Undergraduate Research: Engagement, Mentoring, and Reform

John R. Jungck
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Vice President, IUBS
Editor, Biology International

Mead Chair of the Sciences
Professor of Biology
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Personal History of Research & Mentoring Students: A Growing Legacy

2011
Cell Division Tessellations & Image Analysis; Food Webs
Phylogenetic Analysis & Bioinformatics
Lindenmayer Systems & Fractal Geometry
Biological ESTEEM Project
Knot Theory & DNA
Initiated the BioQUEST Curriculum Consortium
Fulbright Scholar Thailand
Interval Graphs; Voronoi Tessellations
Genetic Codes as Codes
Drug Design for Diseases of the Developing World
Origins of Life: Synthesis of Nucleic Acids & Nonrandomness
NASA Exobiology (Astrobiology) – Sounding Rockets; Moon Rocks
Molecular Sequence Analysis (1st year of college teaching)
Chloroplast Genes: Colinearity of Cytoplasmic Genes and Proteins
Building an Automated Protein Sequencer
Bioremediation: Microbial Clean-up on Industrial Accidents

2004
2003
2002
1999
1986
1985
1976
1975
1974
1968
1968
1966
1966
1964
1960
Where my students have published

- Bulletin of Mathematical Modeling
- Mathematical Modelling of Natural Phenomena
- BioSystems
- Briefings in Bioinformatics
- BIOMAT
- Journal of Heredity
- Bioinformatics (submitted)

- Bioscience
- Journal of Young Investigators
- CBE Life Science Education
- BioQUEST Library
- The Biological ESTEEM Project
- BEDROCK Problem Spaces
- MAA Digital Classroom Resources
Where my students have recently presented:
Where are some of my recent students who have gone on to do graduate work in bioinformatics, biostatistics, computational biology, and mathematical biology?

Anna Decker  University of California Berkeley
Katie Geist  Washington University
Ariella Gladstein  University of Arizona
Vanja Klepac-Ceraj  Harvard University
Winnie Kretschmar  Cambridge University
Han Lai  Carnegie Melon University
Joe Reitstetter  University of Washington
Adrian Smith  Arizona State University
Marcin Wiczla  University of Chicago
Undergraduate Research:
Engagement,
Mentoring,
and
Reform
Sharing with the already committed:

I don’t presume that I’m saying anything that either you aren’t currently doing or haven’t thought about; but what I can share is a perspective on how we tell our story to others about what and why we do it – and – provide some of the published literature to back up the practices that we are engaged in.
THE BELLOIT BIOLOGIST

Volume 29 2010

Beloit Biologist

32 years

Look Around
The Center for the Sciences
The Beloit Biologist is a journal published annually by the Beloit College Biology Department that publishes critical reviews and primary research manuscripts written by Beloit College students. Critical reviews examine one or more hypotheses using data available in the primary literature. Primary research manuscripts present and discuss research results for the first time. Manuscripts submitted to The Beloit Biologist are written for a general biological audience. Students writing manuscripts for submission to the journal participate in the Biology Department’s capstone course, BIOL 387.

In this course,
- students **develop a question and one or more testable hypotheses** about a biological topic,
- gather and evaluate information from the **published literature** that pertains to the testable hypotheses,
- **write a critical review or primary research manuscript** on the biological topic,
- submit a manuscript to The Beloit Biologist,
- **review manuscripts submitted by other students** to The Beloit Biologist,
- **revise** a manuscript in response to constructive criticism from the instructor, associate editor, and peer reviewers,
- create and present a **poster** at the Biology Poster Session, and
- create a **CV or resume and cover letter** for use in applying for jobs and/or graduate school.

The Beloit Biologist is published in May and is distributed at the Biology Department Commencement Breakfast.
Changing views

- Copy right
- Patents
- Registered trade marks
- Trade secrets
- Licenses
- Contracts
- Insider

- Copy left
- Commons
- Open source
- Public Library of Science
- National Science Digital Library
- Cite Seer
- Freeware, shareware, LINUX
- Personal web pages with easy downloads
- P2P
- BioQUEST resource center

Visit: http://www.edu-cyberpg.com/Internet/copyleft.html
Writers, Readers, & Knowledge Makers

We want you

1) as writers, to feel the pressure of a reader’s presence

2) as readers, to discover a vocabulary with which to consider writing

3) as knowledge makers, to view the social and incremental way that knowledge is constructed, one response at a time.

Technical Comments

- Grammar, Syntactical Felicity, Spelling
- Audience
- References
- Illustrations
- Format: Adherence to guidelines
- Are all elements present?
- What do you as a reader not understand or need further clarification?
- Concrete suggestions for improvement beyond the mechanics ...
Note Well

• You will be evaluated in your undergraduate research not only by your papers and presentations, but the quality of your investment in your colleagues’ work.

• Thus, peer reviewing is an essential and important part of this summer’s work.

• Peer reviewing is an essential and important part of scientific community construction and the production of vetted, quality new knowledge.
Undergraduate Research Experiences: 
Synergies between Scholarship and Teaching

By Tim Elgren, past president of the Council on Undergraduate Research and associate professor of chemistry, Hamilton College, and Nancy Hensel, executive officer of the Council on Undergraduate Research

For good reason, undergraduate student-faculty collaborative research opportunities are firmly embedded in the landscape of the New Academy. Undergraduate research and creative expression are now distinct categories of excellence in the U.S. News & World Report rankings. Collaborative research speaks to some of our most fundamental educational objectives by providing a personalized education, exemplifying engaged pedagogy, and promoting students' intellectual independence and maturation. Barrett Seaman's recent account of undergraduate residential life cites undergraduate research experiences as one of the ways that students make close personal connections with faculty mentors (2005).

These relationships are particularly important at a time when undergraduates are seemingly more disengaged in their education and rarely interact with faculty members outside of the classroom. These connections with faculty, across all academic disciplines and at a wide range of institutions, can be particularly meaningful to students deemed “at risk,” including first-generation college students and minorities. For the past twenty-six years, the Council on Undergraduate Research has been a steady advocate and resource for institutions and faculty members seeking to implement research with undergraduates and create supportive environments in which these activities can flourish. Since 1989, Project Kaleidoscope has also brought together faculty and administrators to strengthen the learning and undergraduate research environments for mathematics and science.

Curricular and Institutional Transformation

We often cite the transformative effect research experiences can have on our undergraduate students, but the movement to provide more of these opportunities across all disciplines has led to significant transformations of curricula and institutions as well. Curricula that incorporate discovery-based and active learning have been designed to better prepare students for the independence required for a successful research experience (Karoktsis and Elgren, forthcoming). Such curricular changes promote greater exposure to the primary literature; create opportunities to articulate and test hypotheses and intellectual models; and encourage students to contextualize and communicate objectives, approaches, analyses, and conclusions. These changes infuse research and research-like experiences into the curriculum.

Faculty members also stand to benefit from these curricular reforms. The curriculum is the purview of the faculty and should be a direct expression of what faculty value in education. It is also one of the ways that faculty gain some control over time, which many regularly cite as their primary limiting resource. Balancing a scholarly agenda with heavy teaching commitments easily consumes available time, but utilizing the curriculum to better prepare undergraduates for independent research serves them well and prepares them to contribute to faculty members’ own scholarly work. Building synergy between these two activities has recently been referred to as an act of “enlightened self-interest” (Mills 2005).
Calibrated Peer Review™
Writing, Collaboration, and Critical Thinking

http://cpr.molsci.ucla.edu

Arlene A. Russell, UCLA

University of Maryland
November 13, 2003
Calibrated Peer Review

Introduction

Calibrated Peer Review (CPR)™ is a Web-based program that enables frequent writing assignments even in large classes with limited instructional resources. In fact, CPR can reduce the time an instructor now spends reading and assessing student writing.

CPR offers instructors the choice of creating their own writing assignments or using the rapidly expanding assignment library. Although CPR stems from a science-based model, CPR has the exciting feature that it is discipline independent and level independent.

CPR funding has been generously provided by the National Science Foundation and by the Howard Hughes Medical Institute.
Mean multiple choice test scores were significantly better for topics taught using CPR compared with those taught using traditional instruction.

$72 \pm 2\%$ versus $65 \pm 2\%$, $P < 0.001$, Paired t-test.
Peer Review

- How would you define Peer Review?
- What are your expectations for Peer Review?
- When would YOU want peer review?
- What sort of responses would YOU appreciate?
- What feelings might YOU have about receiving responses to your work?
Peer Review Template

- [http://www.middlesex.mass.edu/carnegie/MCCCG/MCCReviewGuidelines.htm](http://www.middlesex.mass.edu/carnegie/MCCCG/MCCReviewGuidelines.htm)

- Adapted from:


  Guidelines for Review
  - Author Name:
  - Reviewer Name:
  - Paper Title:
  - Date:
  - General Comments:
• **Clear Goals**: Does scholar state basic purposes of his/her work clearly? Does the scholar define objectives that are realistic and achievable? Does the scholar identify important questions in the field?

• **Adequate Preparation**: Does the scholar show an understanding of existing scholarship in the field? Does the scholar bring the necessary skills to his or her work? Does the scholar bring together the resources necessary to move the project forward?

• **Appropriate Methods**: Does the scholar use methods appropriate to the goals? Does the scholar apply effectively the methods selected? Does the scholar modify procedures in response to changing circumstances?

• **Significant Results**: Does the scholar achieve the goals? Does the scholar's work add consequentially to the field? Does the scholar's work open additional areas for further explorations?

• **Effective Presentations**: Does the scholar use a suitable style and effective organization to present his or her work? Does the scholar use appropriate forums for communicating work to its intended audiences? Does the scholar present his or her message with clarity and integrity?

• **Reflective Critique**: Does the scholar critically evaluate his or her own work? Does the scholar bring an appropriate breadth of evidence to his or her critique? Does the scholar use evaluation to improve the quality of future work?

Information Life Cycle

- Primary Research = Discovery
- Secondary Research = Dissemination
- Communication
- Submission
- Peer Review
- Publication

Colors:
- Blue: Typical undergraduate research
- Green: Added experience of undergraduate conferences and poster sessions
- Red: New opportunity provided by JYI
Aims & Scope

**PRIMUS: Problems, Resources, and Issues in Mathematics Undergraduate Studies** is a refereed journal devoted to dialogue and exchange of ideas among those interested in teaching undergraduate mathematics. This includes those who prepare students for college level mathematics, those who teach college level mathematics, and those who receive students who have been taught college level mathematics.

Each issue contains relevant and worthwhile material for those interested in collegiate mathematics education. While the primary interest is in first person descriptive and narrative articles about implemented teaching strategies and interesting mathematics, there is also opportunity for writing broad survey articles, formal studies of new teaching approaches, assessments of planned and in place strategies, and general discussion writing on teaching undergraduate mathematics.
Regularly run: Modeling Contests
Why should you publish or present your work?

- Professional obligation
- Way your findings make their way into practice and policy (classroom, industry, society)
- Improve visibility of yourself, department, university, company, government agency
The Importance and Value of Mentoring Undergraduates

Mentors play a significant role in providing intellectual stimulation for their student protégés. Through working together on a research project of mutual interest, students become colleagues with their mentors and other members of the research group. Sometimes these relationships last long after the student completes his or her degree and ultimately develop into strong professional interactions.

Students learn first-hand the nature of science or engineering. They apply what they have learned in the classroom to real-world problems at the forefront of science and technology. They have (perhaps for the first time) the opportunity to ask new questions, solve unsolved problems, or develop new devices or processes. They learn to work with the ambiguity brought by not knowing the next steps or one question leading to many new questions.

Undergraduate research is an apprenticeship. The mentor teaches through example and coaching, and students learn by doing. Delving into a problem and exploring the unknown provide the best learning environment for most students. Students develop critical thinking and analytical skills. As they take intellectual ownership of a project, they often develop the ability to make research decisions, learn the questions to ask, and gain the confidence to ask questions.
Features: Points of View

Should Students Be Encouraged To Publish Their Research in Student-Run Publications?

A Case Against Undergraduate-only Journal Publications
Scott F. Gilbert

Undergraduates: Do Research, Publish!
John R. Jungck, Margaret Harris, Renee Mercuri, and Joshua Titus

Weighing the Pros and Cons of Undergraduate-only Journal Publications
Vivian Siegel

Note from the Editors
Points of View (POVs) addresses issues faced within life science education. Cell Biology Education has launched the POV feature to present two or more opinions published in tandem on a common topic. We consider POVs to be "Op-Ed" pieces designed to stimulate thought and dialogue on significant educational issues. Each author has the opportunity to revise a POV after reading drafts of the other POVs. In this issue, we ask the question, "Should students be encouraged to publish their research in student-run publications?" This question has been debated at institutions and has presented an unresolved challenge with the advent of open access publishing as exhibited by the Journal of Young Investigators (http://www.jyi.org). Three POVs are presented. Scott Gilbert, Professor of Biology at Swarthmore College, is well known for his developmental biology textbook, John Jungck, a CBE editorial board member and Professor of Biology at Beloit College, is founding director of EcolabQuest; Margaret Harris (Boston, Duke University), Renee Mercuri (Science Journalism, University of Warwick, and Joshua Titus (Biology, Beloit College) are staff members of the Journal of Young Investigators. Vivian Siegel is the Executive Director of Public Library of Science (http://www.plos.org) and former editor of Cell. The authors bring a wealth of publishing experience and different points of view to the debate. Readers are encouraged to participate in the online discussion forum hosted by CBE at http://www.celldis.org/discussion/public/ main.cfm.

While there are several positive arguments for undergraduate research journals, I think that the negatives far outweigh the values they may have. My first argument is that a journal geared toward the publication of undergraduate research would differ from any "up the ante" and increase the pressures on students. Right now, my undergraduates do not need a published paper to get into an excellent graduate school or medical school or to be competitive for a fellowship. What they need is a letter of recommendation, wherein I write that the student has drive, persistence, intellectual curiosity, and that she or he knows how to plan experiments with the appropriate controls. The fact that the student's research has not yet reached the publication stage is not a consideration. If there were an undergraduate research journal, such a publication might become unexpected "credential."

The second argument against an undergraduate research journal is that it would significantly increase the stress on faculty. One of the joys of pursuing research at a primarily undergraduate institution (at least, after one has tenure) has been the ability to do the research without having to have a program within 100% chance of success. Moreover, I can work on topics that might take years to accomplish (and which would never be assigned to a graduate student). The research that I have done on turtle leather development investigates an organism that has a breeding season of 18 months each year. By the time we know what to look for, we have to wait 18 months for the next experiment. When we publish a paper, there may be 5 years worth of data on it. It takes time to make such a paper, and I would not want to publish pieces of it so that each undergraduate could have a paper published by the time she or he applies for fellowships or graduate degree programs.

Another stress on faculty members may involve competition between those who publish in such journals and those who don't. Would such papers in undergraduate journals count toward tenure and promotion? Are they "real" papers? Should someone who builds a story over a number of years be penalized for not publishing it bit-by-bit and accruing numerous "publications?"
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What they need is a letter of recommendation, wherein I write that the student has drive, persistence, intellectual curiosity, and that she or he knows how to plan experiments with the appropriate controls.

The fact that the student’s research has not yet reached the publication stage is not considered a disadvantage. If there were an undergraduate research journal, such a publication might become an expected “credential.”

Scott Gilbert
Swarthmore College
It would be interesting to know if any article in these journals has been cited by anyone outside its home institution or whether any of the journals is indexed in searchable databases such as PubMed. In other words, the journals risk being little more than “vanity journals.”

Thus, I do not think that an undergraduate research journal provides benefits for the undergraduates that outweigh the costs of time and other resources. I also doubt that such a journal would have articles of significant benefit to science or the scientific community. Moreover, I believe that such a journal would only put more publication pressure on faculty members and weaken one of the fundamental reasons for pursuing research with undergraduates. The risks of publishing an undergraduate research journal outweigh any possible benefit such a journal might have. I think that there are other, more important places where we can put our limited funds and time.

Scott Gilbert
Swarthmore College
RESEARCH is not complete until it is published. A science education is not complete until students fully participate in all aspects of professional scientific culture. This means they have to understand the values of the profession that they are joining. Although undergraduates are provided opportunities to recognize the importance of research, too often they fail to appreciate that research is not complete until it is published. Values of researchers necessarily include publishing, peer review, and priority, but these values are not part of textbook information, traditional labs, and mass lectures or accessible through passive learning. Occasionally, students are listed as co-authors of articles in professional journals, but typically they are credited for their work in the acknowledgments. Rarely are students fully involved in both the writing and peer review process. Full engagement and benefit in undergraduate research will not be realized until peer review and publication are standard expectations of these critical experiences.
Not only publications,
But awards as well and activism!
Davidson's Bacterial Computer Wins Gold in Synthetic Bio Competition

December 04, 2007

Contact:  Bill Giduz

A team of student biologists representing Davidson and collaborators from Missouri Western State University recently brought home the gold from the 2007 international Genetically Engineered Machines (iGEM) Competition. Their work, which involved constructing a "bacterial computer," began in May of 2007, when four Davidson students and two from outside the college took on the project full-time in the college's genomics lab. Funding for the project came from the Howard Hughes Medical Institute and Davidson Research Initiative.

It was the third year Davidson has sent a team to the competition, which attracts synthetic biology teams from around the world. This year's Davidson effort built on last year's project of "flipping" genetic material to represent the stacking of burned pancakes of different sizes into correct order and orientation. This year's *E. coli* "computer" flipped genetic material to solve a mathematical puzzle called the Hamiltonian Path Problem.

The Davidsonians on the team celebrated their achievement with ice cream recently. They are (back l-r) Karmella Haynes, Jim Dickson, Malcolm Campbell, and (front l-r) Andrew Martens, Will DeLoache, and Laurie Heyer.
About SPUSA: Mission and History

The mission of Student Pugwash USA is to promote social responsibility in science and technology.

We prepare science, technology and policy students to make social responsibility a guiding focus of their academic and professional endeavors by:

- Examining the societal impacts of science and technology;
- Creating open and objective forums for debate;
- Fostering the exchange of ideas among diverse communities;
- Exploring solutions to current dilemmas in science and technology; and
- Cultivating the analytical skills needed to address future challenges.

SPUSA is guided by a respect for diverse perspectives and, as such, does not adopt advocacy positions on substantive issues. In order to create effective change, students first must understand the issues at stake, become trained in social activism, and contemplate their ethical and moral responsibility to themselves, and to society as a whole.

A student founded SPUSA in 1979 with the fundamental belief that young people play a vital role in determining the socially responsible application of science and technology. In 1955 Albert Einstein, Bertrand Russell, and other eminent scientists issued a manifesto urging scientists to "think in a new way" about their moral responsibilities in the nuclear age. In 1957, the first Pugwash Conference was held in Pugwash, Nova Scotia, bringing together some of the greatest scientific minds to address nuclear weapons issues and the social responsibility of scientists. SPUSA strives to convene the next generation of scientists around today's parallel issues.

SPUSA is the US student affiliate of the Pugwash Conferences on Science and World Affairs, recipients of the 1995 Nobel Peace Prize.
MENTORING: AFFECTIVE, SOCIAL, CULTURAL
Effects of an educational intervention on female biomedical scientists’ research self-efficacy

Lori L. Bakken · Angela Byars-Winston · Dawn M. Gundermann · Earlise C. Ward · Angela Slattery · Andrea King · Denise Scott · Robert E. Taylor

Received: 10 February 2009 / Accepted: 16 August 2009 / Published online: 23 September 2009 © Springer Science+Business Media B.V. 2009

Abstract Women and people of color continue to be underrepresented among biomedical researchers to an alarming degree. Research interest and subsequent productivity have been shown to be affected by the research training environment through the mediating effects of research self-efficacy. This article presents the findings of a study to determine whether a short-term research training program coupled with an efficacy enhancing intervention for novice female biomedical scientists of diverse racial backgrounds would increase their research self-efficacy beliefs. Forty-three female biomedical scientists were randomized into a control or intervention group and 15 men participated as a control group. Research
Talking about Leaving: Why Undergraduates leave the Sciences

Elaine Seymour and Nancy Hewitt (Westview, 1997)

Reviewed by Danielle R. Bernstein (danny@hikertohiker.org)

ABSTRACT

Elaine Seymour and Nancy Hewitt are sociologists at the Bureau of Sociological Research at the University of Colorado in Boulder. The book is an indepth report of a huge, multi-campus study of Science, Math and Engineering (SME) students. Who sticks with SME and who switches out to another field? This review concentrates on the gender attributes and traits of switchers and nonswitchers

Most Important Single Generalization
Switchers and nonswitchers did not differ by individual attributes of performance, attitude and behavior. They had the same array of abilities, motivations and behaviors. What distinguished the survivors from those who left was the development of particular attitudes, coping strategies and serendipity. Few switchers (10%) left because they have discovered that a non-science discipline was more suited to their abilities. There was no gender difference in this regard. Non switchers cited intrinsic interest in the subject as a prime source of motivation more than twice as commonly as switchers.

Individual coping skills include:
Competence - knowing the material
Confidence - knowing that you know the material
Persistence - stick with it
Assertiveness
Strong interest in the discipline
Strong interest in the career
A support system, bonding with other women in SME
"Field switching is only the tip of an iceberg: The same set of problems that prompt some science, mathematics, and engineering undergraduates to leave make persistence difficult for those who stay." (Cover jacket).

"Contrary to the common assumption that most switching is caused by personal inadequacy in the face of academic challenge, one strong finding is the high proportion of factors cited as significant in switching decisions which arise either from structural or cultural sources within institutions, or from students' concerns about their career prospects (p. 32)." The four most commonly cited concerns leading to switching decisions (also cited by between 31 and 74 percent of the non-switchers) were:

1. Lack or loss of interest in science
2. Belief that a non-S.M.E. major holds more interest, or offers a better education
3. Poor teaching by S.M.E. faculty
4. Feeling overwhelmed by the pace and load of curriculum demands.
Tinto's principles of effective retention:

1. Effective retention programs are committed to the students they serve. They put student welfare ahead of other institutional goals.
2. Effective retention programs are first and foremost committed to the education of all, not just some, of their students.
3. Effective retention programs are committed to the development of supportive social and educational communities in which all students are integrated as competent members.

Commonalities of effective retention commitments:

• enduring commitment to student welfare
• a broader commitment to the education, not mere retention, of all students
• an emphasis upon the importance of social and intellectual community in the education of students.
Tinto Model

- Prior qualifications
- Individual attributes
- Family attributes e.g., mother's education
- Teaching, learning support, facilities, etc.
- Academic integration
- Dropout decisions
- Goal Commitment
- Institutional Commitment
- Social integration
- Debt, counselling, medical, personal, family events, etc.
"Although programs can be most helpful, they cannot replace the absence of a high quality, caring, and concerned faculty and staff. Institutions should therefore not be misled by the use of modern technology and marketing strategies. The road to institutional commitment and thus to student commitment does not require very elaborate or high-cost interventions. Rather, effective retention calls for sustained effort of the part of all institutional members to give to each and every student serious and honest attention on a daily basis. It requires, if you will, a continuing commitment to the education of students. No technology, however sophisticated, can replace that sort of commitment (Tinto, p. 201)."
Tinto's Model of Voluntary Student Departure

What is a peer-reviewed publication?

- Evaluation of your research and your proposed publication/presentation by colleagues with similar knowledge and experience. Usually done anonymously.

What is the value of peer-review?

- Part of self-regulation of profession
- Many readers don’t have the expertise to judge the quality and importance of the research.
- Helps identify which projects to fund
- Helps identify which research findings to publish
- Helps in personnel reviews (who to hire and promote)
- Assesses the reliability of research & findings
Sources

• **Journal of Young Investigators**, [www.jyi.org](http://www.jyi.org)

• American Journal of Undergraduate Research, ([http://www.ajur.uni.edu/](http://www.ajur.uni.edu/))

• Thanks to: Steneck, Nicholas H., *Introduction to the Responsible Conduct of Research*, Office of Research Integrity, U.S. Dept. of Health & Human Services
Cooperative Learning Research Support


- Over 300 Experimental Studies
- First study conducted in 1924
- High Generalizability
- Multiple Outcomes

Outcomes

1. Achievement and retention
2. Critical thinking and higher-level reasoning
3. Differentiated views of others
4. Accurate understanding of others' perspectives
5. Liking for classmates and teacher
6. Liking for subject areas
7. Teamwork skills
Small-Group Learning: Meta-analysis


Small-group (predominantly cooperative) learning in postsecondary science, mathematics, engineering, and technology (SMET). 383 reports from 1980 or later, 39 of which met the rigorous inclusion criteria for meta-analysis.

The main effect of small-group learning on achievement, persistence, and attitudes among undergraduates in SMET was significant and positive. Mean effect sizes for achievement, persistence, and attitudes were 0.51, 0.46, and 0.55, respectively.
How Undergraduate Research has changed undergraduate STEM education more generally

New Courses

New Modules

New Collaborations

New Curricula

Transformed Syllabi & Revised Courses
(more emphasis on quantitative reasoning, data analysis, hypothesis testing, problem solving, modeling, ...)

Team-Teaching
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<th>University</th>
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<td>Sweet Briar College</td>
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<td>Beloit College</td>
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**Mathematical Modelling of Natural Phenomena**

**Special issue on Education**

*(co-editor Elsa Schaeffer)*
Selective Use of the Primary Literature Transforms the Classroom Into a Virtual Laboratory

Sally G. Hoskins *, 1, Leslie M. Stevens † and Ross H. Nehm * §

Abstract

CREATE (consider, read, elucidate hypotheses, analyze and interpret the data, and think of the next experiment) is a new method for teaching science and the nature of science through primary literature. CREATE uses a unique combination of novel pedagogical tools to guide undergraduates through analysis of journal articles, highlighting the evolution of scientific ideas by focusing on a module of four articles from the same laboratory. Students become fluent in the universal language of data analysis as they decipher the figures, interpret the findings, and propose and defend further experiments to test their own hypotheses about the system under study. At the end of the course students gain insight into the individual experiences of article authors by reading authors' responses to an e-mail questionnaire generated by CREATE students. Assessment data indicate that CREATE students gain in ability to read and critically analyze scientific data, as well as in their understanding of, and interest in, research and researchers. The CREATE approach demystifies the process of reading a scientific article and at the same time humanizes scientists. The positive response of students to this method suggests that it could make a significant contribution to retaining undergraduates as science majors.
IT Tools specifically designed as research tools; e.g., data-logging, image analysis, modeling, stat packages, bioinformatics, and phylogenetics

Only effective educationally if students apply to a problem that they have some ownership of and they use these IT tools “if students apply these tools with respect to the objectives of research activity and contribute to praxis of research by evaluating and modifying the application of these tools”
**Modeling in Biology Education**

- **Digital Learning Material for Model Building in Molecular Biology**
  - Tinri Aerter-Wilmsen et al.
  - Universität Wageningen, Netherlands

**Drosophila morphogen gradient**

- regulation at gene expression level
- role of gradients
- presence of positive feedback

found design cycle transferable to other modeling activities

*easy to adopt & adapt*

(University of Zurich, Switzerland)


BioQUEST & 3P’s

- Problem Posing
- Problem Solving
- Peer Persuasion
Exploring Cyberlearning in Biology Education
What is Cyberlearning?

Cyberlearning: learning that is mediated by networked computing and communications technologies.

The choice of the term is deliberately parallel to "cyberinfrastructure," a term coined at NSF^3 and now widely used there and elsewhere. In the
Advantages of Undergraduate Research

Undergraduate Research:

Engagement,
Mentoring,
and
Reform
Israel
(France, England, Greece, Switzerland & Italy, and Israel)
Argumentation in support of student scientific inquiry

later:
Marcia Linn
U C Berkeley
&
Philip Bell
U Washington

SCOPE
Science Controversies Online

even later
Science article on
MIT Project

Engaging Students in Science Controversy Through an Augmented Reality Role-Playing Game

Eric Rosenbaum, Eric Klopfer, Britton Boughner
MIT
National Laboratory Practical

An Inquiry Oriented Laboratory Examination
Pinchas Tamir
Hebrew University of Jerusalem

Manipulation
Self-Reliance
Observation
Experimental Design
Communication
Reasoning

Practical counts 40% of total score