VISION AND CHANGE IN UNDERGRADUATE BIOLOGY EDUCATION: A VIEW FOR THE 21ST CENTURY
Student Conversations
Preliminary Report

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During the 2007-2008 national Conversations on Undergraduate Biology Education, faculty and others indicated the need to directly engage students in further Vision and Change efforts. As both learners and potential future members of the STEM workforce, students are key stakeholders with a direct investment in the effectiveness of undergraduate biology education.

In response to the need for student perspectives, a "mini-conversation" was piloted at NSF in August 2008 with a small group of undergraduates finishing their summer internships at NSF. Using this conversation as a model, participants in the national Conversations on Undergraduate Biology Education were invited to hold a student mini-conversation on their campus during the spring of 2009. The following is a summary of both the NSF and campus-based conversations, including data about the participants and a summary of student responses.

A. Summary Data on Conversation Participants

Conversations were held at the following 13 institutions: Bates College, The City College of New York – CUNY, Ohio State University, Tennessee State University, University of Massachusetts – Boston, University of North Carolina – Charlotte, University of Akron, University of Chicago, University of Colorado – Boulder, University of Maryland – College Park, University of Nebraska – Lincoln, University of Tennessee – Knoxville, and the University of Washington (two conversations).

The conversations included 231 students, with majors as follows: Biological sciences = 99, other STEM fields = 71 (19 disciplines represented), Humanities = 34 (12 disciplines represented), Arts = 6 (5 disciplines represented), Undeclared = 21.

B. Summary of Student Responses

Professors and biologists care about biology, but why should the rest of us care?

- Biology can connect many topics, both within STEM and more broadly – "biology is life"
- Innovation in other fields often depends on biology

- Everyone needs some knowledge of biology in order to make informed decisions as adults – about health, nutrition, the environment, conservation, "green" living, etc.
- Biology can teach problem-solving skills and an understanding of the scientific method in general; everyone should understand what does and doesn't constitute evidence for a claim
- Biology can help make connections between self and society
- "Facts are at our fingertips" – biology can help illustrate the context and connections
- Biology presents a good way to communicate about science, because many biology topics are immediately relevant and relatable to anyone's life
- An understanding of biology can make people feel more engaged with the earth and its environment and more inclined to take steps to protect it
- Good biology education is needed for global competitiveness
- Biology education is needed to provide solutions for diminishing resources/sustainability issues
- Since many non-majors take biology as their required lab science course, it's a gateway to get more students interested in science

In what ways are we making progress?

- Labs done well can force us to apply what we've learned and this is where the concepts really stick
- Peer-assisted learning groups are a great experience for both the leaders and the attendees
- In some upper level classes, we have been expected to design our own experiments and this is really engaging
- We've had more small group work and investigation of problems with real-world relevance
- There are more opportunities to get involved in research as undergrads (e.g. REU)
- There are more programs that increase the diversity of students in science
- Early biology courses gave me the confidence to ask and answer new questions
- Most programs require some science so more students are exposed to it
- Stories relevant to biology are often in the news so that emphasizes the importance of studying biology

- Tutors are more widely available and the stigma of having one is fading
- Lab equipment and other technology has gotten cheaper and more accessible, so we've had more chances to use it
- Science is more visible in pop culture: shows like CSI, House, Mythbusters, etc.
- Our campus made an effort to integrate some topics across the whole curriculum
- More learning materials are available online

In what ways can biology education be improved? (Issues and recommended solutions)

<u>"Old school" lecture style is frustrating and not engaging</u>

Recommended solutions and strategies:

- Professors should ask open-ended questions where they don't know the answer – so you are defending your answer and not guessing what the professor wants
- More opportunities for small group work and chances for discussion (e.g. peer teaching/learning), especially in large-enrollment courses
- Incorporate demonstrations or media (e.g. YouTube) to illustrate topics
- Use quizzes during or after each lecture (e.g. with clickers) to keep students engaged and see what they did or didn't learn
- The information presented should be appropriate for both visual and auditory learners – just putting all the lecture text onto a PowerPoint isn't very effective

<u>Introductory courses are too broad</u>

Recommended solutions and strategies:

- Give entering Bio 101 students a diagnostic test, and split them into three groups: the ones who really need more basics to supplement what they didn't get in high school, the ones ready for 101, and the ones ready for something more advanced. Stop the "one size fits all" Bio 101
- Reduce the amount of information in classes; teach students how to learn so they can gain depth on their own
- Have more topic-based or concept-oriented courses, especially for non-majors

<u>Less emphasis on memorization</u>

Recommended solutions and strategies:

- More emphasis on application and problem-solving – if science changes so much why are we trying to memorize everything?

- More emphasis on the "how" of science: what is the evidence and how did we obtain it?
- Have projects where knowledge needs to be applied instead of exams where facts are regurgitated
- More essay questions on exams: even in classes where we discuss broader concepts, we are still tested on the fine details
- Use case studies where the professor facilitates a discussion about them

More connections across the curriculum

Recommended solutions and strategies:

- Professors should be more explicit about what they want students to get out of the course and why it's necessary to know those things
- More connections between lecture and lab components within an individual course
- More connections across the disciplines (e.g. between chemistry, physics, and biology)
- More standardization across different sections of the same course
- There should be greater discussion of the curriculum as a whole with the students – why you need this course, that technique, etc., and how it all fits together. Have a short seminar course before or with introductory biology for those who know they want to be biology majors
- More interdisciplinary courses

"Canned" labs are ineffective/uninteresting

Recommended solutions and strategies:

- Have more inquiry-based labs where we don't know the answer ahead of time
- Let the students engage in more troubleshooting (instead of the TAs) so we understand why something did or didn't work
- More opportunities for creativity, like designing our own lab experiments, especially early on and not just in upper-level courses
- Learn how to work with real data – learn to deal with ambiguity and that science can be "messy"

Courses feel disconnected from "real-world" science: more relevance/context needed

Recommended solutions and strategies:

- Incorporate more discussion about how biology impacts our lives
- Read more primary literature and recent developments – what's going on in the field right now?
- Learn to critically analyze the current literature
- Biology majors should take a history/philosophy of science or a science-and-society course
- Have topic-based courses designed around real-world relevant issues

Career development resources are lacking

Recommended solutions and strategies:

- The career center should have more resources for those who don't want to go to medical school. Students are getting more interested in interdisciplinary careers and applying biology to other fields but information about those careers can be hard to find
- Provide an introductory level seminar-style course on "what can you do with a biology degree?" that highlights different career opportunities
- Advisors should be more aware of current opportunities and how to help students find information about potential careers

Better mentoring is needed

Recommended solutions and strategies:

- More chances to find mentors besides just the academic advisor, whose time can be stretched thin
- More organized system for peer mentoring, such as pairing underclassmen with upperclassmen in the same major for guidance

More chances to do research and/or learn how research is done

Recommended solutions and strategies:

- Attendance at research seminars should be required or extra credit
- Research experience in a professor's lab should be a required part of the curriculum; make these research experiences easier to find/access
- Offer a course on experimental design and/or research methods
- The campus brings in outside researchers to talk about what they do, but we don't know about the research in our own departments – have faculty lead seminars on their own work

- Offer workshops for students who want to explore different lab techniques in more detail
- Have a "shadow a professor for a day" activity where students learn how a research lab works

More opportunities/interactions outside the classroom

Recommended solutions and strategies:

- Greater encouragement of outside learning through group study, student affairs groups, discussions, etc.
- More organized opportunities for students to engage in volunteer activities or outreach to the community; let them be role models for K-12 students (e.g. working with science fairs or with summer programs for high school students)
- More study-abroad programs that are tailored for biology students: learn how science is done in other countries
- Broaden the memberships in biology clubs – get more non-biologists involved
- Use Facebook or other social networking sites to help create communities of students interested in similar topics

Teaching doesn't seem valued

Recommended solutions and strategies:

- Students don't feel empowered to expect good teaching – the professors care more about their research. Increase the expectation of excellence in teaching – all professors should be familiar with educational theory and there should be more professional development for faculty to enhance their teaching skills. Maybe pair new faculty with more experienced faculty who have demonstrated good teaching skills.
- Instead of professors blaming the students for poor performance, encourage them to look at what they could do differently
- More value on teaching the intro courses – we seem to get the least-interested professor. Offer some incentives for teaching these courses.
- More avenues for student feedback – professors need to be attuned to what students want out of the class, what they feel they are missing, and students need to feel that they have a voice
- There should be more 'face-time' with faculty (office hours or small discussion groups)
- Sites like ratemyprofessor are popular with students, but not always embraced by campuses and often a venue for student complaints; maybe a more organized

effort could be made to get all students to give and share feedback on courses so students can make more informed decisions and so faculty can see that student opinions are important and hold weight

More opportunities to develop quantitative skills

Recommended solutions and strategies:

- Offer more courses on quantitative abilities including statistics, programming/computer science, technology, etc. tailored for biology students

More opportunities to develop communication skills

Recommended solutions and strategies:

- More writing assignments in class and/or seminar courses on writing
- More student presentations with chances for feedback

Less emphasis on competition

Recommended solutions and strategies:

- Students feel that there is too much pressure to get "good grades" to get into graduate and professional programs. They are discouraged from trying new and different courses for fear of harming their GPA. Allow four "stretching your mind" courses – where at the end of the course you can opt out of having your course grade reported.

How can we continue to include students in the "Vision and Change" effort?

While only a handful of conversations had time to address this question, several facilitators commented that the students felt honored that their input was being sought by such a large-scale effort and that their perspectives would be shared with a diverse group of educators from all over the country.

- More focus groups like this one
- Provide feedback and updates including how these student conversations guided the effort
- Organize a student conference to discuss issues in biology education
- Create a website or discussion board to allow students to interact and receive updates
- Send surveys to students to get their input on issues that arise

About the Author

Catherine L. Fry is a AAAS Science & Technology Policy Fellow in the Division of Undergraduate Education at the National Science Foundation. She received her Ph.D. in ecology and evolutionary biology from the University of Maryland, College Park in 2006. During her graduate studies, she was active both in the classroom and in several outreach programs aimed at enriching undergraduate biology education for majors and non-majors.

Her experiences with teaching and mentoring deepened her commitment to strengthening science education, prompting her to become more broadly involved in education efforts after completing her doctoral studies. While a AAAS Fellow at NSF, she has collected and analyzed data on the scope and impact of projects supported by the Course, Curriculum, and Laboratory Improvement (CCLI) program, designed and published a series of widely distributed documents to disseminate information about the division's programs to a variety of audiences, and been an active member of two working groups organizing national initiatives aimed at advancing and improving undergraduate STEM education.

Originally from Illinois, Catherine also holds a B.A. in biology with a concentration in environmental science from Knox College in Galesburg, IL.