National Conference
May 20-22, 2012
Bryant Conference Center

The Conference is funded under the National Science Foundation Grant TPC0554594. The project focuses on an examination of the teaching and learning of undergraduate science in the United States and the subsequent impact on students. Opinions expressed in conference reports and discussions are those of the authors and do not necessarily reflect those of the National Science Foundation.

www.nseus.org
This publication was produced by
National Study of Education in Undergraduate Science (NSEUS)
Research Based Undergraduate Science Teaching
National Conference
The University of Alabama, Tuscaloosa, AL
May 20-22, 2012

Editors:

Sharon A. Ross, M.Ed.
Dennis W. Sunal, Ph. D.
Cynthia Szymanski Sunal, Ph.D.
Cheryl L. Mason, Ph.D.
Dean Zollman, Ph. D.
Research Based Undergraduate Science Teaching Conference II

Sunday, May 20, 2012

5:30 – 8:00 PM    Conference Registration
Reception – Information Conference participant Interaction:
Bryant Conference Center * Room RAST B

Monday May 21, 2012

Strand 1: Implementing and Sustaining Reform in Undergraduate Science Teaching

7:30-8:30 AM    Registration and Full Breakfast: Bryant Conference Center * Room: RAST A

8:30-8:40 AM    Welcome, Introductions, and Overview of the Day: Bryant Conference Center * Room: RAST B

- Dennis W. Sunal, The University of Alabama, Science Education
- Cynthia Szymanski Sunal, The University of Alabama, Office of Research on Teaching in the Disciplines
- Cheryl L. Mason, San Diego State University, Biology and Science Education

8:40-9:00 AM    Delphi Study 1: Bryant Conference Center * Room: RAST B

Donna Turner, The University of Alabama, Deborah McAllister, The University of Tennessee at Chattanooga, and April Nelms, University of North Georgia
9:00-9:30 AM  **Keynote Speaker:** Bryant Conference Center * Room: RAST B

*Lawrence B. Flick, Dean, College of Education, and Professor, Science and Mathematics Education in Partnership with College of Science, Oregon State University*

“Reform or Revolution? Undergraduate Science Education in Diverse Contexts for Learning”

9:30-9:45 AM  **Discussion of Keynote Paper:** Bryant Conference Center * Room RAST B

Moderator: Cheryl L. Mason, San Diego State University

9:45-10:00 AM  **Break**

10:00–10:30 AM  **Panel 1: The Reform Process:** Bryant Conference Center * Room RAST B

“An Ambitious Plan in Undergraduate Science STEM Education”

*Barbara Burke, Barbara Hoeling, Michael Page, and Edward Walton, California Polytechnic University – Pomona*

10:30-10:45 AM  **Discussion of Panel 1 Presentation:** Bryant Conference Center * Room RAST B

Moderator: Dennis W. Sunal, The University of Alabama

10:45-10:55 AM  **Break**

10:55-11:25 AM  **Panel 2: The Reform Process:** Bryant Conference Center * Room RAST B

“Beginnings to New Horizons”

*Paul Adams, Germaine Taggart, Fort Hayes State University and Zdeslav Hrepic, Columbus State University*

11:25-11:40 AM  **Discussion of Panel 2 Presentation:** Bryant Conference Center * Room RAST B

Moderator: Michael Odell, University of Texas at Tyler

11:40 AM-12:40 PM  **Lunch will be provided:** Bryant Conference Center * Room RAST A
Monday May 21, 1:00 – 5:00 pm

Strand 2: Teaching STEM Courses: What Works

NOTE: Concurrent Sessions 1A and 1B with follow-up Discussion, occur 12:40–2:10 PM

12:40-1:55 PM  Concurrent Session 1A: Strategies for Enhancing Learning: Bryant Conference Center * Room Wilson (2nd Floor)

• “How do Summer Undergraduate Research Experiences Compare to Other Models?”

  Omolola Adedokun, Purdue University

• “Learning Inquiry and Nature of Science through Undergraduate Research: Mentoring Matters”

  Maya Patel, Ithaca College

• “You Can Learn a Lot about Teaching Undergraduates from Preschoolers”

  Dana Byrd, Texas A&M University at Kingsville and Gene Byrd, The University of Alabama

1:55-2:10 PM  Discussion of Concurrent Session 1A: Bryant Conference Center * Room Wilson (2nd Floor)

Moderator: Lloyd Barrow, University of Missouri

12:40-1:55 PM  Concurrent Session 1B: Instructional Practices: Bryant Conference Center * Room Lackey (2nd Floor)

• “Cooking From Scratch: Development of Inquiry Based Activities for the General Microbiology Laboratory”

  Josephine Taylor, Stephen C. Wagner, and Sarah Canterberry, Stephen F. Austin State University

• “Teaching Undergraduate Physics Through a Research-based Clicker Methodology”

  Lin Ding, The Ohio State University
• “Combating ‘One and Done’: Maximizing the Impact of an Undergraduate Science Course”

_Peter Holden, University of Massachusetts, Boston_

1:55-2:10 PM  **Discussion of Concurrent Session 1B:** Bryant Conference Center * Room Lackey (2nd Floor)

Moderator: Mitchell Klett, Northern Michigan University

2:10-2:25 PM  Break

NOTE: Concurrent Sessions 2A and 2B, with follow-up Discussion, occur 2:25–4:05 PM

2:25-3:50 PM  **Concurrent Session 2A: Best Practices in Curriculum:** Bryant Conference Center * Room Wilson (2nd Floor)

• “Alignment of High School and College STEM Curricula”

_Michael Odell, University of Texas at Tyler_

• “An Online Undergraduate Astronomy Lab Course”

_Gene Byrd, The University of Alabama_

• “A Curriculum Experiment in Climate Change Education Using an Integrated Approach of Content Knowledge Instruction and Student-Driven Research, Year 2”

_Paul Adams, Fort Hayes State University_

• “Bridging Gaps between Research and Education in Biofuel Technologies”

_Rong Zhang, Auburn University, Frank Armstead, Tuskegee University, Q. Peter He, Tuskegee University, and Jin Wang, Auburn University_

3:50-4:05 PM  **Discussion of Concurrent Session 2A:** Bryant Conference Center * Room Wilson (2nd Floor)

Moderator: Gerald Krockover, Purdue University

2:25-3:50 PM  **Concurrent Session 2B: Key Issues in Course Reform:** Bryant Conference Center * Room Lackey (2nd Floor)
• “A Research-Based Transformation of Purdue’s Modern Mechanics Course”
  
  *Rebecca Lindell, Jack Doyle, Adam Szewciw, and Andrew Hirsch, Purdue University*

• “Identifying Shifts in Pedagogical Content Knowledge (PCK): Outcomes of a “Scientific Teaching” Course for Biology Graduate Teaching Assistants at a Large Research University”
  
  *Kathleen Hill, Arizona State University*

• “IMPACT’s Role in Improving undergraduate STEM Education at Purdue University”
  
  *Hosi Karzai and Frank Dooley, Purdue University*

• “Promoting Conceptual Change Through Course Design: Supporting the Physics Content Development of Pre-Service Teachers”
  
  *Will Stoll, Kadir Demir, and Brett Criswell, Georgia State University*

**3:50-4:05 PM**

**Discussion of Concurrent Session 2B:** Bryant Conference Center * Room Lackey (2nd Floor)

*Moderator: Sytil Murphy, Shepherd University*

**4:05-4:20 PM**

**Break**

**4:20-4:40 PM**

**Delphi Study 2:** Bryant Conference Center * Room RAST B

*Donna Turner, The University of Alabama, Deborah McAllister, The University of Tennessee at Chattanooga, and April Nelms, University of North Georgia*

**4:40-5:00 PM**

**Wrap-Up:** Bryant Conference Center * Room RAST B

• Cheryl L. Mason, San Diego State University
• Dennis W. Sunal, The University of Alabama
Strand 3: Assessing and Evaluating Student Outcomes in Undergraduate Science Courses

7:30-8:30 AM  Registration and Full Breakfast: Bryant Conference Center * Room: RAST A

8:30-8:40 AM  Welcome, Introductions, and Overview of the Day: Bryant Conference Center * Room: RAST B

- Cynthia Szymanski Sunal, The University of Alabama, Office of Research on Teaching in the Disciplines
- Cheryl L. Mason, San Diego State University, Biology and Science Education

8:40-8:50 AM  Delphi Study Report with Working Groups Established: Bryant Conference Center * Room: RAST B

Donna Turner, The University of Alabama, Deborah McAllister, The University of Tennessee at Chattanooga, and April Nelms, University of North Georgia

8:50-9:20 AM  Keynote Speaker: Bryant Conference Center * Room: RAST B

David Hammer, Professor, Departments of Education and Physics and Astronomy, Tufts University

“The Challenges and Possibilities of Meaningful Assessment in Large Lecture Introductory Physics”

9:20-9:30 AM  Discussion of Keynote Paper: Bryant Conference Center * Room RAST B

Moderator: Christy McKinnon, University of Incarnate Word

9:30-9:40 AM  Break

9:40-10:10 AM  Paper Presentations: Bryant Conference Center * Room RAST B

- “Learning Through Action Research While Teaching Undergraduate Science”
Penny Gilmer, Florida State University

- “Improving Student Outcomes in Organic Chemistry Through Action Research”

Gail Horowitz and Laura Rabin, Brooklyn College, City University of New York

10:10-10:20 AM Discussion of Paper Presentations: Bryant Conference Center * Room RAST B

Moderator: Corinne Lardy, San Diego State University

Strand 4: Using Research to Evaluate the Success of Reform

10:20-10:50 AM Keynote Speaker: Bryant Conference Center * Room: RAST B

John Dantzler, Educational Research, The University of Alabama

“Researching Reform: Designing studies to understand the impact of reform methods in undergraduate science classrooms.”

10:50-11:00 AM Discussion of Keynote Paper: Bryant Conference Center * Room RAST B

Moderator: Dianne Robinson, Hampton University

11:00-12:15 PM Symposium: National Reform Study Results: Bryant Conference Center * Room RAST B

- “Brief Overview of the NASA/NOVA Faculty Professional Development Program – 1995-2006”

Michael Odell, University of Texas at Tyler

- “National Study of Education in Undergraduate Science – 2006-2012 – What Was Learned”

Dennis Sunal, Cynthia Szymanski Sunal, Erika Steele, Donna Turner, The University of Alabama; Cheryl Mason, Corinne Lardy, San Diego State University; Dean Zollman, Kansas State University; Mojgan Matloob-Haghandikar, Winona State University; and Sytil Murphy, Shepherd College
• "Investigating the Impact of Professional Development on the Pedagogical Content Knowledge of University Faculty".
  
  Donna Turner, The University of Alabama

• “The Impact of Science Education Reform on Students’ Perceptions of the Learning Environment”
  
  Erika Steele, The University of Alabama

• “Students’ Reasoning and the Level of Interactivity in Science Content Courses”
  
  Dean A. Zollman, Kansas State University, Mojgan Matloob-Haghanikar, Winona State University and Sytil Murphy, Shepherd University

• “Impact of reformed courses on the science teaching self-efficacy beliefs of preservice and inservice elementary teachers”

  Corinne Lardy and Cheryl L. Mason, San Diego State University

12:15-12:25 PM  Discussion of Symposium: Bryant Conference Center * Room: RAST B

  Moderator: Emmett Wright, Kansas State University

12:25-1:30 PM  Lunch will be provided: Bryant Conference Center * Room RAST A
Tuesday May 22, 1:30 – 5:00 pm

**Strand 5: Developing a Research Agenda and Action Plan**

**1:30-1:40 PM**  **Overview of Strand 5 Activities:** Bryant Conference Center * Room RAST B

The afternoon will focus on developing a research agenda in a collaborative group. The outcome will be the identification of groups of higher education faculty whose intent is to develop and seek funding regarding research on reform of undergraduate entry-level science courses.

- *Dennis W. Sunal, The University of Alabama*
- *Cheryl L. Mason, San Diego State University*

**1:40-2:40 PM**  **Working Groups Meet – Develop Elements of a Research Agenda:** Bryant Conference Center * Rooms RAST B, Wilson, Lackey, RAST A

**NOTE:** Each Working Group will have a Facilitator who has expressed interest in the area with which the group is working

**2:40-3:00 PM**  **Initial Whole Group Sharing by Workings Groups of Research Agenda and Action Plan:** Bryant Conference Center * Room RAST B

Moderator: Cheryl L. Mason, San Diego State University

**3:00-3:15 PM**  **Break**

**3:15-4:30 PM**  **Working Groups Meet – Develop Action Plans for Your Working Group:** Bryant Conference Center * Rooms RAST B, Wilson, Lackey, RAST A

**4:30-5:00 PM**  **Wrap Up Discussion and Closing Comments:** Bryant Conference Center * Room RAST B

Moderators: Dennis W. Sunal, Cynthia Szymanski Sunal, The University of Alabama and Cheryl L. Mason, San Diego State University

**6:30-8:30 PM**  **Wrap-Up Dinner:** Hotel Capstone

Information regarding the conference is available on the NSEUS website, [http://nseus.org](http://nseus.org)  
Conference committee co-chairs: Dennis W. Sunal, The University of Alabama,  
dwsunal@bamaed.ua.edu; Cynthia Szymanski Sunal, The University of Alabama,  
cvsunal@bamaed.ua.edu; Cheryl L. Mason, San Diego State University,  
cmason@mail.adsu.edu; and Dean A. Zollman, Kansas State University, dzollman@ksu.edu
The Conference is funded under the National Science Foundation Grant TPC0554594. The project focuses on an examination of the teaching and learning of undergraduate science in the United States and the subsequent impact on students. Opinions expressed in Conference reports and discussions are those of the authors and do not necessarily reflect those of the National Science Foundation.
For specific information on NSEUS, contact:

Project Senior Personnel

**Dennis W. Sunal**
NSF Project PI, The University of Alabama
Ph: (0) 205-348-7010 (personal cell: 205-826-7263)
E-mail: dwsunal@bama.ua.edu

**Cynthia Szymanski Sunal**
NSF Project UA Co-PI, The University of Alabama
Ph: (0) 205-348-8264
E-mail: cvsunal@bamaed.ua.edu

**Cheryl L. Mason**
NSF Project San Diego State University Co-PI,
Ph. (0) 785-532-1619
E-mail: damason@mail.sdsu.edu

**Dean Zollman**
NSF Project Kansas State University Co-PI
Ph. (0) 785-532-1619
E-mail: dzollman@phys.ksu.edu

Project Personnel and Consultants

**Corinne Lardy**, Science Education, San Diego State University  
**Mojgan Matloob-Haghanikar**, Physics, Winona State University  
**Sytil Murphy**, Physics, Shepherd University  
**Erika Steele**, Biology and Science Education, The University of Alabama  
**Donna Turner**, Science Education, The University of Alabama  
**John Dantzler**, Consultant, Education Research, The University of Alabama

NSEUS Advisory Board

**Dorothy (Dixie) Coleman**, Fifth grade elementary teacher, Junction City, Kansas  
**Sami Kinsey**, Curriculum Coordinator, Del Valle, Texas  
**Gerald H. Krockover**, Science Education research, Purdue University  
**Changhua Wang**, Evaluation and Research, Education Northwest, Center for School, Family, and Community Education Northwest, Portland, Oregon  
**Sandra Ray**, Recent member, Alabama State Board of Education
Research Based Undergraduate Science Teaching Conference II Proceedings

Research Based Undergraduate Science Teaching, a national conference on the best practices in teaching undergraduate science and their impact on student learning outcomes, was held May 20-22, 2012 at the University of Alabama’s Bryant Conference Center. The conference was sponsored by the National Study of Education in Undergraduate Science (NSEUS) a project funded by the National Science Foundation and The University of Alabama Office of Research on Teaching in the Disciplines.

Keynote speakers included Lawrence B. Flick, Dean, College of Education, and Professor, Science and Mathematics Education in Partnership with College Science, Oregon State University; David Hammer, Professor, Department of Education and Physics and Astronomy, Tufts University; and John Dantzler, Educational Research, The University of Alabama.

Highlighted in the conference were the results of the five year NSEUS national study investigating undergraduate science classrooms. The goal of the National Study of Education in Undergraduate Science (NSEUS) project was to examine the impact of reformed undergraduate entry-level science courses that differ from traditional courses. Extensive site visits with courses and students at 20 colleges and universities as well as over 90 graduates of the courses now serving as in-service teachers in K-12 schools were conducted by a team of investigators from the University of Alabama, Kansas State University, and San Diego State University.

Conference II research presentations included over 60 researchers from universities and colleges from 25 states and participation in discussion and work groups by all conference attendees from 40 universities, colleges, and agencies.

To access a Conference II agenda and archived resources with speaker videos, papers, and PowerPoints go to the Conference II section on the NSEUS web site at http://nseus.org

Dennis Sunal, Donna Turner, and Cynthia Sunal, University of Alabama; Dean Zollman, Kansas State University; and Cheryl Mason, San Diego State University conference committee co-chairs.

For more information, contact Sunal at dwsunal@bama.ua.edu.
<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A curriculum experiment in climate change education using an integrated approach of content knowledge instruction and student-driven research, Year 2:</td>
<td>Paul Adams, Fort Hays University</td>
<td>1</td>
</tr>
<tr>
<td>Beginnings to New Horizons:</td>
<td>Paul Adams, Fort Hays State University, Germaine Taggart, Fort Hays State University, Zdeslav Hrepic, Columbus State University</td>
<td>2</td>
</tr>
<tr>
<td>How do summer undergraduate research experiences compare to other models?</td>
<td>Omolola Adedokun, Purdue University, Ann Bessenbacher, Purdue University, Loran Parker, Purdue University, Amy Childress, Purdue University, Lisa Kirkham, Purdue University, Dorothy Teegarden, Purdue University, Wilella Burgess, Purdue University</td>
<td>3</td>
</tr>
<tr>
<td>An ambitious plan in undergraduate science STEM education:</td>
<td>Barbara A. Burke, California Polytechnic State University Pomona, Barbara Hoeling, California Polytechnic State University Pomona, Michael Page, California Polytechnic State University Pomona, Edward Walton, California Polytechnic State University Pomona</td>
<td>4</td>
</tr>
<tr>
<td>You can learn a lot about teaching undergraduates from preschoolers:</td>
<td>Dana Byrd, Texas A&amp;M University at Kingsville, Gene Byrd, University of Alabama</td>
<td>5</td>
</tr>
<tr>
<td>An online undergraduate astronomy lab course:</td>
<td>Gene Byrd, University of Alabama</td>
<td>6</td>
</tr>
<tr>
<td>Researching reform: Designing studies to understand the impact of reform methods in undergraduate science classrooms:</td>
<td>Joh Dantzler, University of Alabama</td>
<td>7</td>
</tr>
<tr>
<td>Promoting conceptual change through course design: Supporting the physics content development of pre-service teachers:</td>
<td>Will Stoll, Georgia State University, Kadir Demir, Georgia State University, Brett Criswell, Georgia State University</td>
<td>8</td>
</tr>
<tr>
<td>Teaching undergraduate physics through a research-based clicker methodology:</td>
<td>Lin Ding, The Ohio State University</td>
<td>9</td>
</tr>
</tbody>
</table>
Reform or revolution? Undergraduate science education in diverse contexts of learning: Lawrence B. Flick, Oregon State University ................................................................. 10

Learning through action research while teaching undergraduate science: Penny Gilmer, Florida State University ......................................................................................................................... 11

The challenge and possibilities of meaningful assessment in large lecture introductory physics: David Hammer, Tufts University ........................................................................................................... 12

Bridging gaps between research and education in biofuel technologies: Rong Zhang, Auburn University, Frank Armstead, Tuskegee Univeristy, Qinghua (Peter) He, Tuskegee University, Jin Wang, Auburn University .................................................................................................................. 13

Identifying shifts in pedagogical content knowledge (PCK): Outcomes of a “scientific teaching” course for biology graduate teaching assistants at a large research university: Kathleen Hill, Arizona State University ................................................................................................................................. 14

“Combating one and done”: Maximizing the impact of an undergraduate science course: Peter Holden, University of Massachusetts .................................................................................................................. 15

Improving student outcomes in organic chemistry through action research: Gail Horowitz, Brooklyn College of the City University of New York, Laura A.Rabin, Brooklyn College of the City University of New York .................................................................................................................. 16

IMPACTS’s role in improving undergraduate STEM education at purdue university: Hosi Karsai, Purdue University, Donalee Attardo, Purdue University, Chantel Levesque-Bristol, Purdue University, John Campbell, Purdue University, Tomalee Doan, Purdue University, Frank Dooley, Purdue University, Mickey Latour, Purdue University, Gabriela Weaver, Purdue University, Cliff Weil, Purdue University, Dale Whittaker, Purdue University, Rebecca Lindell, Purdue University .................................................................................................................. 17

Impact of reformed courses on the science teaching self-efficacy beliefs of preservice and inservice elementary teachers: Corinne H. Lardy, San Diego State University, Cheryl Mason, San Diego State University .................................................................................................................. 18

A research-based transformation of purdues’s modern mechanics course: Rebecca Lindell, Purdue University, John Doyle, Purdue University, Max Kagan, Purdue University, Jordan Stecklof, Purdue University, Adam Szewciw, Purdue University, Mark Haugen, Purdue University, Andrew Hirsch Purdue University .................................................................................................................. 19
Students’ reasoning and the level of interactivity in science content courses: Dean Zollman, Kansas State University, Mojgan Matloob-Haghanika, Winona State University, Sytil Murphy, Shepherd University ................................................................. 20

Alignment of high school and college STEM curricula: Michael Odell, University of Texas at Tyler .................................................................................................................. 21

Brief overview of the NASA/NOVA faculty professional development program 1995-2006: Michael Odell, University of Texas at Tyler ........................................................................................................... 22

Learning inquiry and nature of science through undergraduate research: Mentoring matters: Maya Patel, Ithaca College .................................................................................................................. 23

The Impact of science education reform on students’ perceptions of the learning environment: Erika Steele, University of Alabama .................................................................................................................. 24

National study of education in undergraduate science 2006-2012: What was learned?: Dennis Sunal, University of Alabama, Cynthia Sunal, University of Alabama, Donna Turner, University of Alabama, Erika Steele, University of Alabama, Cheryl Mason, San Diego State University, Corinne Lardy, San Diego State University, Dean Zollman, Kansas State University, Mojgan Matloob-Haghanika, Winona State University, Sytil Murphy, Shepherd University .................................................................................................................. 25

Cooking from scratch: Development of inquiry based activities for the general microbiology laboratory: Josephine Taylor, Stephen F. Austin State University, Stephen C. Wagner, Stephen F. Austin State University, Sarah Canterberry, Stephen F. Austin, State University .................................................................................................................. 26

Investigating the impact of professional development on the pedagogical content knowledge of university faculty: Donna Turner, University of Alabama ............................................. 27
Research Based Undergraduate Science Teaching
Conference II

Abstracts

This interactive conference will focus on improving teaching in undergraduate science and its short- and long-term impacts on student outcomes. Conference strands include, (1) Implementing and Sustaining Reform in Undergraduate Science Teaching, (2) Teaching in the Disciplines: What Works (Physics/Chemistry/Biology/Geosciences), (3) Assessing and Evaluating Student Outcomes in Undergraduate Science Courses, (4) Using Research to Evaluate the Success of Reform, and (5) Developing a Research Agenda and Action Plan.

1. Paul Adams

“A Curriculum Experiment in Climate Change Education Using an Integrated Approach of Content Knowledge Instruction and Student-Driven Research, Year 2”

Paul Adams, Fort Hays State University

One of the greatest challenges facing the world is climate change. Coupled with this challenge is an under-informed population that has not received a rigorous education about climate change other than what is available through the media. Fort Hays State University is in a second year of piloting a course on climate change targeted to students early in their academic careers. The course is modeled after our past work (NSF DUE-0088818) of integrating content knowledge instruction and student-driven research where there was a positive correlation between student research engagement and student knowledge gains. The second pilot offering utilizes a mix of inquiry-based instruction, problem-based learning, and student-driven research to educate and engage the students in understanding climate change. The course was collaboratively developed by a geoscientist and science educator. The course model is unique in that 50% of the course is dedicated to developing core knowledge and technical skills (e.g. global climate change, critical analysis, writing, data acquisition, data representation, and research design), and 50% to conducting a research project using available data sets from federal agencies and research groups. A key element of the course is a focus on data sets to make climate change relevant to the students. The impacts of course changes from the first offering to the second offering significantly improved student performance in research and understanding of climate change.
concepts. The course design has potential to improve student understanding and research skills in undergraduate students at other institutions.

2. Paul Adams, Germaine Taggart, and Zdeslav Hrepic

“Beginnings to New Horizons”

Paul Adams, Fort Hays State University, Germaine Taggart, Fort Hays State University, Zdeslav Hrepic, Columbus State University

Fort Hays State University became part of the NASA-NOVA network in 1997 with its effort A Model of Integrated Science and Mathematics Instruction for Preservice K-9 Teachers. This work was followed-up with another NASA-NOVA effort in 1999, Implementation and Integration of Inquiry-Based Science and Mathematics Learning for the Preparation of K-12 Teachers. These original efforts led to the modification of five courses – two in physics, one in mathematics, one in education, and one in chemistry. While the specific course adaptations done fifteen years ago have been replaced or modified as the original faculty have retired or moved on to other positions, the impact of this effort is still present on the campus with the remaining faculty team and at other institutions for the faculty that have left Fort Hays State University. The panel session will examine how these initial efforts were used to engage faculty members in improving undergraduate education beyond the original NASA-NOVA team in improving undergraduate education, serve as a hot bed for collaboration and course development that led to two NSF grants, changes in faculty teaching and assessment styles, publications related to our work, continuing development of new courses (four at present), and improvement in teaching undergraduate science teaching and undergraduate research at Fort Hays State University (KS) and Columbus University (GA).

3. Omolola Adedokun

“How do Summer Undergraduate Research Experiences Compare to Other Models?”

Omolola Adedokun, Ann Bessenbacher, Loran Parker, Amy Childress, Lisa Kirkham, Dorothy Teegarden & Wilella Burgess, Purdue University

Undergraduate research experiences (UREs) have been shown to be effective in recruiting, retaining and graduating students, especially underrepresented minorities, in science, technology, engineering and mathematics (STEM) majors. A variety of URE program models exist across American colleges and universities. Despite the wide range of URE models, current URE research and evaluation rarely considers differences in models when examining student experiences and outcomes in research programs. The goal of the current paper is to compare the impact of URE structure on student outcomes.

The study uses a nonequivalent pre-post control group design to compare program outcomes among four models of URE participation: summer term, single academic semester, two academic semesters, and full academic year. The analyses revealed no significant group differences in
program outcomes between summer and single semester participants. However, compared to the summer group, students that participated for two academic semesters reported higher gains in awareness of available research career opportunities and writing research papers for publications. Similarly, participants in yearlong experiences reported higher gains than the summer participants in research skills, understanding of research procedures, and awareness of available research career opportunities and awareness of specialized research career options. The limitations of the study and implications for undergraduate STEM education are discussed.

4. Barbara Burke, Barbara Hoeling, Michael Page, and Edward Walton

“An Ambitious Plan in Undergraduate Science STEM Education”

Barbara A. Burke, Barbara Hoeling, Michael Page, Edward Walton, California Polytechnic State University-Pomona

Cal Poly’s STEM program is working to increase the graduation rate of STEM majors through enhanced teaching of STEM courses, and providing early discipline involvement opportunities. The California State Polytechnic University, Pomona has an enrollment of twenty thousand students, with over two thousand majors in the College of Science, and close to five thousand majors in the College of Engineering. More than 24 ethnicities and cultures are represented. For First-Time-Freshmen who enter Cal Poly Pomona in STEM disciplines, only 28.7% persist and graduate as STEM majors within six years. One study of students who left STEM indicated that there were no significant identifiable differences between students that explain why one group chose to leave SME disciplines while the others remain. High rates of student attrition seemed to be based on students’ perception of the quality and character of education in Science Math and Engineering courses, and less on students’ academic abilities. This five-year STEM program is now in its second year. Our panel will share the work, the results, the issues, and plans to affect undergraduate STEM teaching reform enhancements.

We will report results of our research and development activities in:
   1. General college physics course redesign efforts
   2. General College chemistry enhancements
   3. Efforts to engage students in their major disciplines early in their college career
   4. Concerns and Issues that challenge implementation of STEM teaching enhancements
   5. Design of effective first-year experiences
   6. Plans to enable implementation and sustain reform enhancements

5. Dana Byrd

“You can learn a lot about teaching undergraduates from preschoolers”

Dana Byrd, Texas A&M University at Kingsville, Gene Byrd, University of Alabama

Research on student learning and teaching requires a rigorously defined and well-tested task. The “Tower of London” puzzle is a well-tested problem-solving task requiring multi-step planning toward a solution. Also, enthusiastic participants with few confounding factors are needed. Four and five year-old preschoolers are starting multistep reasoning and provide good
subjects. The Tower of London task with increased levels of complexity has been used up through older adults for cognitive ability testing. One important well-substantiated finding of the preschooler research studies is that talking about future moves (rather than just making moves) greatly improves children’s performance on the task. We will discuss future strategies for on-line and regular undergraduate courses inspired by these results. We have already carried out a preliminary modification of a University of Alabama on-line introductory astronomy course taking into account these results. The primary task is answering a closed-book multiple choice exam on subject matter presented by lectures and text readings. The course has a large set of specific learning objectives used in writing the lectures and exam questions. Previously, students simply answered the multiple choice questions after the lectures and readings. In a preliminary application of the above studies, short answer or brief essay questions were added to the course each related to the course learning objectives. The students were encouraged to prepare and submit as an extra credit assignment their answers to these questions. This would correspond to the preschoolers’ “talking to themselves” about steps in the task. We will compare the multiple choice final exam scores of class sections prior to and after this writing assignment was included.

6. Gene Byrd

“An Online Undergraduate Astronomy Lab Course”

Gene Byrd, University of Alabama

An online undergraduate astronomy lab course taught since the start of 2009 will be described. This is a companion to an online “lecture” astronomy course. Compared to the lecture course, it was more of a challenge to create an online lab course. However, it turns out that astronomy is well suited for this format. The core curriculum learner objectives adopted by our Department of Physics and Astronomy were used in writing the course. In the context of these, specific active objectives were written for each of twelve lab exercises. This course emphasizes non-virtual observations and experiments when possible. To identify objects for observation and photography, students use a “classic” Edmund Scientific Co. paper “star wheel” and/or the free Stellarium PC planetarium software. Posted images from digital cameras and phones facilitate submitting, sharing and grading observations. A lens and tube kit is used to explore optics and the functions of a telescope. A simple but steady home-made mounting has been developed for the assembled telescope. With their camera, the star maps and the kit telescope, the students are expected to observe and photograph the Moon, planets and bright stars. More ambitious students try for star clusters and galaxies. Beyond imaging, with their cameras and a diffraction grating, students can photograph, identify and submit spectra of different sources. A “pin-hole” protractor is used for table-top angular size vs distance and stellar parallax experiments. Students submit for grading prose answers, data calculations, drawings and photos in an “observational notebook”. In addition, class discussion among students, open book multiple choice assessments and, lastly, a closed book proctored multiple choice final exam are used in grading. A grant from the University of Alabama College of Continuing Students supported the author’s preparation of this course.
7. John Dantzler
Keynote Speaker

“Researching Reform: Designing Studies to Understand the Impact of Reform Methods in Undergraduate Science Classrooms”

John Dantzler, University of Alabama

Research on reform methods in undergraduate science education has produced evidence supporting reform teaching. As researchers move forward with testing models related to reform teaching methods in science, methodological challenges present barriers to examining cause and effect relationships. A discussion of these methodological challenges surrounding experimental and correlational designs, psychometrics, and alternative methods is an opportunity for researchers to develop collective goals in this area. What are the limitations of experimental research in social science? What are the limitations of instruments as measures of dependent variables? What is the role of non-experimental methods? The presentation preceding Strand 4 is intended to stimulate conversation about challenges and future directions in the area of reform teaching methods research.

8. Kadir Demir, Will Stoll, Kadir Demit, and Brett Criswell

“Promoting Conceptual Change Through Course Design: Supporting the Physics Content Development of Pre-Service Teachers”

Will Stoll, Kadir Demir, Brett Criswell, Georgia State University

The focus of this paper is the development of a unique physics course at Georgia State University to produce pre-service secondary science teachers who have the capability of facilitating deep conceptual understanding in high-school physics students – a course which has been developed through the true collaborative efforts of faculty from the College of Arts & Sciences and from the College of Education, and which gives appropriately-apportioned attention to both physics content and physics pedagogy. A brief overview of the development process of the course will be highlighted starting as an ad hoc effort of ‘guest lectures’ in a physics class highlighting the research promoting conceptual change to its current form as a formalized course that purposefully weaves together the physics content with the discussion of models of teaching for conceptual change. The unique curriculum incorporated which purposefully focuses on the concept acquisition of the physics principles of mechanics, heat transfer, and waves within the context of conceptual change teaching strategies [e.g. Clement’s (1993) work on bridging analogies, diSessa’s (1993) p-prims model and Slotta’s and Chi’s (2006) ontological misclassification framework] will be presented. In addition, the nature of the collaboration behind the physics and science education faculty will be detailed highlighting the conceptual change occurring through the process. This overview of the course is presented as the groundwork for a proposed study to examine the initial implementation of the course this summer.
9. Lin Ding

“Teaching Undergraduate Physics through a Research-based Clicker Methodology”

Lin Ding, The Ohio State University

Abstract: Student personal response systems, also known as clickers, have been widely used in undergraduate science classrooms to engage students in active learning. In physics, a number of clicker resources that target students’ conceptual understanding are available. These materials typically are individual questions that are discretely designed and used, with each addressing a distinct concept. Differing from the traditional materials, a new clicker methodology is developed and tested in our studies based on the theory of contextualized learning. Specifically, we have created coherent sequences of clicker questions; within each sequence 3-4 seemingly disparate questions are systematically crafted to address the same underlying key concept but are embedded into different contexts. Through consistent exposure to these sequences, students are trained to flexibly seek and apply learned core concepts across diverse situations; thus effectively reducing their difficulties associated with context-dependent learning. Following this sequence-based clicker methodology, we have created, validated, and implemented ~150 question sequences, sufficient in number to cover the entire introductory physics. Empirical results from real classroom implementation and testing show our clicker materials have significantly increased students’ conceptual understanding—measured by concept inventories—as well as enhanced their learning interest.

10. Lawrence B. Flick

Keynote Speaker

“Reform or Revolution? Undergraduate Science Education in Diverse Contexts of Learning”

Lawrence B. Flick, Oregon State University

Science education at all levels is embedded in large systems that are being challenged by the rapid growth of information technologies. While the existence of these technologies depends in part on university science education, delivering that education is slow to respond to the implications of that technology. Governance and reward structures draw faculty away from engagement with undergraduates even as science education is promoted as an essential for all students. Research is building our knowledge about effective teaching and learning both in and outside the classroom, yet inertia of the system threatens to dampen or swallow innovation. We are experiencing a revolution in the contexts of learning that may bring a full-scale cultural change in the way faculty interact with students to promote understanding in science.
11. Penny Gilmer

“Learning through Action Research While Teaching Undergraduate Science”

Penny Gilmer, Florida State University

Using cultural historical activity theory as the theoretical framework, I conducted action research in an upper division undergraduate biochemistry class, focused on improved student interest and learning using collaborative groups and technology. Each collaborative team developed ten web sites on major themes taught in first semester biochemistry and presented three of these sites in class. The factors that enhanced the students’ interest and learning of biochemistry included communities, tools, and division of labor, while the rules within the university tended to diminish interest and learning. Using ethnographic, autobiographical, fictional, and metalogical lenses, I learned from the action research to improve my teaching. I contacted students I could find ten years after the course and found ways the experimental course influenced them.

12. David Hammer

Keynote Speaker

“The Challenges and Possibilities of Meaningful Assessment in Large Lecture Introductory Physics”

David Hammer, Tufts University

Much of the difficulty in assessing student learning, in undergraduate science or earlier, is that assessment is part of what students should be learning to do. The practices of science are all about assessing the quality of ideas about the natural world, both at the level of the community knowledge (“can we conclude there is a Higgs boson?”) and at the level of individual understanding (“have I sufficiently understood Dr. X’s counter-argument?”). Unfortunately, testing in schools often encourages students to assess knowledge and understanding by authority.

In this talk, I discuss research regarding the need for practices of assessment more closely aligned with the discipline. I will also discuss my own practices as an instructor, in large-lecture introductory physics courses in working toward meaningful assessment, both of students and by students. I cannot remotely claim to have “solved the problem,” but I can suggest possibilities.

13. Qinghua (Peter) He

“Bridging Gaps between Research and Education in Biofuel Technologies”

Rong Zhang, Auburn University, Frank Armstead, Tuskegee University, Qinghua (Peter) He, Tuskegee University, Jin Wang, Auburn University

There are very limited biofuels courses or programs devoted to engineering undergraduate education. This lack of engineering biofuels education was also noted in, which concluded that
there is a large void of biorenewable curricula in U.S. colleges and universities. One specific evidence of such shortage is that, during the ten years between 1998-2007, among thousands of papers presented at the national American Society for Engineering Education (ASEE) conferences (http://www.asee.org), only 25 papers were related to biofuels education. Contrary to the lack of efforts in biofuels education for engineering undergraduates, there are enormous specialized research centers on biofuels technologies established in the past few years, especially in the chemical engineering field. These research centers mainly focus on advanced research and graduate/post-graduate education in engineering. The research results generated from these centers are usually published on scientific journals, which involve high levels of technical knowledge and complexities that only specialized scientists can understand. As a result, the available biofuels educational materials are quite dispersed and no single comprehensive literature source on biofuels processes exists that is suitable for engineering undergraduate education. Consequently, there is a significant gap between advanced biofuels research and undergraduate biofuels education in engineering. In this work, we will first discuss the need of biofuels education in engineering and the gap between advanced biofuels research and undergraduate biofuels education. Then we will talk about why among different engineering majors, chemical engineering is in a unique position to address this educational need. Existing efforts will be reviewed and their drawbacks will be discussed. Finally we will present our proposed solutions that address different learning styles. We will also discuss how the proposed solutions enhance students’ active learning and engagement.

14. Kathleen Hill

“Identifying shifts in pedagogical content knowledge (PCK): Outcomes of a “Scientific Teaching” course for biology graduate teaching assistants at a large research university”

Kathleen Hill, Arizona State University

In the fall of 2011, the School of Life Sciences (SoLS) at Arizona State University launched an “Innovative TA” program in an effort to support preparing future biology faculty in effective undergraduate science teaching. The program was designed such that selected biology graduate students were provided with opportunities to design and implement curriculum that makes use of innovative teaching strategies. During the spring of 2012, “Innovative TAs” participated in a semester-long course designed to provide opportunities for graduate TAs explore effective teaching strategies. The initial course offering was considered as a pilot study leading to a larger research project to be conducted in the following academic year. Evidence provided in TA responses and work products during the pilot study supports a positive shift in the graduate students’ pedagogical knowledge. Future plans for the TA training include maintaining a similar course design while integrating the use of technology and supporting the implementation of effective teaching strategies within different contexts. A mixed-methods study will be conducted during the 2012-2013 academic year with data collection designed to document and explore changes in PCK among graduate biology TAs following the training program.
15. Peter Holden

“Combating ‘One and Done’: Maximizing the Impact of an Undergraduate Science Course”

Peter Holden, University of Massachusetts Boston

A significant number of undergraduate students not majoring in science limit their college science exposure to one course due to negative feelings and anxieties about science. This decision is often reinforced by programmatic constraints and overloaded general education requirements that squeeze science from the curriculum. When the students in question aspire to careers in education, this ‘one and done’ phenomenon is particularly problematic. To address the situation as manifest at Wheelock College, I created and taught an inquiry-based, earth science-themed course for undergraduate students with the goal of efficiently addressing fundamental aspects of science, student attitudes and student learning. The overarching learning goals of the course include:

- Reducing anxieties and negative attitudes about science.
- Assimilation of science content knowledge.
- Improving student understanding of the nature and process of science.
- Facilitating student understanding of connections between science and other forms of inquiry.
- Developing metacognitive awareness and functioning among students.

The pedagogical approach incorporates many reform based practices that have become commonly known (though not uniformly practiced) in recent decades as well as more innovative methodologies such as explicit teaching of behavioral characteristics of creative and expert thinkers. The latter is employed to achieve multiple learning goals but, in particular, to promote use of metacognitive strategies among students. Students conduct, and participate in, investigations of different sizes and time scales throughout the course in constructivist frameworks. A study of a local river system encompasses the entire semester and is predicated on students’ simple, initial questions; while smaller scale investigations focus on constructing understanding of specific concepts. Concurrently, students are prompted to read, discuss and debate ‘thinking’ tools such as abstraction, observation, analogy, and deliberate practice as manifest in science and other fields of inquiry. The results, as suggested by pre- and post-survey results suggest that, on average, there is a positive change in students’ science outlook and assimilation of knowledge. However, positive results are sometimes associated with individual student ‘epiphanies’ that influence the results distribution such that other students appear to be less significantly influenced.

16. Gail Horowitz

“Improving Student Outcomes in Organic Chemistry Through Action Research”

Gail Horowitz, Laura A. Rabin, Brooklyn College of the City University of New York

Action research conducted in an Organic Chemistry classroom at a large, urban, public university has demonstrated that encouraging academic help seeking behavior (a type of self-
regulated learning) improves student outcomes especially for students who enter the course with weaker Chemistry backgrounds. Implications for other science courses and for similar student populations (first generation to attend college) will be discussed.

17. Hosi Karzai

“IMPACT’s Role in Improving undergraduate STEM Education at Purdue University”

H. Karsai, D. Attaro, C. Bristol, J. Campbell, T. Doan, F. Dooley, M. Latour, G. Weaver, C. Weil, D. Whittaker, R. Lindell, Purdue University

IMPACT, Instruction Matters: Purdue Academic Course Transformation, is a Provost-led initiative at Purdue University designed to fund research-based course redesign throughout the university. Unlike other university transformation projects that focus on individual courses or departments, Purdue’s initiative focuses on transforming courses across the campus. The goals of the Purdue IMPACT program are to 1) Focus the campus culture on student-centered pedagogy and student successes; 2) Enable faculty-led course redesign with campus-wide resources; 3) Network faculty through Faculty Learning Communities; 4) Base course redesign on best practices and sound research; 5) Grow and sustain IMPACT by adding new IMPACT faculty fellows annually and 6) Assess and disseminate results to benefit future courses and students. To accomplish these goals, cohorts of faculty have been recruited to participate in weekly workshops and to work in a partnership with a development team to transform their courses. To date, two cohorts of faculty have completed this process. Of the 30 courses currently undergoing transformation, 20 have been in STEM fields. In this talk I will give an overview of the IMPACT process and discuss how this innovative program has helped transform several of Purdue’s large enrollment STEM courses.

18. Corinne H. Lardy and Cheryl Mason

“Impact of reformed courses on the science teaching self-efficacy beliefs of preservice and inservice elementary teachers”

Corinne H. Lardy, Cheryl Mason, San Diego State University

The purpose of this study is to examine the impact of reformed undergraduate science courses developed through NASA Opportunities for Visionary Academics (NOVA) on preservice and inservice elementary teachers’ science teaching self-efficacy beliefs. In addition, this study examines subsequent relationships among participating inservice elementary teachers’ science teaching self-efficacy beliefs, beliefs about their own and ideal science teaching practices, and observed science teaching practices. Eighty-five elementary teachers, 38 university faculty, and 190 undergraduate students from across the United States participated in this study. Data were collected during intensive on-site visits using the Reformed Teacher Observation Protocol (RTOP), semi-structured interviews, and the Science Teaching Efficacy Beliefs Instrument (STEBI-A). From the data set, eight case studies of inservice elementary teachers were
examined in closer detail. Results indicate that participants’ levels of science teaching self-efficacy beliefs were both positively and negatively impacted by the reformed courses. Participants reported that they gained more confidence in their ability to teach science effectively from courses that (a) explicitly connected the science content to the teaching of that content, (b) gave students opportunities to teach the content to others, and (c) sparked students’ interest in the content. Reformed courses may have influenced some individuals to have lower levels of self-efficacy by making them realize how much they do not know about science teaching. A clear relationship was not evident between science teaching self-efficacy and reformed science teaching; teachers with high STEBI scores were just as likely to be observed teaching in a reformed manner as teachers with low levels of self-efficacy. However, interviews and observations revealed additional possible relationships between self-efficacy and teaching and how levels of efficacy beliefs manifested themselves in different ways with different teachers. This study demonstrates the importance of using qualitative data to support quantitative data when studying self-efficacy beliefs of teachers and mechanisms for increasing efficacy.

19. Rebecca Lindell

“A Research-Based Transformation of Purdue’s Modern Mechanics Course”

Rebecca Lindell, John Doyle, Max Kagan, Jordan Steckloff, Adam Szewciw, Mark Haugen Andrew Hirsch, Purdue University

Purdue’s introductory calculus-based physics course, Modern Mechanics, utilizes the Matter and Interaction curriculum by Chabay and Sherwood. Incorporating the results of modern physics, this text presents an alternative approach to presenting the physics content, specifically utilizing a few fundamental principles to explain modern mechanics. In addition, students learn how to visualize physics using computational modeling. We have spent the last year researching ways to transform how we teach this course by utilizing many of the approaches developed by Physics Education Research (PER) and other education researchers. Specific interest was spent on how to make this course more interactive and integrated. In this talk we will present the learning theory behind our research-based model for this transformed course as well as examples of the materials we have developed/adapted for use with this talk. In addition, we will present our solutions to the four key issues that must be addressed by any transformed course: Development, Implementation, Evaluation and Sustainability.

20. Mojgan Haghanikar

“Students’ Reasoning and the Level of Interactivity in Science Content Courses”

Dean A. Zollman, Kansas State University, Mojgan Matloob-Haghanikar, Winona State University Sytil Murphy, Shepherd University

As part of a study of the NSEUS national study, we investigated the quality of students’ reasoning and explored the relationship between sophistication of reasoning and the degree to which the courses were measured to be interactive. First, we devised written content exam
questions, which were open ended and required students to apply recently learned concepts in a new context. All the questions developed were based on a common template that required students to recognize and generalize the relevant facts or concepts and apply them. To evaluate students’ answers, we developed a rubric based on Bloom’s taxonomy as revised and expanded by Anderson et al. Along with analyzing students’ reasoning, we visited 20 universities, observed the courses and used the RTOP to determine their level of interactivity. Statistical analyses indicate some relationship between the students’ reasoning on the exams and the level of interaction in the class.

*Keywords*: interactivity, reasoning, pre-service.

21. Micheal Odell

“Alignment of High School and College STEM Curricula”

Michael Odell, University of Texas at Tyler

Vertical alignment of high school and college STEM curricula is a promising practice to improve student success in the STEM pipeline. The Surveys of Enacted Curriculum (SEC) are a practical, reliable set of data collection tools being used with educators to collect and report consistent data on instructional practices and content being taught. Instructors complete the survey questions though an online system. Upon completion, group data are reported in user-friendly charts and graphs to facilitate analysis of differences across classrooms, schools, or districts. The SEC and resulting data provide an objective method to analyze the degree of alignment between instruction, content standards, and assessments. The surveys include items on school and class characteristics, teacher preparation, and demographics to facilitate comparison of results. In order to utilize the survey the standards must be coded by a team of trained faculty and P-12 educators. With the adoption of the College and Career Readiness Standards (CCRS) and the science TEKS there was an opportunity to code both sets of standards and provide a research-based tool to go beyond simply becoming familiar with the CCRS, but actually examine how well what we teach and the courses/materials we deliver align to the CCRS. The SEC can be used to examine the curriculum to predict student achievement gains, control for content to examine other factors such as instructional strategies, can serve as an outcome measure for change over time, and most importantly examine alignment of standards and assessments.

A team of discipline, education and P-12 faculty was convened to code the Science CCRS and new TEKS. Our goal was to provide a content analysis of the CCRS standards using a two-dimensional taxonomy for describing subject matter content. The data collected were summarized into content maps and graphs that were used to highlight the relative emphasis of academic content embedded in these curricula related documents. The resulting content maps and graphs permit graphic comparisons of instructor reports of instructional content with locally relevant assessment instruments and the standards. Content analysis also served to support alignment analyses into the relationships between instruction, assessment and standards. Results were used to support the information needs of science teacher preparation programs, districts and schools, and were also used in analyses associated with several studies being conducted by the Ingenuity Center at UT-Tyler. Once completed faculty from teacher preparation programs and school districts were able to use the resulting tools to analyze curriculum for alignment with the
CCRS as well as the TEKS. Once coded faculty and teachers can go to the SEC online website and enter their data and receive a printout that examines what they teach and how they teach in regards to the standards. Eventually we will be able to Survey Texas college faculty in key entry-level courses to determine what is actually being taught and expected as well as survey Texas High School Teachers in advanced high school level courses (Not AP) to determine what is actually being taught and expected. This will allow teacher preparation programs to compare the TEKS to the CCRS (identify duplication, gaps, and recommend modifications) and identify and compare instructional practices in high school and college.

22. Michael Odell

“Brief Overview of the NASA/NOVA Faculty Professional Development Program – 1995-2006”

Michael Odell, University of Texas at Tyler

NASA Opportunities for Visionary Academics (NASA/NOVA) was a university STEM faculty professional development program initiated by NASA in 1995. The multifaceted NASA/NOVA program was designed to foster reform in higher education through development and modification of entry-level, undergraduate STEM discipline courses. NOVAs goal was to facilitate course change to enhance STEM literacy of pre-service teachers. Faculty at a total of 103 US colleges and universities were deeply involved in the program over an 12 year period.

23. Maya Patel

“Learning Inquiry and Nature of Science through Undergraduate Research: Mentoring Matters”

Maya Patel, Ithaca College

Undergraduate research experiences (UREs) have the potential to involve students in authentic, cutting-edge scientific inquiry. While research has shown that UREs can be effective in recruiting and retaining students and increasing students’ confidence to do research, the literature on science-learning through undergraduate research is scant. My research investigated what students learned about the practice of scientific inquiry and the natures of scientific knowledge (NOS) and inquiry (NOSI) through participation in summer UREs in cutting edge biotechnology laboratories. I also explored the types of research projects and intern-mentor transactions taking place in the UREs to explain students’ learning outcomes. I employed a mixed-methods approach involving a pre-post assessment of gains and an exploratory investigation of the laboratory research situations. In general, interns’ independent practice of inquiry was of the most basic skills, though their guided practice included many of the more advanced inquiry skills important in developing scientific thinking. While few interns made gains in understandings about NOS, many made gains in understandings about NOSI. NOSI gains were associated with greater autonomy and independent practice of advanced inquiry skills. The exploratory investigation found that mentors played a critical role in determining the type of research project and in driving the intern-mentor transaction. These in turn, contributed to intern’s learning
outcomes. For example, multifaceted research projects (both observational and hypothesis-driven) provided more opportunities to practice advanced aspects of inquiry. Interns engaged in more indeterminate projects, where methods were less prescribed and outcomes less predictable, generally made greater gains in understandings about NOSI.

24. Erika Steele

“The Impact of Science Education Reform on Students’ Perceptions of the Learning Environment”

Erika Steele, University of Alabama

Research has shown that the learning environment has an impact on the approach that students use to learn the course content (Diseth, Pallesen, Brunborg, & Larsen, 2009; Biggs, 2001; Trigwell & Prosser, 1991). When examining the impact of reformed science teaching at the undergraduate level, the question of how students perceive their learning environment arises. The current study of a small national and diverse sample investigated the learning environment existing in undergraduate entry level science courses with various levels of implemented reform. Results identified significant relationships between courses the level of reform implemented in the course and student perception of the learning environment. The level of reform found in the courses was found to vary along a continuum from reformed to traditional instructor orientation and this context significantly affected student perceptions of the learning environment. It was determined that, in order for students to perceive their learning environment as being different, an instructor would have to implement a significantly high level of reform. Qualitative and quantitative analyses revealed that the level of reform implemented in the classroom had a significant effect on how students felt about the control of their learning in the classroom and their abilities to share their ideas with others in the classroom. The abilities to be in control of how they learn course content and share their ideas with others may be important to help students develop a deeper understanding of the course content.

25. Dennis Sunal

“National Study of Education in Undergraduate Science: 2006-2012 – What Was Learned”

Dennis Sunal, Cynthia Sunal, Donna Turner, Erika M. Steele, The University of Alabama; Cheryl L. Mason, Corrinne Lardy, San Diego State University; Dean Zollman, Kansas State University; Mojgan Matloob-Haghanikar, Winona State University; Sytil Murphy; Shephard University

The National Study of Education in Undergraduate Science (NSEUS) was a multi-year, NSF supported research project focused on critical needs in teaching undergraduate science to diverse majors with an emphasis on preparation and long-term development of pre-service K-6 teachers of science. The research question guiding the project was “How do undergraduate entry-level science courses, differing in level of reform, affect student learning outcomes?” The impact of undergraduate standards-based, reformed science courses, as compared to traditional
coursework, was the focus. The entry-level courses were analyzed in a professional development impact design model involving a national sample of reformed and comparison undergraduate science courses from a national population of 103 diverse universities. Quantitative and qualitative data were analyzed using comparative and relational studies of the research design model. The NSEUS study answered these questions:

- What is an effective reform course?
- What elements are effective in science course reform?
- What is inquiry teaching at the undergraduate level?
- How many reform elements do you have to implement at the undergraduate level to show better than average achievement gain? What PCK is needed for faculty to be effective in undergraduate classes?
- What quality of reform element application is needed at the undergraduate level to show better than average achievement gain?

Conclusions relate to: short-term impacts on undergraduate majors in general and long-term effects on matriculated in-service teachers of science and identification of characteristics of faculty instructors and courses producing significant impacts.

26. Josephine Taylor

“Cooking From Scratch: Development of Inquiry Based Activities for the General Microbiology Laboratory”

Josephine Taylor, Stephen C. Wagner, and Sarah Canterberry, Stephen F. Austin State University

Undergraduate students rarely gain direct exposure to vital tools used in microbiology. This paper reports on a series of laboratory exercises developed to engage general microbiology students in hands-on, investigative activities involving research techniques. After training on brightfield microscopes, the class met in the electron microscopy center where they learned about preparing specimens for viewing and how to operate both scanning and transmission electron microscopes. The students then worked in teams to interpret electron micrographs of bacteria and fungi. Pre/post testing revealed that all 17 students improved in their level of knowledge as a result of the activity. The mean test score rose from 44% to 70%; the range of improvement was from 10 – 36%, with a mean value of 26%. In a lab on bacterial transformation, students focused on the work of Lydia Villa-Komaroff, a pioneering Hispanic biotechnologist. In 1978 she was the first to transform bacteria to produce human insulin. Students used procedures similar to those developed by Villa-Komaroff and her colleagues to transform *Escherichia coli* to express Green Fluorescent Protein. Student pre- and post-test data for this approach are currently being analyzed and will be reported in this paper. Our results indicate that the time it took to develop and conduct these “cooking from scratch” activities was well spent. Students were effectively engaged through active learning, improved in their content knowledge, and gained appreciation for the research techniques. In the future we plan to expand the number of laboratory exercises where we employ this type of approach.
This study explored the long-term impact of a ten year professional development project geared towards science education reform on the pedagogical content knowledge of university faculty that participated in this project. On-site case studies were completed with 35 faculty instructors teaching entry-level undergraduate science courses at 19 higher education institutions. The sample was selected from a national population of diverse colleges and universities that had undergone reform in one or more of their undergraduate science courses. The data collection protocol involved classroom observations, interviews, semi-structured interviews, and field notes from multiple instruments and sources. Data were collected during on-site visits from university faculty instructors and their undergraduate students. Quantitative and qualitative analysis identified variations in faculty instructors’ PCK regarding their intended and enacted teaching goals, instruction, and rationale for teaching a specific science concept in observed science lessons. Analysis of quantitative and qualitative data revealed significant pedagogical differences between faculty who participated in the NASA/NOVA professional development project and those who did not. Moreover, the following characteristics regarding the pedagogical content knowledge of faculty instructors who participated in the NASA/NOVA project emerged: (1) content knowledge regarding the science concept taught and observed during instruction; (2) orientations consistent with reform instruction advocated by the National Science Education Standards for effective science teaching; (3) purposeful selection of activities that best engender student understanding of specific science concepts; and (4) reflective practitioner.