Issues Activities: Contents

Issues Projects:
Improving Nonmajors' Views of Science and Critical Thinking Skills

As we have said, decision-making is the central goal of the Workshop Biology course. We want students to see that biological concepts can, and must, be applied to decisions in their everyday lives, as they make lifestyle choices, consume goods and natural resources, vote, and raise the next generation. However, this goes beyond introducing every lecture with a newspaper article showing the topic's current relevance, beyond even taking time out from regular class activities to discuss current issues. We have found that most students simply cannot use information to make effective decisions without good models, practice, feedback, and explicit instruction in critical thinking. A major portion of the course, the Issues Project, is devoted to giving students the skills and confidence they need to effectively deal with important issues on their own.

The Issues Project requires groups of students to research a particular area in depth, with the aim of making a personal decision about a socially important scientific issue. In biology, many issues of social importance (e.g. whether to ban smoking in public, or how to deal with conflicts between economic development and the protection of biodiversity) rest on issues currently being debated by research scientists (whether second-hand smoke causes cancer, or whether a certain species should be classified endangered). Students dealing with the social aspect of such issues must also be able to deal with the scientific aspect. Some issues contain less scientific controversy, such as problems prompted by new developments in medicine and biotechnology (labeling of genetically engineered vegetables, for example), but these still require a thorough understanding of the biology involved.

We use a variety of activities to help students learn to identify and clarify issues, to locate appropriate information and resources concerning their issue, and to critically evaluate the evidence they find. Students also get feedback on their work at several stages by turning in problem statements, abstracts, and rough drafts. This series of assignments allows the instructors to maintain a continuous dialog with student groups on their progress, to emphasize the importance of revision in all types of writing, and to keep the groups on task.

When we began developing the issues activities, we expected the final product to be an individual paper and a group presentation, but have since found poster sessions to be a more effective means for students to present their work. Groups of three to five students each complete a poster, which is a more enjoyable and meaningful activity for most students than writing a paper or giving a formal presentation, and which gives the instructors only 35-50 posters to grade rather than 180 individual papers. We display the posters in the atrium of our main science building, so that not only can the students in the workshop learn from each others' work, students from other classes and other faculty can see their work, in an event that emulates what scientists actually do at professional meetings. These poster sessions have even been influential in getting other faculty to consider changing the way they teach and evaluate students.

The rest of this section includes:

- A "Chinese Menu" of different strategies that can be used to help students accomplish the major elements of the Issues Project
- A more in-depth description of each of the major elements of the Issues Project
- Examples of teaching strategies we have found effective, and handouts we use
- A collection of students' comments about the Issues Project
- A discussion of the philosophical framework of the Workshop Biology course, and how the Issues Project fits in and helps us accomplish our major goals

These materials are all also available on the WWW:
http://biology.uoregon.edu/Biology_WWW/Workshop_Biol/Activities/Issues/Issues.html.

Issues Project "Chinese menu"

Task	Sample Strategies
Identify issues	Look through collection of articles, journals in classroom Read newspaper View **videos/films** Use **list of model issues**/sample problem statements
Choose groups	Match up students by top three favorite issues Match up students based on answers to **"issues pretest"** (aim is to generate controversy) Allow students to choose own groups
Clarify/focus issues	Follow **"issues clarification"** procedure Have groups turn in one-sentence issue statement
Become familiar with resources	Complete **library/Internet familiarization** exercise Create a WWW page with good links (see an example at http://Biology.uoregon.edu/classes/bi101/home.html) Examine specific journals & their contents Invite guest speakers
Evaluate popular literature (news, etc.)	Discuss, as a class, results of library search Complete **"critical evaluation of a claim"** exercise
Evaluate research literature	Review investigative activities, including research paper outline
Decide on project plan	Review models (existing posters, papers, WWW pages, etc.)
Provide feedback on group progress, individual contribution	Short self-evaluations ("What have you contributed?") Periodic summaries of work completed, plans for next steps, indicating who is responsible for what
Get feedback on project plan/rough draft	**"Dry run" poster session** Peer review
Get feedback on final project/paper	Instructor/TA written comments (**"mix & match paragraphs"**) Peer comments/ratings Vote for top three projects
See & understand others' work	Include questions on final exam Give points for providing feedback to other groups
Provide comments on project as a whole	**"Issues Project" evaluation sheet** Include questions on course evaluation

Description of issues project components

Identify issues: We have found that our students are not terribly well informed about current science-related issues, and those they do know about they do not relate to science. After a class discussion about the major challenges facing humanity in the 21st century, one student wrote in her journal that she thought the challenges the class identified, including world hunger, AIDS, environmental problems, and drugs, were extremely serious, but didn't really have anything to do with biology. Throughout the course we use current issues to illustrate and provide direction for studying major concepts; for example, understanding cell division and differentiation helps one to understand cancer. We often show videos (see page 7 for some examples) to introduce a current problem, bring in news stories or encourage students to collect clippings, and keep issues of *Science News* and *Discover* in the lab. The first activity shown on page 8 is a large-lecture activity that has students work in groups to find biology-related articles in a current newspaper issue. Students know from the beginning of the term that they should be on the lookout for an interesting issue to use for their final project.

Page 7 also lists some recent issues addressed in each term. Some issues are more scientific, that is, they involve controversies among scientists over current scientific research, while others are more social, involving conflicts between interest groups over scientific findings, or different individual values pertaining to technological advances. It is important for both students and instructor to clarify the kind of issue the students want to deal with. For example, environmental toxins raise a whole host of issues, some of which are more scientific ("Are environmental toxins disrupting the reproductive ability of certain species?") while others are more social, though they rest in part on scientific evidence ("Should regulations on chemical dumping be tightened?"). Students will need to present different kinds of evidence and arguments for these two issues.

During the first week of the term, we often use an "issue pretest" (page 7) on which students write paragraphs outlining their current understanding of several current issues pertaining to the course. These give us an idea of which issues will be best for the students to deal with, and can be used to assign students to groups. They can also be compared with a similar "posttest" at the end of the term, to see if students' views have changed as a result of the activities.

Choose groups: These students will be working closely together on a major project, so we try to help them form effective groups. Some techniques for doing this include matching up students with similar interests, or based on their answers to the issues pretest. The latter can be good in forming groups with controversy built in, since you can pick students with disparate viewpoints—though this can be tricky. As far as group size, we have found groups of three or four to work best, though five can be good if students are planning a skit or classroom debate. It's possible to do all of this without groups, but cooperative learning is so beneficial for most students that it would be difficult to justify not using groups for this kind of project. In a large class, groups help keep individuals from getting lost and, let's face it, gives the instructor fewer projects to grade. We do allow students who feel strongly about working alone to do so.

Pages 9 and 10 are examples of the handout we use to introduce students to the issues project and a grading sheet for their posters. Giving them the grading sheet at the beginning helps them see exactly what we expect from their posters.

Clarify/focus issues: Starting out with a well-defined, focused problem statement is essential for a good final project. Students often do not have a good understanding of what an "issue" is, and initially state their problem as simply a topic, suitable for a book report. We define an issue as a problem or situation about which informed people disagree. The last activity on page 8 is a large-lecture activity in which students work in groups to identify an issue in an article or video presentation, and to consider what information (particularly biological concepts) they might need in order to make a decision about the issue. Good articles for this activity include essays or editorials

from scientific journals or from *TIME* or the *New York Times* science section; news video clips or sections of videos like those listed on page 7 are also good possibilities.

Become familiar with resources: As we have said, it is crucial for students to be able to find information on their own. In our course, the textbook has become one among many sources of information, and we encourage students to use it as a reference for specific disciplinary knowledge. More important for their issues projects, however, are original research and reports of research in magazines and newspapers. We believe students should feel comfortable with science magazines such as *Science News* and *Discover*, but that they should at least be familiar with the format and content of scientific journals, even if they are limited to the abstract. They also should understand that news reports may not do the research justice, and that they should at least attempt to find the original article. One of our students actually referred in her paper to two newspaper articles and one science magazine article on the same research study, as if they were three separate studies. She had no idea that research findings were reported in any other manner.

To help students learn to find appropriate sources of information, we often have library field trips and associated activities (page 11), including learning to use the library's computer search system, on-line or CD-ROM databases such as Science Citation Index and MedLine, and the World Wide Web. A technique we have found useful is to have students find three or four references that relate to their issue (this can be done as homework, as well), and have each student describe one of their references to the class. This helps to make everyone aware of the different journals and magazines, the kinds of information they contain and their approximate level of difficulty. For example, the *Journal of the American Medical Association* and the journal *Science* both contain not only highly technical papers, but also news reports and essays that are easier to read and often synthesize information presented in papers. Our course (and most other large biology courses for both majors and nonmajors) has its own WWW home page, from which students can access not only important information about the course and the course newsgroup, but also a set of links to other useful resources.

Evaluate popular and research literature: Once students become familiar with information resources, they will discover the need to sift through all of this information and weed out inappropriate, irrelevant, unreliable, redundant, or outdated sources. They need to be able to make some sense out of original research, even if this means simply pulling the main question and findings out of the abstract. The method of using a journal article as a case study described by Herreid (1994b) would be very useful in helping students learn to analyze articles in greater depth. Both journals and popular magazine and newspaper articles make *claims* based on research, expert or popular opinion, or other information. Page 12 is a handout with our adaptation of one method (Tyser & Cerbin, 1991) for evaluating a variety of claims. Again, it works well to introduce this method to students in a class discussion of one article that they have all read. We have found these activities to be very useful in helping students learn to select more appropriate references and to critically evaluate the evidence their find.

Plan project and get feedback; provide feedback on group progress. Giving students models for their work is an excellent way to help them understand the standards you expect and the scope of possibilities open to them. Students should have access to projects done by students in the past; of course, this can be difficult the first time you do an issues project. For papers, existing articles can often be found to serve as models. For posters, our students can view posters by faculty members, which are displayed in parts of our science buildings, as well as posters created by previous classes.

Students need to get feedback on a rough draft of their project at least once. Peer review can be a useful technique, cutting down on the instructor's workload and letting students practice an important skill (page 13 shows a sample peer review worksheet). An instructor's feedback, however, is important also, and putting in some effort on a thorough evaluation of rough drafts often saves a great deal of work in evaluating the final product. For posters, we have found it very useful to have students give very brief (5-minute) "dry run" presentations of their poster plans

prior to the final poster session. Students can simply draw a plan of their poster on an overhead slide and give an overview of its contents. The instructor and other students can then ask questions and make suggestions.

If you give students time in class to work on their projects, encourage them to make effective use of the time by requiring them to turn in a short summary of what they accomplished. If you are concerned about whether each member of the group is contributing something, also have them turn in a plan for the next stage of the project, indicating which group member will be responsible for which tasks. Have students periodically write short self-evaluations of their contribution to the group effort - what have they contributed, and have they done what they said they would do? These assignments can all be given as part of other assignments, such as homework or in-class writing assignments, or even as part of a quiz. Not all instructors are concerned about fair division of labor, but if you are, try to use strategies which encourage group members to become interdependent and self-reliant.

In grading, we are primarily concerned with persuasiveness and effective use of evidence in supporting statements—stylistic considerations are only important when they affect the project's ability to communicate. A useful approach to grading and giving students feedback we have used is for the instructor and TAs to discuss each project and arrive at a consensus grade for the group and each individual, drawing on their assessment of the final project itself and their experiences working with the group. We have used "mix and match" boilerplate comments to give students written feedback, maintaining a database of the most common comments and cutting-and-pasting them into each group's evaluation.

Whether final evaluations take the form of letter grades, points, or written evaluations, we have found it most effective to give both an individual and a group grade. Group grades alone can be counterproductive when one student feels strongly about getting a good grade and ends up doing all the work. Individual grades alone, however, do not encourage teamwork. We have occasionally found it necessary to adjust individual grades when a group member ends up contributing little or nothing. Since we cannot work closely with every group in a large class, we get this information by asking students to give us an assessment of each group member's effort. We have found, however, that it can be counterproductive to worry too much about being perfectly fair in making sure every group member has done an equal amount of work, and rely on the groups to work out their own difficulties, for the most part.

See and understand others' work: One of the most beneficial aspects of presentations and poster sessions, as opposed to papers, is that students have the opportunity to learn from each other. Students can get so wrapped up in their own project (or so burned out by the end of the term) that they will not look at or think about other students' projects without some incentive. In poster sessions, we have found it useful to structure activities which encourage students to pay attention to other students' work. Sometimes we have students pick a few groups and write feedback to them, or we ask students to take notes on several posters of their choosing and write about these on the final exam.

Get students' feedback on the project as a whole: A great deal of useful information about students' self-perceptions of their own learning, and their assessment of the issues project as a learning experience, can be gained from using an evaluation form similar to a course evaluation, but directed specifically at the issues project (page 14). We have found that not only do we get useful feedback about how to structure activities more effectively, but also about the barriers and conceptual difficulties students face in doing a project such as this. Finally, we feel it is an important part of any learning activity to ask students to reflect on what they have learned, in order for them to fully appreciate and value what may be unexpected or unfamiliar learning outcomes.

Videos and films as sources for issues

NOVA (PBS). Example: *Murder, Rape, and DNA* . Most episodes cost $19.95.
Frontline (PBS). Example: *AIDS Research: The Story So Far* .
Other PBS series; example: *Medicine at the Crossroads: Pandemic*
Race to Save the Planet series
National Audubon Society videos; example: *Saving Endangered Species, Population*
National Audubon Society, 950 Third Ave., New York, N. Y., 10022.

Examples of workshop issues

Human Genetics:	Should it be possible to patent human genes? Should genetically engineered crops/livestock be regulated, and if so, how? Should gene therapy (germ line/somatic) be used to treat genetic diseases or disorders?
Cancer:	Should smoking be banned in public places? Do pesticides pose a significant health risk? Are they being properly regulated? What are the implications of the discovery of genes for breast cancer, etc.?
Human Health:	What is the role of dietary cholesterol in heart disease? Do current food labeling regulations sufficiently protect and inform the public? Are national differences in rates of heart disease environmentally or genetically caused?
Reproduction & Development	Should fetal tissue research and use be allowed/paid for by the government? Should mothers of drug-addicted babies be prosecuted for child abuse? What should we do about toxins which may affect reproductive abilities of wild species?
Forest Ecology:	Is breeding and genetic manipulation of forest trees a good idea? Should burned areas of forest preserves be opened up for salvage logging? What should we do about deforestation and extinction of forest species?
Human Populations:	Should population growth around the world be slowed, and if so, how? What are our best options for national/international AIDS control policies? Are government-sponsored mandatory vaccination programs a good idea?

Issues pretest

Give students a list of issues statements and the following assignment (can be in-class or take-home):

First Exercise

Choose two of the above questions, one from each category, and write a paragraph describing your current view of the problem. You may include personal experiences or other sources of information which have an impact on your interest in the subject and your opinions.

Issue Identification and Clarification activity

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Name:
Lab Time:

Participation #1

Part 1: Biology in the News
List the other people in your group (work in groups of 3 or 4)

What is the title of the article that is related to biology?

What biological information is related to your article? (What aspects of biology are important to fully understand the article?)

Part 2: Issues in Human Genetics
What are the issues related to genetics that are important to you? (write down as many as you can think of and put an * next to the three issues that are most important to you)

1.
2.
3.
4.
5.
6.
7.

Part 3: Identifying Issues
What is the issue? (An issue is a question about which informed people may disagree. Write the issue in the form of a short question. Make sure that the issue is worded in such a way that people on both sides of the issue would agree with the wording.)

What is speakers position? (simply write yes or no)

What does the speaker offer for support?

Are there any biological concepts that you would like to understand better in order to make a decision? If so, what are they? If not, why not?

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Issues Project Instructions

One of the roles of scientist is to communicate ideas to other scientist. Discoveries that are not reported die with the discoverer. One of the methods for communicating in the scientific community is through posters. Scientists from all over the world attend conferences where hundreds or even thousands of posters are presented at each conference. Poster sessions have the advantage of presenting a large number of topics in a single place. People roam around and spend time reading those posters that are most interesting to them. We will conduct our own poster session but instead of presenting original research, our posters will address issues. The posters will be displayed in the Willamette atrium for a couple of days during the 10th week of classes. The are worth 20% of your grade. **Posters are due Tuesday November 28th by 5PM.** The poster session will be Wednesday, November 29th during your lab time.

Each person will work in a group of about 3 people (2-4) and produce a poster that addresses an issue related to genetics or cellular biology. Remember that for this class, "an issue is something for which informed people disagree." It must be controversial. For this assignment the issue must also have some interesting biology associated with it. When presenting both sides of the issue it is important that there is a biological basis to support both sides. Ethics are important but arguments that only deal with what is moral or ethical are not sufficient.

These projects have been chosen because they are a way of communicating your findings and ideas to the rest of the class. The posters should be about 2 feet by 3 feet on poster board. You can buy the poster board in the basement of the U of O bookstore for $4.50 or use cardboard. It should include:

- a title in large print. The title should grab peoples attention.
- list of authors
- an abstract that summarizes what the poster is about
- biological concepts necessary to make an informed decision
- arguments for both sides of the issue
- evaluation of the arguments
- conclusion/opinions
- list of references

While we would like you to include all the parts listed above, be creative and original.

Below is an approximation of the evaluation sheet that we will use to grade your poster.

Project Evaluation

Title (10 points) **points _____**
Does it grab peoples attention?
Does it convey the subject of the project?

Abstract (15 points) **points _____**
Does it summarize the project?

Issue (25 points) **points _____**
Is the issue clearly stated?
Does the project stick to one main issue?

Biological Background (25 points) **points _____**
Is there the information necessary to understand the issue?
Is the information accurate?

Arguments (25 points) **points _____**
Are arguments for both sides given?
What is the quality of the arguments?
Are there references given for the arguments?

Evaluation (25 points) **points _____**
Are the arguments evaluated?
What is the quality of the evaluations?

Conclusion (25 points) **points _____**
Do the author's come to some conclusion regarding the issue?
Do they state their opinion?
Is their opinion supported by the evidence?

References (25 points) **points _____**
What is the quality of the references?
Are the references cited properly?

Creativity (25 points) **points _____**
What is the quality of the overall presentation/poster design?
Does the project grab the readers attention?

Sample Library Exploration/Annotated Bibliography exercise

Library Exploration (in class or take-home):

Your groups are preparing a presentation on making a difficult decision about a cancer issue. To help you with the assignment, we've collected several reference articles that may be of interest. Each of you should use the articles and discussions with your group to do three things today.

1. You should narrow your focus and begin to find the material you'll need to make your decisions.

- 2. Using the bibliographies from the articles we've collected, choose an article that you think might help you, and find it in the library.

- 3. Using one of the databases listed in the "library resources" handout, and the links on our WWW home page, find another article that you think might help you.

- **For each of the two articles you've found, Xerox them, put your name and your issue group on them, and turn them in.**

Annotated bibliography (take-home assignment):

Annotations should be no more than three sentences long. Each item should include the name of the group member who submitted the reference, two sentences describing the contents of the article, and one sentence explaining why the article will be useful to the group, or particular members of the group. (The positions statement that each of you will hand in on July 30 can have more and different citations than are included in the group bibliography.)

Bibliographic information should include:
All author names (initials and full last names), year of publication, title of the article, title of the journal, journal volume number, journal page numbers. Example:
Bogus, I. M., and B. A. Fraud (1991). Faking bibliographic references on short notice. *Reader's Digest*, 163:215-217.

GRADING (20 pts total, part of your "Issue Position Paper" grade):

8 pts **turning it in**
on time, typed, at least one citation per group member, in English, etc.

4 pts **descriptions**
How descriptive are your annotations? You can't be encyclopedic in two sentences, but you can convey worthwhile information. Saying an article titled "Our Friend the Spleen" is "an article about the spleen" won't net you many points.

4 pts **breadth**
Did you cover all sides of the issue? Note that your annotations will be *absolutely critical* in persuading us that you've covered your topic.

4 pts **level of authority**
How up-to-date and trustworthy are your sources? A 1992 *Scientific American* item will command more respect than a 1967 clipping from *The National Enquirer*.

Critical Evaluation of a Claim

The ability to critically evaluate claims made by reporters, politicians, insurance sellers, etc. is an important skill you'll be able to use throughout your life. It's a skill particularly vital to scientists. To help you exercise your critical thinking skills, we'll use a five-step framework for evaluating claims.[1]

Step 1 Identify a specific claim and restate it clearly. Determine it's importance.

In addition to simply identifying a claim, ask:
What are possible alternate views?
What are the consequences of the claim being right or wrong?

Step 2 Identify evidence relevant to the claim.

Step 3 Evaluate the quality of the evidence you've found. Some types of evidence are more convincing that others.

The best scientific evidence is a fact or measurement of something that actually exists or has occurred (e.g., an experimental result or an observation of nature). Such evidence must be attributed to a reliable source (e.g., a specific scientist or an article in a scientific journal).

You will want to consider the design of the study that produced the result or observation, of course. Other evidence that might have a bearing on your acceptance or rejection of a claim could include:

"Anecdotal" evidence.
An opinion of a respected person with experience in the area where the claim is made.
The claimant's point of view. (How does the claim affect the claimant?)
A reasonable opposing claim. (Is there evidence for the opposing claim?)

How valuable are each of the types of evidence listed above?

Step 4 Evaluate the validity of the claim.

If the evidence supports the claim	— *conditionally* accept the claim.
If the evidence contradicts the claim	— do not accept the claim.
If the evidence is insufficient	— do not accept the claim.

Step 5 Summarize the reasoning you used to evaluate the claim.

Summarize the *directly relevant* evidence and explain how it supports or contradicts the claim. If the evidence is insufficient, provide a *specific* example of additional information you need to critically evaluate the claim.

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[1] We developed this activity based largely on one published by Tyser & Cerbin, "Critical thinking exercises for introductory biology courses," BioScience vol. 41, no. 1, pp. 41-46 (1991). We are also indebted to John Powell, now a philosophy professor at Humboldt State University, for his help in developing our approach to teaching critical thinking.

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Name of Reviewer:
Lab Time:

Peer Review Worksheet

(worth 10 points on your issue paper)

Indicate where the author has done a particularly good job and where the paper could be improved.

Whose paper are you critiquing? _____

1. Issue statement
What is the main issue?

Does the author clearly state the issue?

Does the issue remain the main focus throughout the entire paper.

2. Support
Does the author point out support for both sides of the issue?

Is the support clearly connected to the issue?

3. Advantages and Disadvantages to Society
How well does the author point out both advantages and disadvantages?

Are they clearly connected to the issue?

4. Evaluation
How well does the author evaluate the arguments?

5. Opinion
Does the author indicate his or her opinion?

How well does the author back up her or his opinion?

6. Clarity of Writing
How well is the paper organized?

Make notes on the paper to help your partner improve their paper.

Evaluation of the "Issues Assignment"

Did you enjoy the assignment? Do you have any interesting recollections or comments about the workings of *your* group? Could the assignment be structured differently to improve the group dynamics?

The goals of the assignment were to help you: 1) learn about one aspect of cancer and its impact on society in depth; 2) practice the skills needed to acquire and process information about a controversial issue; 3) recognize and explore the interplay between science and society; 4) exercise your critical thinking skills.

Are these goals appropriate for a cancer biology class? Was the assignment successful in achieving those goals? What changes would improve the assignment?

Other comments:
(You're welcome to continue on the back, attach sheets, come and talk to one of us, etc.)

Thank you for taking the time to answer these questions. "Future generations" of students thank you too.

Comments from students

End of the year course evaluations (question: "How has this course changed your conception of biology and biologists?")

My conception of biology has definitely changed! The concepts that have changed, or actually been formed this term, deal with forest biology issues. Before this class I didn't realize all of the issues that are currently at hand, how they affect people on a large scale, and that they really are a big deal. It was good timing to learn about these things when major decisions are being discussed, and are always in the news. I definitely have a better idea of how biology issues are everywhere, and can have a great effect on us.

Biology deals with a much larger scope than what I had first imagined. From the basic concepts of biology to the more far reaching areas, biology deals with major issues that come into play in our everyday lives. When you think of science you imagine areas where we either seek the past or the future, but science deals with the here and now. We deal with the areas which have a major influence in how we live today. I still think that scientists need a certain mind set, but it seems to me to be a much broader set than I had envisioned.

I think what has been most helpful for me this year in biology is to realize how important biology is in my everyday life, and how it affects me and the people I love. I guess I never had thought about biology in a personal manner. Biology is important to me. Its issues affect me. I am glad that this year has taught me this.

Some "before" and "after" comments from the same students, early in the year and then at the end.

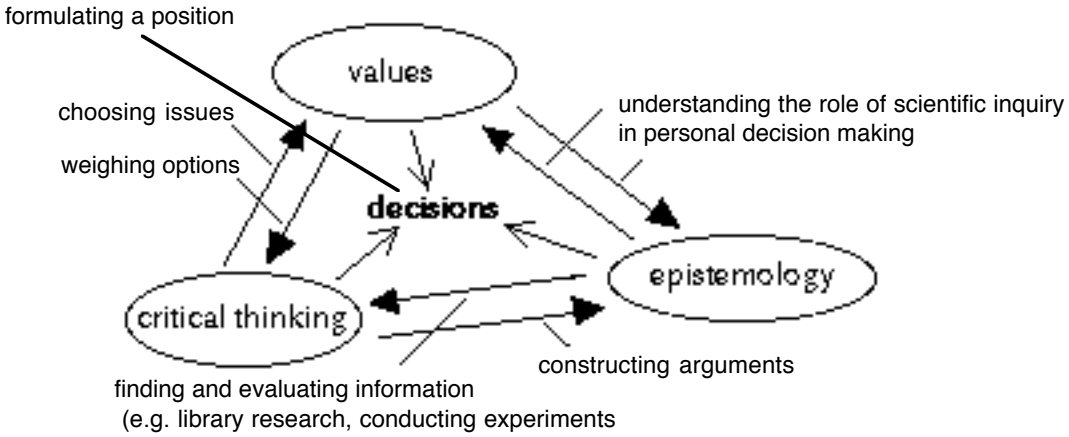
BEFORE: "This is a 100 level class. For this level of class there is too much. The first week of classes we were just overloaded in this class. It was very frustrating as a student just coming off of a vacation and trying to get settled into a new class schedule and term. The amount of work is fine except it requires interpretation and understanding of the stuff we covered, which is fine, only not so much. This is not the only class we have."
AFTER: "My concept of biology as a whole has changed immensely due to this class. This class has been so interesting because we've studied and talked about issues that relate directly to our lives. Most of the topics we've discussed have also been tangible, which usually isn't what I expect from a science class. Although I don't want to admit it because it's been a lot of work, I've enjoyed and learned a lot from our research projects (and most everything else). It has made me learn about something very new and interesting (the yew tree/taxol) that I otherwise wouldn't have researched....This more hands-on, down to earth method of biology class has opened my eyes to new aspects of life, although I do think the work load is excessive."

BEFORE: "I think that this class is TERRIBLE! I have not learned but a few biological concepts and this is not because I am not trying because I have a 4.0 cumulative GPA...I would rather have had weekly quizzes in class rather than a synthetic essay which is opinionated. It appears that you are aware of this dissatisfaction as you are trying to incorporate more facts...Too much individual thinking going on to be organized or to learn."
AFTER: "My view of biology and scientists has changed a lot since I have been in this class. I have learned that biology involves a lot of thought and analyzing. It's not just learning facts but its applying those facts to almost everything around us. Learning how to think in a scientific way is very hard for me but I feel a lot more confident about it now that I have taken this class. One thing that has been so educational for me was learning how biology ties into all of the problems that are going on around me in the environment and the world."

The Role of the Issues Project in Achieving Workshop Biology Goals

In the issues activities, students work in groups to apply the concepts and skills learned in other course activities, reflect on their values, and critically evaluate evidence and opinion related to a particular issue of their choosing. The diagram below shows how these activities relate to the model of decision-making. The final product of these activities presents the students' decisions on the issue and their supporting arguments, and usually takes the form of a paper, class presentation, or poster session.

The Issues Project is a good example of how the decision-making model can be applied to course activities



The model of decision-making helps us define the challenges students are likely to face. Students must learn to: identify issues that are important to them; find and evaluate necessary resources; work together to discuss all viewpoints; and formulate persuasive arguments to support their decision. Instructors must have a thorough understanding of: students' level of intellectual development (for example, how well they deal with ambiguity); what needs students themselves feel they have, and their expectations of science courses and college in general; and barriers that may exist to students' understanding or learning processes (their feelings about working in groups, for example).

The system of goals represented by our model, with decision making at its center, makes assessment of these goals much more clear. Since we now have a better understanding of some of the major factors affecting students' ability to make effective decisions, we can assess students' work in terms of their understanding of the underlying biological concepts, their critical analysis of research studies or expert opinion, and the persuasiveness of their arguments. This focus has been particularly helpful in evaluating group projects, presentations, and posters, where individual students may have arrived at different decisions. It has also helped students understand the criteria for evaluation. Class presentations, in particular, tended to turn into an entertaining debate, but little else. When we focused on decision making, it became clear that groups needed to present enough evidence and valid arguments from all sides to allow the rest of class to make their own decisions on the issue.

Benefits and Challenges

Allowing students to choose and research their own issues has had both its benefits and its challenges. Students all work on different problems, and must be responsible for teaching the rest of the class about their issue, and often the instructor as well. To do this, they must find relevant sources and present supporting evidence, improving their "information literacy" and reasoning skills. Instructors serve more as peer learners and critics than authority figures. There are no "right answers," for these issues, only convincing arguments. This very fact, of course, is disturbing for

many students. Students at lower levels of intellectual development (Perry, 1970) are uncomfortable with the ambiguity inherent in the issues project, not only in terms of the lack of right answers, but also because of the complexity and potential disjointedness of the various activities. We have attempted to reduce some of the concern about the latter by experimenting with different techniques for helping students organize and reflect on their work, such as journals and portfolios. This has decreased significantly many students' frustration with the project as a whole, making it more likely that they will be able to learn and grow intellectually from the experience.

Workload is probably the primary remaining concern, for both faculty and students. Our course format allows us to dedicate significant amounts of in-class time to working on these projects. Asking students to do most of the work outside of class is probably not realistic. Even setting up group meetings outside of class is very difficult for students who work, commute, or take care of families. More importantly, students need the support and frequent feedback available in the classroom. Providing this feedback, being present in class and responding to students' work, is time-consuming for the instructor, as well. Our teaching assistants have been able to fill at least part of this role quite well, particularly our undergraduate TAs who have been through the course before and have a good understanding of the project from a student's perspective.

In spite of these difficulties, and perhaps even because of them, the issues project is a significant experience for students. Our follow-up surveys show that, several years later, it is the one thing about the course they remember well. When our students write about what they have learned in the course, and what they expect to retain, they invariably focus on their understanding of the role of science in society, their increased confidence in addressing scientific problems, and their interest in remaining informed on scientific issues. This, to us, is the most significant argument against the "content coverage" debate. If students not only do not retain detailed content knowledge, as most studies show, but do not *intend* or *expect* to retain it, and consider other kinds of learning more important, we should at least consider their values and expectations as we set course goals and lay out our own expectations.