Emergency contraception and RU-486 (mifepristone): do bioethical discussions improve learning and retention?

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Bodensteiner KJ. Emergency contraception and RU-486 (mifepristone): do bioethical discussions improve learning and retention? Adv Physiol Educ 36: 34–41, 2012; doi:10.1152/advan.00122.2011.—To systematically investigate whether the inclusion of a bioethical discussion improves the learning and retention of biological content, students in two sections of an introductory zoology class were taught the biology behind emergency contraception and RU-486. Students in one section of the course participated in a bioethical discussion, whereas students in the other section participated in a content-only discussion. Pre- and postsurveys, response paragraphs, and a final exam were collected and used to examine the learning and retention of content knowledge. Results suggested that students who participated in a bioethical discussion of emergency contraception and RU-486 learned and retained information better than students who received content-only instruction. Interestingly, students who participated in the bioethical discussion also appeared to be more confident in their answers. The results of this study may inform the teaching practices and goals of science educators who would like to incorporate a discussion of bioethical issues into their curriculum but often feel that content coverage is paramount.

bioethics; biology; content; knowledge; students

GIVEN THE RAPID EXPANSION of biological knowledge, ever-changing biotechnologies, and complex bioethical issues facing society today, it is imperative that students attain a working knowledge of core biological concepts (13, 30). Indeed, as more of the decisions concerning the utilization of technological advancements and scientific discoveries are being passed on to the general public, it has become essential that students become scientifically literate (11). In recognition of the challenges that students will face as they move toward becoming fully functioning citizens, many have called for the inclusion of bioethics in the biology curriculum (e.g., Refs. 1, 13, 16–18, and 30).

Unfortunately, despite repeated calls for the integration of bioethics into the biology curriculum, many instructors remain reluctant to include such topics in their courses. The reasons for this reluctance are many and varied and may include the following: lack of a clear conceptual framework for bioethical discussion (18), unfamiliarity or discomfort with teaching ethical issues (13, 24), traditional lack of concentration on the historical and social aspects of science (15, 25), the interdisciplinary nature of important ethical issues (13), and/or the belief that breadth of content coverage is more important than depth. Thus, many instructors present biological knowledge as a collection of facts and terminology, an approach that portrays biology as an unchanging discipline founded on hard data, which may not obviously relate to social issues.

This traditional approach to the teaching of biology is unlikely to help students integrate information or create meaning beyond memorization and regurgitation (2, 25). Furthermore, failure to discuss ethical and social implications of biological topics deprives students of the opportunity to explore relationships between science and society and may prevent them from realizing connections between biology and the wider world. This is disconcerting, as the connections students make, both within and across subjects, may allow for a more complete understanding of biological concepts, one that goes beyond static definitions (29). In addition, comprehensive discussion of scientific issues, including misconceptions and the empirical evidence refuting them, may be necessary to spur students’ critical thinking (26), and tying biological concepts into issues of social relevance may promote a level of understanding that would facilitate a “habit of mind” that would reach beyond students’ undergraduate curriculum (6). Perhaps even more troubling are findings that traditional approaches to the teaching of biology may actually undermine scientific literacy (25, 27). Thus, if the goal of science education is to foster students’ abilities to form arguments that relate both to the biological content and social implications of an issue (9), traditional methods are likely to fall short.

To begin to address these issues, biology instructors should work to incorporate methods that have been shown to improve learning and retention. For example, in-class discussion is commonly used to promote active learning and may be better than traditional lecture formats at promoting the long-term retention of material (19). Participation in small, peer-group discussions has also been shown to enhance the conceptual reasoning skills of undergraduates enrolled in an introductory biology course (20). As students with higher levels of content knowledge are more likely to develop thoughtful rationales for decisions on scientific issues (22), it may be that instructors should not only focus on instructional methods that improve content knowledge retention but also those that allow for the transfer of knowledge to decision-making tasks (11). Teaching science in the context of “real world” situations has been purported to improve learning and retention of biological content knowledge (1, 6, 15, 21, 26) and should provide a ready conduit for the application of such knowledge to analyses of bioethical issues. However, few studies have systematically examined whether discussing the social, moral, and legal implications of a biological topic would, in fact, increase the learning and retention of relevant biological content.

Thus, to begin investigating whether discussing biological content in an ethical (real-world) context improves learning and retention, students in two sections of an introductory zoology course learned and discussed the physiological mech-
mechanisms of RU-486\(^1\) and emergency contraception\(^2\). Students in one section of the course also participated in a bioethical discussion \((n = 19)\), whereas students in the second section \((n = 22)\) participated in a content-only discussion. It was hypothesized that students who discussed the bioethical implications of these drugs would show enhanced learning and retention over students who discussed biological content only. This smaller question was used as a starting point for the examination of the impact of couching biological content in an ethical context on learning and retention and should provide an impetus for further study on the effectiveness of this approach.

**METHODS**

**Participants**

This study was conducted at a midsize Midwestern university with a total student body of \(\sim 9,100\). Participants were students \((n = 41)\) enrolled in two sections (combined lecture, separate laboratories) of an Introduction to Animal Biology course during the fall 2009 semester. Students in the course were primarily freshman and sophomore students majoring in Biology, Natural Resources, or Health Sciences, but some senior-level and nontraditional students were also enrolled. Students’ ages ranged from 18 to 39 yr, with 90.2% of students between 18 and 23 yr of age. There was no difference in average age between sections, with a mean age of 20.4 yr in the bioethics section and 20.2 yr in the content-only section. The number of biology courses completed ranged from 0 to \(\geq 3\), with 65.9% of all students having taken at least one biology course previously. Again, there was no difference between sections, with 57.9% of bioethics students and 68.2% of content-only students having taken at least one biology course. Due to the controversial nature of the bioethical topic used in this study, demographics on race, marital status, and religion were also collected. Students enrolled in the course were 48.8% female, 92.7% Caucasian, 2.4% Native American, 2.4% Asian, and 2.4% biracial White-Asian. Most students had never been married, whereas 7.5% were living with a partner (2 students in the bioethics section and 1 student in the content-only section) and 5% (1 student in each section) were married at the time of the study. The breakdown of student religious identifications were 36.6% Catholic, 31.7% Christian, 4.9% Protestant, 2.4% Jewish, 4.9% Other, and 19.5% with no religious affiliation. There was no difference between sections in the number of women (47.4% female in the bioethics section vs. 50% female in the content-only section), or number of students identifying as Catholic (31% in the bioethics section vs. 40% in the content-only section) or Christian (32% for both sections). Low percentages of students in the remaining demographic categories precluded further between-section comparisons. All protocols and materials were approved by the Institutional Review Board of the University of Wisconsin (Stevens Point, WI) before the implementation of the study. Written informed consent was obtained before the administration of the first survey, and none of the data were viewed until after final grades had been submitted.

**Data Collection**

All students received instruction on female reproductive anatomy and physiology during the lecture component of the course. This included approximately three 50-min class periods in which ovulation, menstruation, hormonal contraception, and the uses of emergency contraception and RU-486 were discussed. During laboratory the week that RU-486 and emergency contraception were covered in lecture, students in both sections of the course were provided with supplementary readings to reinforce content \((12)\) and were given an opportunity to ask questions and/or discuss content-based information. Additionally, students in the bioethics section read and discussed essays pertaining to social, ethical, and legal issues surrounding the use of emergency contraception \((28)\). In-laboratory discussions were student driven and were moderated by the course instructor. In other words, questions and issues raised by the students were discussed as they arose, with prompting or followup from the instructor only as needed. Confusion over content-based information that became evident during the discussion was addressed by the instructor. All students included in the study attended the full discussion section. To determine baseline levels and the overall retention of content knowledge, students were given pre- and postdiscussion surveys (modified from Ref. 7; APPENDIX). These surveys contained questions designed to assess students’ knowledge of emergency contraception and RU-486 (the primary focus of the present study), students’ attitudes toward the legality of these drugs (ongoing research), and information on student demographics. Immediately after the in-laboratory discussion, a reflective writing exercise in response to the following prompt was also collected: Please write down your thoughts on emergency contraception and RU-486. Describe your thinking and anything you may have learned. What, if anything, do you think others have learned? Finally, a final exam was given \(\sim 2\) wk after the in-laboratory discussions.

**Data Analyses**

The four-point Likert survey questions were scored as follows: 1 = strongly agree, 2 = agree, 3 = disagree, and 4 = strongly disagree. Two-sample \(t\)-tests were then used to compare the parameters between sections, and paired-sample \(t\)-tests were used to compare pre- and postsurveys within sections. Statistical analyses were conducted with Microsoft Excel 2004 (version 11.6.4 for Mac, Microsoft Redmond, WA). Data for mean scored responses are expressed as group means \(\pm SE\). A confidence level of 95% \((P \leq 0.05)\) was the criterion for significance for all comparisons.

In addition to quantitative analyses of survey response data and exam scores, written responses to the reflective writing prompt and to a short answer question on the final exam were qualitatively analyzed by searching for emergent themes and patterns in students’ writings. As this research was primarily to investigate learning and retention of content knowledge, the amount and ways in which students wrote about the biological mechanisms of action of emergency contraception and RU-486 in their reflective paragraphs were examined. Given the hypothesized effect of discussion of bioethics on learning and retention, consideration of moral, ethical, and legal implications of these drugs in students’ reflective paragraphs was also assessed. Student responses to the short-answer question on the final exam were categorized based on discussion of one or more of the ways that emergency contraception prevents pregnancy, whether or not students confused emergency contraception with oral contraception, and the completeness of their answer.

**RESULTS**

**Comparison of Pre- and Postsurveys**

**General questions.** On the presurvey administered before the lecture on female reproductive physiology, all students (from both sections) indicated that they knew there was something a woman could do to prevent pregnancy and that they had heard of emergency contraception. In response to the open-ended question “If you have heard of emergency contraceptive pills, how did you hear about them,” students commonly listed friends, the media (television, radio, etc.), healthcare providers, and/or school as sources of information. Proportions of students listing each of the above as sources did not differ

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\(^1\) RU-486 is also known as mifepristone.

\(^2\) For the purposes of this study, the term “emergency contraception” refers to high-dose progestin, commonly known as Plan B or Next Choice.
between sections. However, the total number of students listing friends as a source decreased (from 58.5% to 36.6%) and the total number of students listing school as a source increased (from 14.6% to 31.7%) from the pre- to postdiscussion survey. Furthermore, whereas the majority of the students (87.8%) across both groups knew emergency contraceptive pills were available in the United States on the presurvey, all students knew they were available on the postsurvey.

**Biological content questions.** Table 1 shows the differences in pre- and postsurvey responses on knowledge-based questions for both sections of the course. Overall, students in the bioethics section demonstrated movement from incorrect to correct knowledge on all but one survey item. Students in the content-only section demonstrated little to no increase in knowledge and, in fact, performed worse on one item. For example, in response to the statement “Emergency contraceptive pills are used primarily to prevent pregnancy,” the number of students in the bioethics section that chose the correct answer (true) increased 21.5%, whereas the number of students who chose the correct answer in the content-only section increased by just 5%. Similarly, in response to the statement “Emergency contraceptive pills are another term for RU-486, the “abortion pill,” there was a 58.0% increase in students choosing the correct answer (false) in the bioethics section and a 13.3% increase in the content-only section.

For the four-point Likert questions, mean response values did not differ between sections on the presurvey, indicating levels of content knowledge and student self-assessment were similar before in-laboratory discussions. Interestingly, within the bioethics section, there was a significant decrease in the mean response (i.e., more students chose strongly agree or agree) to the statement “I understand how emergency contraceptive pills and RU-486 work” from the presurvey to the postsurvey ($P < 0.01$). No such decrease was observed in the content-only section. This finding suggests that students in the bioethics section were more confident in their knowledge than students in the content-only section.

For the statement “Emergency contraception has the same effect no matter when it is taken,” there was no change in the mean response in the bioethics section, but there was a tendency toward a decrease in the mean response in the content-only section ($P = 0.07$). As the statement is incorrect, this tendency toward an increase in mean response suggests decreased understanding of the biological mechanism of action of emergency contraception from the presurvey to the postsurvey in the content-only section.

Mean responses to the statements “There are no known serious side effects associated with progestin-only emergency contraception” and “Emergency contraception does not affect an established pregnancy” decreased pre- to postsurvey within

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**Table 1. Knowledge of emergency contraception and RU-486 on pre- and postdiscussion surveys**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Bioethics Section</th>
<th>Content-Only Section</th>
<th>Percent change</th>
<th>Percent change</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC prevents pregnancy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>True*</td>
<td>68</td>
<td>89.5</td>
<td>21.5</td>
<td>77</td>
</tr>
<tr>
<td>False</td>
<td>16</td>
<td>10.5</td>
<td>5.5</td>
<td>0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>16</td>
<td>0</td>
<td>16</td>
<td>23</td>
</tr>
<tr>
<td>EC is the same as RU-486</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>True</td>
<td>31.5</td>
<td>5</td>
<td>26.5</td>
<td>22.7</td>
</tr>
<tr>
<td>False*</td>
<td>37</td>
<td>95</td>
<td>58</td>
<td>22.7</td>
</tr>
<tr>
<td>Don’t know</td>
<td>31.5</td>
<td>0</td>
<td>31.5</td>
<td>54.5</td>
</tr>
<tr>
<td>I understand how EC and RU-486 work</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly agree</td>
<td>10.5</td>
<td>31.6</td>
<td>21.1</td>
<td>4.5</td>
</tr>
<tr>
<td>Agree</td>
<td>63.2</td>
<td>68.4</td>
<td>5.2</td>
<td>68.2</td>
</tr>
<tr>
<td>Disagree</td>
<td>26.3</td>
<td>0</td>
<td>26.3</td>
<td>22.7</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4.5</td>
</tr>
<tr>
<td>Mean scored response</td>
<td><strong>2.2 ± 0.1</strong></td>
<td><strong>1.7 ± 0.1†</strong></td>
<td></td>
<td><strong>2.3 ± 0.1</strong></td>
</tr>
<tr>
<td>EC has same effect no matter when it is taken</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly agree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Agree</td>
<td>5.2</td>
<td>0</td>
<td>5.2</td>
<td>5</td>
</tr>
<tr>
<td>Disagree</td>
<td>47.4</td>
<td>47.4</td>
<td>0</td>
<td>65</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>47.4</td>
<td>52.6</td>
<td>5.2</td>
<td>25</td>
</tr>
<tr>
<td>Mean scored response</td>
<td><strong>3.4 ± 0.1</strong></td>
<td><strong>3.5 ± 0.1</strong></td>
<td></td>
<td><strong>3.1 ± 0.2</strong></td>
</tr>
<tr>
<td>No known serious side effects with progestin-only EC (correct)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly agree</td>
<td>11.1</td>
<td>11.1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Agree</td>
<td>27.8</td>
<td>61.1</td>
<td>33.3</td>
<td>30</td>
</tr>
<tr>
<td>Disagree</td>
<td>61.1</td>
<td>22.2</td>
<td>38.9</td>
<td>60</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>0</td>
<td>5.6</td>
<td>5.6</td>
<td>10</td>
</tr>
<tr>
<td>Mean scored response</td>
<td><strong>2.5 ± 0.2</strong></td>
<td><strong>2.2 ± 0.2†</strong></td>
<td></td>
<td><strong>2.8 ± 0.1</strong></td>
</tr>
<tr>
<td>EC doesn’t affect established pregnancy (correct)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongly agree</td>
<td>22.2</td>
<td>57.9</td>
<td>35.7</td>
<td>5</td>
</tr>
<tr>
<td>Agree</td>
<td>33.3</td>
<td>36.8</td>
<td>3.5</td>
<td>40</td>
</tr>
<tr>
<td>Disagree</td>
<td>38.9</td>
<td>0</td>
<td>38.9</td>
<td>50</td>
</tr>
<tr>
<td>Strongly disagree</td>
<td>5.6</td>
<td>5.3</td>
<td>0.3</td>
<td>5</td>
</tr>
<tr>
<td>Mean scored response</td>
<td><strong>2.3 ± 0.2</strong></td>
<td><strong>1.5 ± 0.2†</strong></td>
<td></td>
<td><strong>2.6 ± 0.2</strong></td>
</tr>
</tbody>
</table>

Values for responses are percentages of students that gave the indicated answer and values for mean scored responses are means ± SE of scores from a 4-point Likert scale response (where 1 = strongly agree, 2 = agree, 3 = disagree, and 4 = strongly disagree); $n = 19$ students in the bioethics section and 22 students in the content-only section. EC, emergency contraception. *Correct answer. †Values within a section are significantly different ($P < 0.05$); ‡values within a section tended to be significantly different ($P < 0.1$).
the bioethics section ($P = 0.05$ and $P < 0.01$, respectively), but there was no change in mean responses for the content-only section. As these statements are correct, these changes indicate an increase in knowledge level between pre- and postsurveys in the bioethics section but not in the content-only section.

**Comparison of Final Exam Results**

Retention of content knowledge was assessed via questions on the final exam, which was administered 2 wk after the in-laboratory discussions. There were no differences in scores for exam questions related to female reproductive physiology, total exam scores, or final grades between sections. However, qualitative analyses of student responses to the most relevant short-answer question on the final exam [True or false (circle one): Emergency contraception prevents pregnancy through different means depending on what days of the menstrual cycle it is taken. Explain your answer.] indicated differences in the retention of content knowledge between sections. Specifically, more students in the bioethics section correctly cited one or more of the ways in which emergency contraception may prevent pregnancy, and they seemed to have a better understanding of the mechanism of action of emergency contraception overall, as exemplified by the following student statements:

If the egg hasn’t been released yet in the cycle, then the contraception can prevent it from releasing. If it has been released, emergency contraception can make it hard for the sperm to get to the egg by making the fluids thick in the fallopian tube.

Emergency contraceptives prevent pregnancy in three ways. Prevent ovulation. If ovulation occurs then it prevents the egg and sperm from meeting. If fertilization occurs then it prevents the egg from being implanted in the uterus wall.

If it is after ovulation and a pregnancy did not take place nothing happens. If it is before ovulation it stops ovulation from happening. If ovulation did take place, it will prevent sperm from fertilizing the oocyte. On the other hand, more students in the content-only section provided incorrect or incomplete explanations for this short-answer question, and more of them confused emergency contraception with oral contraception, as exemplified by the following student statements:

There are certain times a woman can have a better chance of becoming pregnant. They are during a certain window of opportunity.

The EC [emergency contraception] can alter the hCG [human chorionic gonadotropin] level to help control the estrogen and progesterone level.

It has to be taken at the same time, every time, during the menstrual cycle to prevent the egg from being released. If the egg is released, then the contraception will do nothing to stop it from being fertilized.

**Comparison of Student Reflective Responses**

Similarly, qualitative analyses of student reflective responses indicated a number of differences between sections in the ways in which students were thinking about the drugs and the issues inherent in their use. Students in the bioethical discussion section seemed to be more confident in their knowledge and in their opinions about the drugs than students in the content-only section. For example, students from the bioethics section often made declarative statements as to the legality of the drugs (it should/should not be), whereas students in the content-only section often used qualifying statements (I don’t know/I’m not sure). When students’ responses were categorized into major emergent themes, several additional differences in student thinking became apparent.

**Biological mechanism of action.** Students in the bioethical discussion section seemed to have a better grasp on the differences between the two drugs and often referred to the biological mechanism of action of the drugs in their written reflections, as exemplified in the following student statements:

I knew that there was a difference between the two but I didn’t know what made it that way. I now know the difference.

I learned how each one works.

Plan B [emergency contraception] prevents pregnancy from happening where RU-486 terminates a pregnancy.

At least with Plan B if the pregnancy was there, it does not eliminate it.

In the content-only section, when students did mention the mechanism of action of the drugs, there were often misconceptions, as exemplified in the following student statements:

If there is side effects to using the emergency contraception and RU-486, like not being able to have kids...

However, I would not advise anyone to take emergency contraception religiously because it decreases the effects.

**Ethical considerations and moral judgments.** Not surprisingly, students in the bioethics section also mentioned abortion, availability, and other ethical/legal considerations more often than the content-only students, as exemplified by the following student statements:

I think that they should be legal. Plus I think big chain pharmacies should sell [them] and religion should not be a factor.

I think that both should be available over the counter. It is a person’s own belief when life starts. The government has to separate church and state. RU-486 should be legal because if you are going to have an abortion you should do it as soon as possible and not wait until the 3rd trimester or partial birth, which is thankfully illegal.

RU-486 should not be legal over the counter because I feel that if a pregnancy is already developed it was ‘meant to be.’ I personally would not like to know that there is a possibility that I don’t exist because my mother took RU-486.

Roe vs. Wade gave states the power to legalize abortion in the first trimester, so I don’t see a big deal with having the emergency contraception. I think if RU-486 is used during the first trimester, then it’s alright. After the first trimester, states should have the power to prohibit use.

Students in the content-only section seemed to be more judgmental, often referring to individuals that may need emergency contraception or RU-486 as “careless,” “irresponsible,” or “dumb” and cited instances of rape or incest as acceptable uses for these drugs more often than students in the bioethics section, as exemplified by the following student statements:

Personally I think that emergency contraception should be used for just that, emergencies. As in having a baby would endanger the mother’s life or if other methods of contraception were used appropriately and conception still occurred.
I think it’s good to have emergency contraception for emergencies. I don’t think it’s right for people to take advantage of it just because they’re dumb and didn’t think about it before.

I think that using emergency contraception is okay if the females were raped or have been sexually abused. For the other females, I think that they must live with the conscience because they weren’t smart enough to use another kind of contraception.

I think they are a good thing only in certain cases, for example: if a girl got raped and then pregnant, then it is a terrific thing, but if they are used just because of carelessness, then I feel that is a touchy subject. I don’t think this type of technology should be abused, but [it is] a good idea for the right situation.

Wider education. Interestingly, a number of students in the bioethics section invoked the need for increased awareness of how the drugs work so the public would be better able to make informed decisions. In other words, students exposed to bioethical discussions were more likely to recognize previous gaps in their own understanding and extend that outward, to make assumptions about the need for wider education on this topic in the public at large. This was exemplified by the following student statements:

By having a knowledge of the difference, women can now make a more informed choice about emergency contraception.

The public gets these two confused with one another.

But I also feel that there should be a required "E.C. 101" breakdown of the pill so patients know what they are taking, rather than simply that the pill prevents pregnancy.

I think there is a general lack of knowledge regarding emergency contraception and RU-486. Ignorance breeds ignorance. I think massive education would be necessary before an informed decision can be reached.

I think that education is key! Health classes and sex ed. courses are being taught in middle and high school and I think it is vital to teach potentially sexually active teens and young adults about their options, but without the proper information people may not know where or how to get it or that it exists. The school I attended didn’t educate me on the subject; my parents thankfully had knowledge and foresight to teach me about this matter. But it shouldn’t be up to the parents. It should be up to the education system.

DISCUSSION

Although many have suggested that teaching science in the context of “real world” situations may facilitate learning and retention (8, 10, 16, 21), this study is one of the first to systematically examine the effectiveness of this approach. In the present study, students who discussed bioethical issues surrounding the use of emergency contraception and RU-486 demonstrated an increase in content knowledge from the presurvey to the postsurvey. Furthermore, students who discussed the bioethics of the two drugs seemed to be more confident in their understanding. Students who received content-only instruction did not show such gains and, in fact, demonstrated decreased levels of understanding in some instances. Thus, bioethical discussion enhanced the learning and retention of biological content knowledge. These findings support those who have argued for the inclusion of bioethics in the biology curriculum and underscore the need for pedagogical reform.

It is, perhaps, not surprising that bioethical discussion enhanced learning, as it is the connections students make, both within and between subjects, that help students create an understanding of concepts that goes beyond memorization (29). It is also likely that students who participated in the bioethical discussion were more engaged (4) and/or took a more active role in the learning process (19, 26), and that a heightened interest level translated into increased learning and retention over those students in the content-only section. The improved confidence noted in students from the bioethical discussion section also agrees with the findings of Frisch and Saunders (10), who found that students perceived an increase in content knowledge when they listened to stories. Taken together, these data suggest that placing biological content in a social context may help students create meaning and retain information long term.

Although exam scores and final grades were similar for both sections, students in the content-only section demonstrated limited increases in content knowledge from the presurvey to the postsurvey. Furthermore, students in the content-only section tended to lose content knowledge on one survey item and seemed more confused in their written responses. This suggests that not only does the inclusion of bioethical discussion enhance learning, but a lack of bioethical consideration may impede understanding. Indeed, it has been argued that courses focusing on memorization of facts are counterproductive (27) and that scientific literacy requires the ability to question and form connections between concepts (11, 27). Whether such differences in the acquisition and retention of content knowledge would hold true for less controversial topics remains to be determined, and further study is warranted.

It has often been argued that the inclusion of social, ethical, or moral issues in the biology curriculum is necessary to produce scientifically literate citizens able to fully participate in wider social debates (1, 6, 11, 13, 16–18, 30), and analyses of students’ written responses provide further support for this position. Specifically, students in the bioethics discussion section seemed to produce richer, more diverse response paragraphs, indicating different thought processes and higher levels of topic engagement than their content-only counterparts. This finding is in agreement with those of Lindell and Milczarek (15), who found that biology students encouraged to challenge preconceptions and examine biases were more open to questioning, more sensitive to how they framed arguments, and more likely to think about an issue before expressing an opinion. Students in the bioethical discussion section also seemed more willing to declare their position on the legality of emergency contraception and RU-486. This may be tied to the increased level of content knowledge in the bioethical discussion group, as students need to understand the basic biology behind an issue before they can make intelligent ethical decisions (13, 26). Similarly, students in the bioethics section were more likely to refer to biological mechanisms of action of the drugs in their responses, which is consistent with the finding that students with higher levels of content understanding are more likely to use scientific perspectives in their socioscientific arguments (22). Students in the bioethical discussion section were also more likely to cite a need for increased public awareness and education on the issue, seemingly recognizing previous gaps in their own understanding and projecting that outward. This potentially increased perceptive ability further supports those who argue that the inclusion of socioscientific

How We Teach

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issues in the biology curriculum will help students develop social awareness (22, 23).

Students’ previous knowledge and belief systems may influence the learning process (5, 25) and, given the controversial nature of emergency contraception and RU-486, may have impacted the students’ ability and/or willingness to fully comprehend the biological mechanisms of these drugs. Levels of presurvey content knowledge and demographic information, including personal relationship status and religious affiliation, were similar across sections, however, so the influence of such factors on learning should have been consistent. It has also been suggested that students are able to form an understanding of a scientific concept (such as evolution) regardless of their beliefs (5). Nonetheless, student beliefs are very difficult to change (5, 14), and the possible influence of students’ predispositions on the learning and retention of content knowledge in the present study cannot be discounted. Inherent differences in student attitudes may also help to explain why students in the content-only section invoked morality in their written reflections more often than students in the bioethics section. An exploration of the possible role of students’ attitudes on learning is beyond the scope of this report, but a followup study examining the influence of bioethical discussion on students’ attitudes is ongoing and may provide insights into the degree to which students’ predispositions influenced understanding.

Current approaches to teaching biology primarily focus on the mastery of laboratory skills and knowledge of facts, theories, and equations (15, 18), and most Biology majors are not exposed to important issues in the practice of science, such as professional, research, or biomedical ethics (30). Given the often overwhelming amount of content, staffing demands, and time limitations, it is no surprise that most instructors cite time constraints as the dictator of their pedagogical approach (3). Nonetheless, with the number and complexity of issues facing modern society, it seems that now, more than ever, we are in need of a scientifically literate populace. And, as discussion of bioethics does, indeed, enhance learning and retention, the question shouldn’t be whether we can afford the time to fit discussions of bioethical issues into our courses but whether we can afford not to. If the goal of biology educators is to give students the skills to practice the process of science, to question concepts and thoughtfully engage with scientific evidence, and to fully participate in wider social debates, then the inclusion of social aspects in the biology curriculum should be viewed as essential.

APPENDIX 1: STUDENT SURVEY

Study identification number __________

Please circle or fill in your answers to the following items. You may skip any question that you are uncomfortable answering. Please do not put your name on this survey.

1. As far as you know, if a woman has just had unprotected sex or thinks her birth control may have failed, is there anything she can do in the following days to prevent pregnancy?
   - Yes
   - No
   - Don’t know

2. Have you heard of emergency contraceptive pills, sometimes called morning-after pills?
   - Yes
   - No
   - Don’t know

3. If you have heard of emergency contraceptive pills, how did you hear about them?
   - Don’t know

4. As far as you know, are emergency contraception pills currently available in the United States?
   - Yes
   - No
   - Don’t know

5. Emergency contraceptive pills are used primarily to prevent pregnancy.
   - True
   - False
   - Don’t know

6. Emergency contraceptive pills are another term for RU-486, the “abortion pill.”
   - True
   - False
   - Don’t know

7. I would approve of emergency contraceptive use in cases of (check all that apply):
   - ____ Birth control failure
   - ____ Rape or incest
   - ____ Unprotected sex

8. The chance of a woman becoming pregnant with unprotected sex is:
   - Low
   - Moderate
   - High

9. I have a religious or moral objection to emergency contraception.
   - Strongly agree
   - Agree
   - Disagree
   - Strongly disagree

10. I understand how emergency contraceptive pills and RU-486 work.
    - Strongly agree
    - Agree
    - Disagree
    - Strongly disagree

11. Emergency contraception has the same effect no matter when it is taken.
    - Strongly agree
    - Agree
    - Disagree
    - Strongly disagree

12. The risk of pregnancy is low enough that it is not worth getting or taking emergency contraception.
    - Strongly agree
    - Agree
    - Disagree
    - Strongly disagree

13. There are no known serious side effects associated with progesterin-only emergency contraception.
    - Strongly agree
    - Agree
    - Disagree
    - Strongly disagree

14. A woman is more likely to have unprotected sex if she has easy access to emergency contraception.
    - Strongly agree
    - Agree
    - Disagree
    - Strongly disagree

15. Emergency contraception should be illegal in the United States.
### How We Teach

Strongly agree  
Agree  
Disagree  
Strongly disagree

16. **RU-486 should be illegal in the United States.**  
   - Strongly agree  
   - Agree  
   - Disagree  
   - Strongly disagree

17. **Emergency contraceptive pills should be available over the counter.**  
   - Strongly agree  
   - Agree  
   - Disagree  
   - Strongly disagree

18. **RU-486 should be available over the counter.**  
   - Strongly agree  
   - Agree  
   - Disagree  
   - Strongly disagree

19. **Emergency contraception does not affect an established pregnancy.**  
   - Strongly agree  
   - Agree  
   - Disagree  
   - Strongly disagree

20. **Pharmacists should not have to fill a prescription for a drug if they believe it is inconsistent with their religious beliefs.**  
   - Strongly agree  
   - Agree  
   - Disagree  
   - Strongly disagree

### Fill in, mark, or circle your answers to the following items.

1. Age: _____
2. Sex:  
   - Male  
   - Female  
   - Other
3. Race:  
   - White  
   - African-American  
   - Native American  
   - Latino  
   - Asian  
   - Other  
   - Don’t know
4. Marital Status:  
   - Married  
   - Living with a partner  
   - Divorced  
   - Separated  
   - Never been married
5. Practicing religion:  
   - Protestant  
   - Catholic  
   - Jewish  
   - Christian  
   - Muslim  
   - Other  
   - No religious affiliation
6. Number of college-level Biology courses successfully completed:  
   - 0  
   - 1  
   - 2

### DO BIOETHICAL DISCUSSIONS IMPROVE LEARNING?

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### DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

### AUTHOR CONTRIBUTIONS

K.J.B. conception and design of research; K.J.B. performed experiments; K.J.B. analyzed data; K.J.B. interpreted results of experiments; K.J.B. drafted manuscript; K.J.B. edited and revised manuscript; K.J.B. approved final version of manuscript.

### REFERENCES


