do you know right from wrong?	My brain made me do it! Criminal behavior and mental illness; culpability	Mental enhancements: drug usage for depression, attention deficit/ADHD, intelligence, etc.
Social-Intuitionist Model	Neuroimaging and privacy: the law, neuro-judgment, lie detection and research subject mental privacy	Society vs. disorders
What is neuroethics?	Cognitive/neuropsychiatric enhancement and authenticity: who gets it and when?	Using scans and other tests to predict future behavior
Foundations of bioethics: deontology and consequentialism	Pleasure, entertainment, the reward pathways, and “cognitive liberty”	Corporate monopolizations of potentially helpful research or products
Dax’s case	Selecting phenotypes of our offspring	Neuromarketing
Foundations of bioethics: feminist and narrative ethics	When does neurological life begin?	Medically assisted suicide
Dax’s case revisited: embodiment, cognition, and morality	Pain management and addiction to pain killers	End-of-life pain management
Mindfulness, collectivism, eastern perspectives	Clinical research on and use of psychedelics (including possible pros and cons of changing scheduling)	Memory blunting
Terry Shiavo case	Where do we draw the line between mental disorder and normal functioning? The DSM V	Mind control and the power of persuasion using “group think”
Cultural understandings of informed consent	Are animals capable of experiencing pain?	Pain and suffering in animals
Moral development		Torture in the military
Psychiatric disorders: stigma and life-changing events		Neuroeducation
Huntington’s disease: family dynamics		Implications of chronic video game use
Alzheimer’s disease		Diagnosing a psychopath
Depression		Prosecution of mentally ill; culpability
Schizophrenia		Genetic counseling and mental abnormalities, eugenics, and selecting phenotypes
Belief vs. fact		Embryonic stem cell use in neurodegenerative disease treatment
Ethical wills		Cyborgs and control of prosthetics
What makes us human?		Deep brain stimulation: helping vs. personal gain. How far is too far?

Table 1. Topics Covered.

behavior and mental illness, cognitive/mental /neuropsychiatric enhancement, memory blunting, pain and suffering in animals, and many more.

For each topic, the instructors delivered a “Neuroscience Nugget,” illustrating how neuroscience informed, contributed to, or created the ethical dilemma at hand. Class time was spent with students in groups at each table defining terms, identifying stakeholders and points of view, discussing actions or potential actions, and arguing resolutions to conflicts. Directions and guiding questions for these discussions were provided on the podium-controlled central screens. Students were

encouraged to utilize electronic and internet resources, collecting ideas on their white boards or in locally projected documents. Discussions took place among pairs, triads, groups of four or five, or whole tables. After sharing our summaries of the tables' discussions, time was set aside at the end of most class periods for students to write in-class reflections, giving students the opportunity to reflect personally on what was covered during class and their group's discussion.

Beyond the content, the class focused on the development of logical arguments, writing skills, oral presentation skills, and teamwork. Students were expected to present and argue both their own views and those of others. Topics and exercises were chosen to help students understand multiple points of view and to gain an understanding of what it is like to have altered mentation, i.e., a brain disease or disability. Readings and multimedia reports were drawn from the primary neuroscience literature as well as philosophy, policy, and legal literature and popular media.

Student groups chose topics for presentations from a large list compiled both by students and instructors. In individually written position papers, students constructed their own approach to this ethical issue. In the paper, students were expected to present neuroscience background, ethical issues, societal norms, and relevant points of view pertaining to the issue. Their papers argued in favor of one response or resolution to the issue at hand. These individual arguments informed the group presentation. Students were encouraged to adopt a presentation format that included audience interaction and discussion; these varied from mimicking the daily class structure to role-play, short skits, and video presentations.

ANALYSIS OF COURSE IMPACT ON STUDENTS

Student Characteristics

The undergraduate students who took the course were from all undergraduate levels, freshman to senior. Over half were neuroscience minors, as intended (Table 2). Neuroscience majors and students majoring in the neuro-related fields of psychology, speech therapy, and kinesthesiology and in the biology-related fields of biology, biochemistry, genetics, physiology, and dental hygiene also enrolled. Non-science majors included engineering, math, economics, communications, political science, and business. Students self-reported they aspired to careers in research, medicine, and dentistry, the medically related fields of nursing, physical therapy, pharmacy, speech therapy, psychology, and counseling and the non-science fields of engineering, business, statistics, math, and journalism (Table 3). The most unusual professional aspiration was to become an interrogator for the Marines. Only 5% indicated a desire to become a neuroscience researcher while 24.5% indicated more general interests in becoming a professor or research scientist. Thus the class appeared to reach a diverse set of students with broad interests somewhat focused in biological and health sciences.

% of students	Major	Minor
Neuroscience	19.1	51.7
Neuro-related	35.5	
Biology-related	30.9	
Non-science	15.6	
Unknown		48.3

Table 2. Student Academic Programs.

% of students	Anticipated Profession
Neuroscience	4.7
Medical/Dental	23.6
Allied Health	12.3
Psychology	13.2
Research/Professor	24.5
Non-science	12.3
Unknown	9.4

Table 3. Anticipated Student Professions.

Defining Issues Test

The Defining Issues Test (DIT) was administered at the beginning of the course both years and at the end of the course in 2012 (Fig. 1). All students in attendance took the test, which was explained initially as a self-assessment and at end of course as a curricular assessment (Bebeau, 2002). For each ethical scenario presented in this assessment, the respondent must identify which factors they considered important in resolving the dilemma. The DIT measures whether an individual tends to invoke one of three moral schemas based on Kohlberg's theory of moral development: Personal Interests schema, Maintaining Norms schema, and Postconventional schema (Rest et al., 1999a). These schemas are ordered developmentally. The Personal Interests schema is invoked when an actor justifies their decision based on maintaining relationships, avoiding negative personal consequences, or otherwise maximizing personal benefits. The Maintaining Norms schema represents justifying decisions based on maintaining universally accepted social order and the law. The Postconventional schema represents decisions justified by shared moral ideals or philosophies built upon consensus and logical consistency. Limitations to Kohlberg's theory of moral development have been adequately discussed elsewhere (Gilligan, 1982; Haidt, 2001). The DIT, however, remains a useful tool for measuring changes in one aspect of ethical thinking (May and Luth, 2013) and was deemed suitable for use in this class as our goal was to improve moral judgment.

Two forms of the test are available, the original DIT1 published in 1979 and an equivalent, updated version published in 1999 (Bebeau and Thoma, 2010). DIT1 and DIT2 score reports include scores for each schema; Personal Interests (PI), Maintaining Norms (M), and Postconventional (P). Each of these scores is the percent of items selected that invoke that schema. The score for each schema (PI, M or P) then represents the extent to which someone prefers that type of moral reasoning. The

score reports also include an N2 score, which represents the extent to which someone prefers Postconventional schema and rejects Personal Interests schema; thus, the N2 score depends on changes in both Postconventional and Personal Interests scores (Bebeau and Thoma, 2010).

At the beginning of the semester in spring of 2012, the class average DIT1 Postconventional (P) score was 44.54 (Fig. 1). Undergraduate students' DIT1 P scores average in the lower 40s and their DIT2 P scores average in the 30s and 40s, so our undergraduates' pre-course P scores are consistent with those reported in the literature (Rest et al., 1999b; Bebeau and Thoma, 2010). By the end of that semester, the class average DIT2 P score was 53.15, an increase of almost 9 points, significantly greater than at the beginning of the semester and appropriate for 45 hours of classroom time. This degree of change was comparable to that observed in some case-study based medical and legal ethics courses (Self et al., 1998; Bebeau, 2002). The next cohort of students' average DIT2 P score was 44.46 at the beginning of the semester in spring of 2013, which was not significantly different from the initial DIT1 P score of spring 2012 students (one-way ANOVA). In spring of 2012, the class average Maintaining Norms (MN) score decreased significantly as well, indicating the use of reasoning that upheld established norms declined. The effect sizes for these changes were small, with a Cohen's *d* for P of 0.18 and for MN of 0.26. The class average Personal Interests (PI) score, reflecting use of justifications for decisions based upon the interests of the protagonist, did not change over the semester. The average N2 score also did not change significantly as a consequence.

Administration of the DIT at the beginning of the course both years (DIT1 in 2012, DIT2 in 2013) served as a platform for discussions in our session on moral development. The similarity of initial scores for both cohorts supports the demonstrated equivalence of both test versions and suggests comparable sets of students enrolled each year (Bebeau, 2002). By administering the DIT at the beginning (DIT1) and end (DIT2) of the course in 2012, we quantified shifts in students' moral reasoning and judgment, documenting that the first course objective (Box 1) was met. The degree of change may reflect the 45 hours of class meeting time. Self et al. (1998) demonstrated that more than 20 hr of small group case study was required to produce significant change on the DIT (Self et al., 1998). After taking the course, students had a higher preference for Postconventional moral thinking and decreased application of Maintaining Norms schemas, which correlates with more mature thinkers' stages of moral development (Rest et al., 1999a). The DIT has been used in this way by others to assess the effectiveness of educational interventions in improving these components of moral judgment (Bebeau, 2002; Bebeau, 2006; Bebeau, 2009). Consistent with our course goals, spring 2012 post-course P and MN scores showed significantly more nuanced and sophisticated reasoning than initially.

Student Goals

At the beginning of the semester, the first short writing assignment instructed students to explain their personal goals for the course. The goals ranged from restatements of the idea of learning about ethical issues posed by neuroscience to desires to learn how to respectfully understand and respond to differing opinions among classmates. Over the two years, 110 student responses produced 268 different goals. Most students expressed more than one goal, with an average of 2.5 ± 1.2 goals stated per student. The ideas fell into three broad categories relating to ethics, science, and skill development (Table 4).

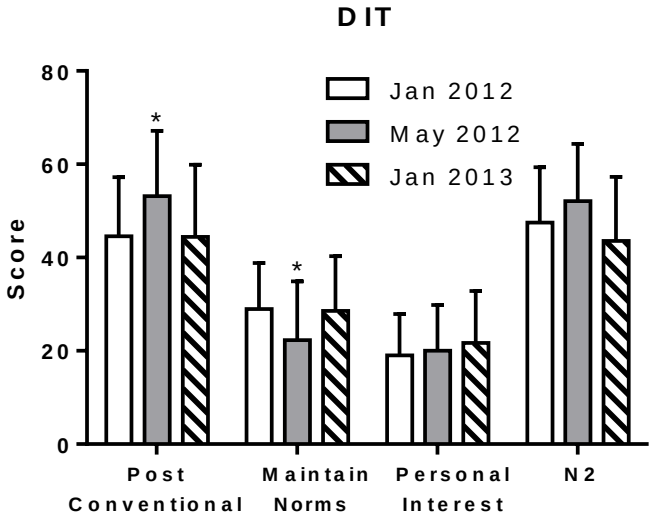

Figure 1. Average class scores on the Defining Issues Test (DIT) in 2012 and 2013. Data are mean ± stdev, N= 37, 32, 78 in Jan 2012, May 2012, Jan 2013, respectively. One way ANOVAs for Post Conventional and Maintain Norms scores were significant, $p<0.01$ and $p<0.02$, respectively. * $p<0.05$ Bonferroni post tests compared to Jan 2012 values (Graphpad Prism v6.01).

Forty three percent of the stated goals reflected students' desires to struggle with ethical problems posed by neuroscience, biology, or medicine, to explore diverse points of view, and to develop their own cognitive skills regarding how to address these issues. At the beginning of the semester, the realization that addressing neuroethical issues would improve their own abilities to reason, create arguments, and make decisions demonstrated that approximately 25% of students anticipated personal growth from this class experience. Twelve responses within this category explicitly stated students expected to step out of their comfort zones, to become more open minded, or to learn about themselves. Since the class was required for the Neuroscience Minor designation, the desire to learn more neuroscience was consistent with our understanding of why students would be taking the course.

Many students expressed a desire to improve their writing and oral presentation skills, consistent with activities listed in the syllabus. Others wanted to become better at expressing opinions and working in groups, consistent with the format and environment of the class. Understandably, some students openly expressed a desire to get a good

Category	Goal	# of Responses	% Total Ideas	% Students
Ethics	Understand impact of Neuroscience on ethics, behaviors, and research	59	22.0	52.4
	Broaden personal horizons or views	26	9.7	22.9
	Understand Medical ethics	19	7.1	18.1
	Understand Bioethics	12	4.5	11.4
	Development of reasoning, argumentation, and/or decision making	28	10.4	24.8
Science	Learn Neuroscience	37	13.8	35.2
Skills	Improve writing, speaking, and/or group work skills	54	20.1	43.8
	Develop scholastic process skills, keep up with assignments, get good grades	24	9.0	21.9
	Have fun, meet other students, influence careers	9	3.4	8.6
TOTAL		*268*	*100.0*	

Table 4. Student Goals.

grade, while others acknowledged that keeping up with the reading and writing assignments was itself a goal. While not aligned with the ethical focus of the class, this latter goal was appropriate as some of these students had diagnoses of ADHD. Six responses expressed solely skill goals and not ethics or scientific knowledge acquisition goals. Similarly, five responses expressed only a desire to learn neuroscience and had no skill or ethical components. So initially, ten percent of students' expectations were not perfectly aligned with course objectives.

Student Assessment of Own Learning

At the end of the semester, one of the students' final short writing assignments required them to reflect on the course and answer the following questions: How have your ideas about ethics changed since the beginning of this class? How have you accomplished your goals for this course? What have you learned intellectually and personally? Over two years, 106 student responses included 528 ideas about what they had gotten out of the course, with an average of 5.0 ± 1.9 ideas stated per student. Only two students stated one idea each, one expressing that their reasoning had developed and another expressing that they had learned about neuroethical issues. Students' responses to these reflection questions fell into the same broad categories as their initial goals, relating to ethics, science, and skill development (Table 5).

Ideas that fell within the broad category of ethics include those related to bioethics, broadened views, neuroethics, developed reasoning, and value of the course. Seventy five percent of students responded that they had acquired an understanding of bioethical ideas. Their thoughts included learning the importance of professional ethics in the fields of neuroscience, research, and health care and how to apply bioethical frameworks in these settings. Seventy one percent of students stated that their own views had become broader, more inclusive, or refined. These included responses that students are more open, respectful, empathetic, and sympathetic and that they more frequently question their own views. They reflected upon the complexity of their newly developed diverse perspectives on neuroethical issues and the absence of absolute right or wrong. Sixty five percent of students responded that they had learned about a range of neuroethical issues, including how neuroscience informs our understanding of morality and ethics. Thirty one percent of students volunteered that they had learned something in this course that they would use in other courses, in their future careers, or in their daily lives. Additionally, twenty eight percent of students included ideas about their improved critical thinking, reasoning, or analysis skills. Within this ethical category 105 out of 106 students voluntarily acknowledged one or more personal gains; 72 students acknowledged four or more personal gains.

Twenty three percent of students addressed the impact this course had on their neuroscience knowledge. Eighteen percent of students gained neuroscience knowledge through the course. Seven percent of students wrote that they did not learn more neuroscience and wished the course contained more specific scientific content. Two students in this category were ambiguous, writing both that they gained no neuroscience knowledge and that they did learn a few things about neuroscience. Consequently the percent of students who felt they learned neuroscience (18%) plus those who felt they didn't (7%) exceeded the percentage who responded in this category. The recognized gains in ethical understanding may have eclipsed students' initial goals of learning more neuroscience as more students were concerned about science content initially than at the conclusion of the course.

Nine percent of students' responses addressed skills acquired through the course. These included improved reading, writing, and oral communication as well as more developed leadership and teamwork skills. Most interestingly, four students felt they had become better listeners over the semester, a behavioral change that we had not anticipated. In addition, this category included general statements about scholastic skills goals (punctuality, good grades, attendance, etc.). Two percent of students said they accomplished scholastic skill goals, while another two percent said they did not.

Students' responses confirmed that for the majority of students, course objectives have been met. Responses including ideas about having learned bioethical frameworks, their application, and the importance of ethics in neuroscience, medicine, and research (75% of students)

Category	Outcome	# of Responses	% Total Ideas	% Students
Ethics	Broadened views	149	28.2	70.8
	Gained knowledge of ethical frameworks, applied frameworks, importance of ethics for professionals	147	27.8	74.5
	Understood interplay between neuroscience and ethics	77	14.6	65.1
	Developed reasoning, logic, critical thinking, and/or analysis	30	5.7	28.3
	Gained something valuable from the course that could be used in other courses, professional life, or daily life	46	8.7	31.1
Science	Gained neuroscience knowledge	19	3.6	17.9
	Did not gain neuroscience knowledge	7	1.3	6.6
Skills	Improved reading, writing, speaking, leading, listening, and/or teamwork skills	43	8.1	32.1
	Accomplished scholastic skills goals	6	1.1	5.7
	Did not accomplish scholastic skills goals	2	0.4	1.9
	Did not meet work ethic goals	2	0.4	1.9

Table 5. Student-Reported Outcomes.

are consistent with our third course objective: "Foundations of bioethics." Responses that students learned about neuroethical issues (71% of students) were consistent with our fourth course objective, "Introduction to ethical issues raised by neuroscience." For the second course objective, "Development of the skills necessary for effective communication and teamwork," 38% of students recognized gains in these areas as opposed to the 66% who initially anticipated improvements. Without quantitative measures of these behaviors, it is difficult to determine if not enough attention was paid to skill development or if the ethical gains overshadowed skill improvements such that students did not report the latter.

DISCUSSION

The DIT and the analysis of students' self-evaluations revealed that an active learning experience exploring the ethical issues posed by contemporary neuroscience can improve student moral reasoning skills. The increased student DIT P scores demonstrated development of a more mature appreciation of the components, context, and considerations that go into making an ethical judgment. These gains are consistent with previously documented effects of a student-centered discussion-based course on moral reasoning (Hartwell, 1995; Bebeau and Faber-Langendoen, 2014). DIT scores have been positively correlated with acquisition of professional ethics and performance in a number of clinical settings including medicine, nursing, dentistry and physical therapy (Sheehan, 1978; Rest, 1979; Sheehan et al., 1980; Kirchner et al., 1994; Bebeau, 2009). The active learning experience expanded student awareness of how ethical issues arise and can be handled in contemporary life. Students reported growth in their appreciation and understanding of neuroethical issues, ethical frameworks, and others' points of view. These outcomes were consistent with three out of four of our course objectives: moral judgment development, foundations of bioethics, and introduction to ethical issues raised by neuroscience.

We did not formally assess development of the skills necessary for effective communication and teamwork, which was our second learning objective. However, analysis of student writing in a high school-level ethics curriculum demonstrated that case analysis sharpens and deepens students' ability to think critically (Chowning et al., 2012), so comparable changes may be expected from this writing intensive course.

Course Content

Understanding how our brains operate in various decision-making modes may improve our ability to make decisions in critical situations (Lampe, 2012). In this sense, neuroethics can be taken to mean not only the study of how neuroscience knowledge challenges ethical perspectives on legal and social issues but also the study of how our brains function when ethical decisions have to be made (Lampe, 2012). Ethical and moral judgments are based on value systems that spring from innate dispositions and cultural and conceptual frameworks (Greene, 2003; Haidt, 2007). Neuroscience is beginning to explain the numerous brain systems subserving various modes of decision making, including how personal history and the salience of events and experience inform judgments (Redish, 2013). Our course content covered both the observed classification of values and the multiple central nervous system networks involved in communication and decision making. Understanding how we formulate and respond to an ethical situation should inform our abilities to act within the boundaries of a framework or set of values (Lampe, 2012). Not only does emerging neuroscience knowledge pose new social problems, but it may also provide us with insights that will improve our mindfulness when addressing ethical dilemmas (Lampe, 2012). Therefore, neuroscience content in the course may inform the process of ethical decision-making, the decisions themselves, and student outcomes.

While the need for training in the ethical aspects of the conduct of neuroscience research remains high (Kehagia et al., 2012), this course aimed to address broad neuroethical issues that include, but reach beyond, the responsible conduct of research particular to practicing scientists and clinical researchers. This course was not designed to teach the regulations, i.e., Institutional Review Board or Institutional Animal Care and Use Committee procedures that proscribe how scientists conduct human or

animal experiments in an ethical manner. Such mandatory ethical training for graduate students, postdoctoral fellows and faculty is distinct from that offered in the Neuroscience and Society course. The undergraduates in our course were headed towards too great a variety of professions to spend focused time on the procedural ethical issues for any one health, science, or social science profession. Rather, the class considered broader issues such as the cognitive and emotional capacities of animals, consideration of the consequences of failed consent procedures, and the cultural contexts of who can give consent when.

Thus our course provided a generalized background in practical ethical reasoning and bioethics with a particular focus on neuroethics. This helped improve understandings of the relationship between empirical work in neuroscience and normative ethics and prepared students for further graduate or postgraduate ethical training in their chosen fields. By exemplifying the application of moral sensitivity, moral reasoning, moral motivation, and moral implementation as components of appropriate application of frameworks to situations relevant to students' lives, this course strengthened students' insight and reflective abilities and hopefully their ability to make better future choices (Rest, 1979; Swisher, 2005). By addressing broad ethical, legal, and social contexts, we were able to provide students with the foundation for expanding their field-specific ethical knowledge as they progress into further graduate or professional education (Lee et al., 2013).

Pedagogy in Neuroethics Education

The collaboration between a bioethicist and a neuroscientist was critical for designing a course structure that combined the foundation provided by ethical frameworks into discussions on the broader impacts of neuroscience. We employed pedagogical methods used to teach ethics in practice-based settings that would engender thoughtful dialog and mutual respect. Critical components of this pedagogy included active learning, a classroom designed for discussions, interdisciplinary content and individual student writing and reflection. While none of these are uniquely novel, their combination provided a formula for the successful student learning reported here.

Our approach mirrors that advocated for clinical ethics training in the neurological sciences: "1) presentation of the cases and ethical concerns, 2) presentation of fundamental ethical frameworks, and/or "classic" cases to inform ethical analysis in-depth, 3) interactive discussion of the cases" (Buchman et al., 2009a). We accepted where students were initially in their ethical thinking, presented frameworks and case studies, and promoted ample discussion on how to apply those frameworks to resolve how individuals should act in these situations. Active learning approaches incorporating real world situations and the humanities have also been successfully employed for ethics training within other branches of professional practice, including physical therapy and engineering (Bebeau, 2002; Kallenberg, 2009; Buchman et al., 2009b; Delany et al., 2010; Buchman et al., 2012). In engineering education, teamwork fosters interpersonal interactions that force acceptance of other points of view and make grappling with difficult ethical challenges more than a theoretical exercise (Kallenberg, 2009). Our course approached ethical issues through the lenses of legal, policy, and social perspectives, as well as the neuroscientific contribution, effectively integrating these interdisciplinary ideas, as called for in the preparation of students entering medical professions (Anderson and Giordano, 2013).

We were fortunate to be able to offer our course in a building equipped with active learning classrooms. The student gains documented in our study mirror what might be expected from use of active learning pedagogy within this intentionally designed environment. Students in undergraduate biology and physics courses taught in these spaces earn significantly higher grades than predicted from their incoming ACT scores (Beichner et al., 2007; Cotner et al., 2013).

While we have not formally evaluated the writing component of the course, the amount of writing and reflecting it entails contributed to students' involvement with the material. Reflective writing and journaling are pedagogical techniques that put individual students at the center of their own learning (Cooper, 1998). In each of the daily required reading responses, students were instructed to present their own analyses of the ideas in assigned readings, linking these ideas to major course concepts. Such arguments were often shared during the group discussions, challenging and reinforcing individual stances. Reflecting both in writing and in discussion provided students with the opportunity to concretely situate their ethical thoughts within arguments and contexts (Nalette, 2005). Their penultimate reflections provided us with the data we analyzed for this report.

A review of a set of publicly available undergraduate neuroethics syllabi (Center for Neuroscience & Society, 2013) revealed that ten of seventeen utilized active learning strategies. Universally, courses surveyed the entire field of neuroethics through multiple readings on topics in which neuroscience challenges a societal belief or practice. None appeared to address issues of use of animals in research or other practice-based ethical issues. Many syllabi simply listed readings, so pedagogical approaches could not be discerned. Only three syllabi included readings on various ethical frameworks. Eight syllabi included multiple student writing assignments; three included a single assigned paper. Five syllabi required student oral presentations and six specified student participation in discussion or recitation sections. Two courses included laboratories, some sort of data analysis, and/or grant writing. Our course contrasted with these by stressing daily writing, active discussions, and student presentations as central pedagogical components. Our course most closely resembles a problem-based learning neuroethics course which aimed to develop integrative thinking and considered judgment utilizing team-based approaches to navigating and solving fractious problems (Ameet and Risman, 2014). While plenty has been written on the need for neuroethics education, very little has been written on *how* to teach neuroethics effectively

(Presidential commission for the study of bioethical issues, 2014). Given our course's success in achieving its objectives, the pedagogical approach outlined here serves as a model for how to effectively teach neuroethics at the undergraduate level.

Public Awareness of Neuroscience

The majority of literature calling for neuroscientists to engage the public in understanding the ethical challenges raised by contemporary neuroscientific advances calls for information transfer from the scientist to the community (Secko et al., 2008). Public lectures or media interviews fail to truly engage the community in sufficient dialog, to promote an inclusive process fostering respect, reflection, mutual understanding, consensus building, and joint decision-making (Secko et al., 2008). Deliberative democracy methods, which "emphasize informed deliberations of citizens and a two-way interaction between decision makers and the public" (Secko et al., 2008, p. 294), provide tools for such engagement in the broader public sphere (Secko et al., 2008). In an educational setting, building skill sets in undergraduates for these interactions through deliberation and dialog prepares the next generation of citizens and scientists.

One way to answer the calls for increased public awareness of neuroscience and the potential ethical issues arising from it (Sahakian and Morein-Zamir, 2009; Illes et al., 2010) is to place that experience within an undergraduate liberal arts educational framework. Moral philosophy has been a part of American higher education since the 19th century (Sloan, 1978). In this tradition, the University of Minnesota Liberal Education requirements situate ethics education in the context of each discipline's influence on society as an integral part of the undergraduate experience. By making our Neuroscience and Society course an option within a neuroscience major, it aligns with the call to provide training in neuroethics for future neuroscientists (Sahakian and Morein-Zamir, 2009; Illes et al., 2010). By making this course a component of a neuroscience minor, we have institutionalized the process of educating the public in the emerging issues posed by contemporary neuroscience.

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