CUR Focus

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Bio2010 – Challenges, Opportunities, and Concerns

The ways in which we think about and pursue research in biology, and science overall, are changing rapidly, and the ways through which we teach and enhance student learning must likewise change. This integration of the actuality of the scientific research endeavor, and its corresponding mandate for science education, is the heart and soul of the publication now commonly referred to as "*Bio2010*"[1]. Indeed, research at the cutting edges of science has changed the way biologists, and for that matter all scientists, work, forcing us to develop research agendas that are cross-fertilized by multiple scientific disciplines. Mathematicians and computer scientists are developing models, for example, that will be crucial when trying to decipher the role played by a single gene among hundreds of thousands, and laser beams are being used by biologists, chemists and physicists to manipulate molecules. The vast majority of the current drivers of science demand an unprecedented understanding, and fusing of, multiple disciplines in a seamless manner. Such drivers include: understanding of biomolecular machines; determining how far we can push chemical self-assembly to gain understanding of the origin of self-replicating systems; learning what controls the genetic destiny of cells; harnessing the synthetic capacity of life; building biological cell systems and networks; gaining a sense of microbial diversity and its impact on our global ecosystem; understanding global surface temperature trends; and learning if we are alone in the universe.

An interesting set of challenges are placed before scholar/educators who are equally vested in research and teaching as they seek ways to help students to see and learn the integrated flow of knowledge that is science. It is not merely the issue of what content is taught, but also the fundamental pedagogical approach to teaching science must be addressed as well. Science must be taught in the same manner through which science is learned. Classical lectures can be replaced with inquiry-based classes and laboratory classes must promote ways through which students learn as scientists learn, by asking questions and subsequently designing and conducting experiments to seek answers, analyzing data, and drawing conclusions based on evidence. There must be active and aggressive assessment of outcomes to help educators to understand if indeed learning occurred, change approaches to teaching (when necessary) from what is gleaned from the assessment data. Therefore, the key is that we must teach as we practice our profession – scientifically[2]. Lastly, and importantly, we must affirm and embrace scientific research and science education as equal partners in the academic research enterprise. Peter Bruns from HHMI states the issue clearly and succinctly: *"We need to dispel the notion that excellent teaching is incompatible with first-rate research*[3]*."* Indeed, at research universities and, surprisingly, at many of the institutions to which CUR members belong, the reward system – tenure, sabbaticals, pay raises and promotion – is based on success in research in a way that is often out of balance with the educational mission of enhancing student learning.

CUR members (and here I include all institutions that claim ownership of CUR principles through organizational memberships) must address some key issues to remain a leader in the reform of science education as articulated by *Bio2010*. The development of new courses with an enhanced interdisciplinary flavor, and the introduction of new pedagogical approaches, is time-consuming and risky for faculty engaged in the process of educational reform. If indeed teaching is undertaken scientifically, then we can expect that some pedagogical approaches (or for that matter, entire courses themselves) may have to undergo several evolutionary forms before the right balance of content and pedagogical approach is found. Students more accustomed to traditional courses, and those with a too-focused pre-vision of what they expect to gain from a class can become frustrated and this could easily result in muddled teaching evaluations when standard institutional course teaching forms are used. How institutions understand and work to manage this risk for faculty members is critically important to moving reform forward. Furthermore, faculty members in departments with a vertical, sequential curriculum can find themselves "at risk" because of concerns raised by some colleagues about what or how much (or little) "content" is being transmitted to students as they progress up the intellectual food chain of the course sequences. Again, institutions must take such issues exceptionally seriously and work with departmental chairpersons to find ways to encourage faculty curricular initiative in what often may be a stifling environment.

On the research front, the power of embracing students as research partners is an exceptional model of enhancing faculty development as well as excellence in student learning through the research enterprise. This is the key strength of CUR. I do believe, however, that we must continue to hone and expand our efforts in undergraduate research. One way to do this would be to further enhance the "declared majors only" or "senior thesis" modes of research that are often the core strength of our programs by bringing teams of students from diverse disciplinary areas (including non-science disciplines when appropriate) into our research laboratories to develop in them the sense of working collaboratively in an interdisciplinary manner to address complex scientific problems. We need also to find mechanisms to expand research opportunities for as yet uncommitted first and second year students to further encourage them to pursue a science-based career and to help them to better put their early science courses in a research context.

The faculty and institutions that form the constituency of CUR are well poised to accept the challenges necessary to prepare the next generation of research scholar/educators who will work at the bleeding edges of scientific research. CUR faculty members have made the commitment, by virtue of career choice, to teach as well as conduct research with undergraduate students being the key in all aspects of endeavor. But we need to remember always the delicate balance of maintaining the fragile co-existence of educational innovation and quality research. I believe we must assess how much progress have we made in having undergraduate research embraced at our institutions (and perhaps even among ourselves) for what I think it really is – the purest form of student learning and, concomitantly, one of the best examples of faculty teaching that can be found. I fear that at many institutions, doing research with undergraduates is still considered an "add on" rather than an integrated component of the total workload for a faculty member. How institutions frame undergraduate research as part of the involved calculus that defines faculty workload such that faculty have institutional recognition for the educational component of research will be critical to the very nature of undergraduate research.

Faculty members must also recognize their important role in promoting institutional change. Serious questions need to be asked, and the answers agreed upon, for reform to take root. For example, how do faculty embrace the educational value-added of student learning through scientific teaching, and in research laboratories, when they sit on institutional professional assessment committees to make tenure and/or promotion decisions on our colleagues? Do we look at teaching excellence as measured in classrooms and teaching laboratories only by a student course evaluation form? Are publication counts and grant money accrued still the coin of the realm in tenure and promotion decisions or are these balanced with educational reform initiatives and involvement of students in research? Do departments and tenure and promotion committees value peer-reviewed published manuscripts based upon pedagogical scholarship undertaken with students in the same way that they might value a basic research paper?

My belief is that questions and issues such as those noted above constitute the next frontiers to be addressed on institutional, and individual faculty member, basis. Barriers between disciplines must be overcome, expectations for faculty success as scholar/educators must be thoughtfully articulated with a new agenda in mind, and students must be nurtured in learning through research in classes, and teaching and research laboratories, from their earliest times on campus. These challenges are set forth not only for the CUR community, but I feel strongly that CUR is precisely the community that must take the lead in addressing them.

Footnotes

[1] National Research Council, Committee on Undergraduate Biology Education to Prepare Research Scientists for the 21st Century. *BIO2010: Transforming Undergraduate Education for Future Research Biologists.* Washington, DC: The National Academies Press; 2003.

[2] Handelsman J, Ebert-May D, Beichner R, Bruns P, Chang A, DeHaan R, Gentile J, Lauffer S, Stewart J, Tilghman SM, Wood WB. Scientific teaching. *Science.* 2004:521-522.

[3] http://www.hhmi.org/news/042304.html

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