2012 National Summer Conference

Integrating STEM Education Research into Teaching: Knowledge of Student Thinking

June 20 to 22, 2012 · The University of Maine · Orono, Maine

Hosted by the Maine Center for Research in STEM Education
and The Jackson Laboratory

http://umaine.edu/center/2012-summer-conference

Program Contents

Wednesday, June 20, 2012
8:45 AM to 9:45 AM
Wells Conference Center

Keynote Speaker – Karen King
Director of Research
National Council of Teachers of Mathematics

Keynote: The Mathematical Education of Teachers: The Role of Disciplinary Grounding in Mathematics Education

Recent research in the mathematical demands of the work of elementary mathematics teaching has revolutionized the perspective on the mathematics these teachers need as part of their preparation and led to the creation of valid and reliable measures of this mathematical knowledge linked to student achievement. However, attempts to generalize this work to secondary mathematics teachers and teaching has been less fruitful. In this talk, I discuss the recent focus in K-12 mathematics education on the Standards for Mathematical Practice in the Common Core State Standards in Mathematics and the need for teachers and students to be grounded in the reasoning habits of mathematics to ensure opportunities for future students to learn mathematics at the highest levels. Drawing upon research and stories of future high school teachers and current middle and high school students, as well as recent recommendations from CBMS and accreditation standards, I discuss the ways in which current frameworks for mathematical knowledge for teaching may not fully capture these ways of knowing or habits of mind. I conclude with considerations for mathematicians and mathematics educators for discussing the important role of mathematics in secondary mathematics teacher education.

Karen King Bio

Karen D. King, Ph.D. is the Director of Research for the National Council of Teachers of Mathematics located in Reston, Virginia, the largest professional association of mathematics teachers in the world, serving the US and Canada. She recently transitioned from a position as associate professor of mathematics education at New York University's Steinhardt School of Culture, Education, and Human Development. Previously she served as a program director at the National Science Foundation (NSF) in the former Division of Elementary, Secondary, and Informal Education where she managed projects primarily in the Teacher Professional Continuum Program. She also oversaw curriculum projects in Instructional Materials Development and policy for the Education and Human Resources Directorate. She has worked as a professor of mathematics education at San Diego State University and Michigan State University.

Dr. King's current research focuses on urban mathematics reform, the mathematics preparation of elementary and secondary teachers, and the policies of mathematics teacher professional development. She has been the principal investigator or co-principal investigator of National Science Foundation funded grants totaling over $2,000,000 over the span of her career and published numerous articles, book chapters, and a recently co-edited book titled *Disrupting Tradition: Research and Practice Pathways in Mathematics Education* with William Tate, IV and Celia Rousseau Anderson. She also serves as part of the writing team for the revision of *The Mathematical Education of Teachers*, which describes the mathematics teachers need to know and be able to do to be successful in light of the Common Core State Standards in Mathematics.

Dr. King has served as associate editor of the *Journal for Research in Mathematics Education* and was a member of the RAND Mathematics Study Panel, which made recommendations to the U.S. Department of Education about future research funding in mathematics education. She received a BS in mathematics from Spelman College and a Ph.D. in mathematics education from the University of Maryland, where she conducted research on mathematics teacher thinking. She also serves on numerous committees focusing on research in mathematics education and teacher education with national organizations, including the Association of Mathematics Post-secondary teacher educators, the Benjamin Banneker Association, and the National Board for Professional Teaching Standards.

Wednesday, June 20, 2012
7:00 PM to 8:00 PM
Wells Conference Center

Keynote Speaker – Marianne Wiser
Associate Professor and Chair, Hiatt School of Psychology
Department of Psychology, Clark University

Keynote: What is Different about a Learning Progression Approach to Standards and Curriculum Development? Affordances and Challenges

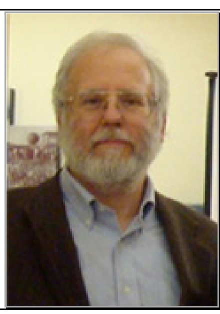
Learning progressions can provide strong coherence to new standards and curricula. Learning progressions focus on core ideas (e.g., matter, energy). They represent how students' thinking could develop coherently and meaningfully (given appropriate instruction) over an extended period of time (from early childhood to high school and beyond). Learning progressions are informed by conceptual development research as well as scientific theories. They specify intermediary learning targets--stepping stones. Each stepping stone is conceptually closer to the scientific theory than the previous while giving students the resources to progress toward the next one. I will use learning progressions for energy and matter to illustrate the nature of learning progressions, what they afford to science education, and the challenges they pose.

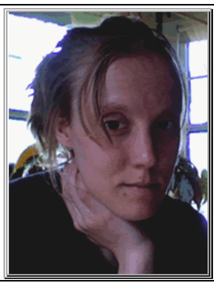
Marianne Wiser Bio

Marianne Wiser received a Bachelor's Degree in Oceanography from the University of Leige, Belgium in 1973 and a Ph.D. from Massachusetts Institute of Technology in 1981. She has been at Clark University since that time.

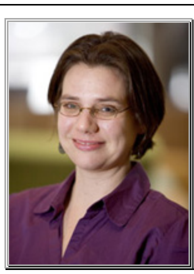
Dr. Wiser is studying conceptual change in children, students, and the history of science. Her main topics of research are symbolic development and science learning. Current projects focus on the development of numerical knowledge and number notation in young children; the development of young children's understanding of the nature and function of printed words (pre-reading skills) and how they come to understand the alphabetic nature of our writing system; young children's ability to use models and maps; and young children's conception of matter, weight, and materials. Another topic of research is teaching and learning physics in high school, with special emphasis on microgenetic processes, mental models, parallels with history of science, and the integration of situated cognition approaches with theories of mental representations.

Speakers, Panelists and Workshop Facilitators

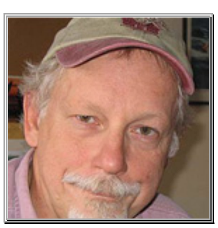
	Erika Allison Project Director, Maine Physical Sciences Partnership University of Maine Orono, ME *Workshop Facilitator*: **Stop Sneering at Engineering: Strategies for Exciting & Engaging Your Students**
	Sharon Barker Director, Women's Resource Center University of Maine Orono, ME *Moderator*: **Strategies to Build Participation in STEM**
	Anita Bernhardt Science & Technology Specialist State of Maine Department of Education Augusta, ME *Invited Speaker*: **Science Leadership - What the Framework and Next Generation Science Standards will Demand (K-12)** *Workshop Facilitator:* **Crosscutting Concepts in the Next Generation Science Standards (K-12)**
	Beth Bisson Assistant Director for Outreach and Education Maine Sea Grant Orono, ME *Panelist*: **Community Projects and Involvement in STEM Education**
	Mitchell Bruce Associate Professor, Department of Chemistry and RiSE Center University of Maine Orono, ME *Contributed Talk*: **Using Lab-Based Analogies for Meaningful Understanding**
	Chris Cash Director of Student Assistance Programs Institute for Broadening Participation Damariscotta, ME *Panelist*: **Strategies to Build Participation in STEM**

	Shelley Chasse-Johndro Associate Director, Project Opportunity & Project Reach University of Maine Diversity Leadership Institute Orono, ME *Panelist*: **Strategies to Build Participation in STEM**
	Timothy Conner Lecturer, Geology Department SUNY Cortland Cortland, NY *Invited Speaker*: **De-Criminalizing High Stakes Exams, through Effective Teaching, using Project-Based Learning Modules** *Workshop Facilitator*: **A Place-Based Project-Based Learning Unit for Rural Schools – School Yard Project-Based Learning Modules**
	Allison Dorko Master of Science in Teaching Graduate, RiSE Center University of Maine Orono, ME *Contributed Talk*: **Calculus Students' Understanding of Area and Volume in Non-Calculus Contexts**
	Grace Eason Associate Professor of Science and Science Education University of Maine – Farmington Farmington, ME *Invited Speaker*: **Service Learning in an Undergraduate Introductory Environmental Science Course: Getting Students Involved with the Community**
	Eugenia Etkina Professor of Science Education and Chair, Department of Learning and Teaching Graduate School of Education, Rutgers, The State University of New Jersey New Brunswick, NJ *Invited Speaker*: **Physics Pedagogical Content Knowledge** *Workshop Facilitator*: **Helping Your Students Learn Physics and Think Like Scientists**
	Wilhelm Alexander Friess Associate Professor of Mechanical Engineering Education and Director of Brunswick Engineering Program and Discovery Center University of Maine Orono, ME *Invited Speaker*: **US Engineering Education in the Middle East: First Year Challenges**

	David Harmon Senior Engineer, IBM Systems and Technology Burlington, VT *Contributed Talk*: **The Battle of the Electric Marimba Bands – A Pilot Project-Based STEAM Program** *Workshop Facilitator*: **Low-Cost Electronics for STEM Education**
	Andrew Heckler Associate Professor, Ohio State University Columbus, OH *Invited Speaker*: **Which is Better: Fast and "Thoughtless", or Slow and Reasoned?** *Workshop Facilitator*: **A Method for Constructing Good Questions for Use in Class, Homework and Tests: The Dissection of a Scientific Concept into its Relevant and Irrelevant Dimensions**
	Benedikt Harrer Ph.D. candidate, Department of Physics and Astronomy University of Maine Orono, ME *Contributed Talk*: **Student-Teacher Interactions for Bringing out Student Ideas About Energy**
	Kelly Ilseman Program Coordinator, Upward Bound Programs University of Maine Orono, ME *Panelist*: **Strategies to Build Participation in STEM**
	Wendy Johnson Biology Teacher, Lansing Catholic High School Lansing, MI *Invited Speaker*: **The Impact of Avida-ED Digital Evolution Software on Student Understanding of Natural Selection** *Workshop Facilitator*: **Experimenting with Natural Selection in the Classroom using Avida-ED Software**
	Kim Kastens Co-Director, Lamont-Doherty Earth Observatory and the Department of Earth & Environmental Sciences Columbia University New York City, NY *Invited Speaker*: **Spatial Thinking in High School Earth Science** *Workshop*: **Fostering Spatial Thinking in High School Earth & Space Science Students**

	Ruth Kermish-Allen Education Director Island Institute Rockland, ME *Invited Speaker*: **Connecting Community with STEM Education**
	Karen King Director of Research National Council of Teachers of Mathematics *Keynote Address*: **The Mathematical Education of Teachers: The Role of Disciplinary Grounding in Mathematics Education** *Workshop Facilitator*: **Looking for and Expressing Regularity in Repeated Reasoning: Math Magic Tricks as an Entry to Algebra**
	Amy Lark Specialist Faculty and Doctoral Student, Science Education College of Education, Michigan State University East Lansing, MI *Invited Speaker*: **The Impact of Avida-ED Digital Evolution Software on Student Understanding of Student Understanding of Natural Selection** *Workshop Facilitator*: **Experimenting with Natural Selection in the Classroom using Avida-ED Software**
	Laura Millay Master of Science in Teaching Student RiSE Center, University of Maine Orono, ME *Contributed Talk*: **Knowledge for Assessment (K4A): How Do Teachers Use Knowledge When They Design Written Assessments for their Classrooms and Interpret Students' Responses?**
	Sarah Nelson Assistant Research Professor Senator George J. Mitchell Center and Maine's Sustainability Solutions Initiative University of Maine Orono, Maine *Panelist*: **Community Projects and Involvement in STEM Education**
	Rebecca Price Assistant Professor, School of Interdisciplinary Arts & Sciences University of Washington Bothell, WA *Invited Speaker*: **Good Question! Using Students' Prior Knowledge to Teach Evolution**

	Dawn Rickey Associate Professor, Department of Chemistry Colorado State University Ft. Collins, CO *Invited Speaker*: **Enhancing the Effectiveness of Chemistry Lectures through the Use of Guided-Discovery Activities** *Workshop Facilitator*: **Designing and Implementing Guided-Discovery Activities to Enhance Students' Understanding**
	Richard St.-Pierre Senior Senior Electrical Engineer – Education Outreach IBM Systems and Technology, Burlington, VT *Contributed Talk*: **The Battle of the Electric Marimba Bands – A Pilot Project-Based STEAM Program** *Workshop Facilitator*: **Low-Cost Electronics for STEM Education**
	Lisa Schultz Master of Science in Teaching Graduate and 9th Grade Science Teacher Old Town High School Old Town, ME *Contributed Talk*: **Using a NetLogo Model to Understand the Greenhouse Effect**
	Hannah Sevian Associate Professor of Department of Curriculum and Instruction, and Associate Director of the Center for Science and Mathematics in Context (COSMIC) University of Massachusetts, Boston, MA *Invited Speaker*: **Refinement of a Learning Progression about Structure of Matter** *Workshop Facilitator*: **Using a Learning Progression Framework to Investigate Thinking about Benefits, Costs and Risks in Chemical Design**
	Jonathan Shemwell Assistant Professor, Science Education and RiSE Center, Cooperating Assistant Professor of Physics College of Education and Human Development, University of Maine Orono, ME *Invited Speaker*: **On the Ground with the Next Generation Science Standards: How Teachers Grapple with the Re-Prioritization**
	Dan Shepardson Departments of Curriculum and Instruction and Earth and Atmospheric Sciences Purdue University West Lafayette, IN *Invited Speaker*: **Students' Conceptions of the Greenhouse Effect, Global Warming, Climate Change, and the Earth's Climate System** *Workshop Facilitator*: **Teaching and Learning about the Earth's Changing Climate System**

	Michael Steele Department of Teacher Education Michigan State University East Lansing, MI *Invited Speaker*: **Shaping the Mathematical Storyline: Leveraging Student Thinking through Rich Classroom Discussions** *Workshop Facilitator*: **Creating the Mathematical Storyline and Planning for Rich Discourse**
	MacKenzie Stetzer Assistant Professor, Department of Physics and Astronomy and RiSE Center University of Maine Orono, ME *Workshop Facilitator*: **Using Free-Response Questions to Probe Student Thinking**
	Marianne Wiser Associate Professor and Chair, Hiatt School of Psychology Department of Psychology, Clark University Worcester, MA *Keynote Address*: **What Is Different About a Learning Progression Approach to Standards and Curriculum Development: Affordances and Challenges** *Invited Speaker*: **How Elementary Curricula on Matter and Energy Based on Learning Progressions Can Prepare Students to Learn Science Effectively in Middle School** *Workshop Facilitator*: **Designing Learning Progressions and Translating Them Into Curricula**
	Michael C. Wittmann Associate Professor, Department of Physics and Astronomy and RiSE Center, and Cooperating Associate Professor, College of Education and Human Development University of Maine Orono, ME *Contributed Speaker*: **New Ways of Investigating the Canonical Ball Toss Problem**
	Bill Zoellick Director of Education Research and Chief Financial Officer Schoodic Education and Research Center (SERC) Institute Winter Harbor, ME *Contributed Speaker:* **Who Do You Turn To? How Teachers Support Each Other in the Maine Physical Sciences Partnership Project** *Workshop Panel Moderator*: **Community Projects and Involvement in STEM Education**

Schedule-at-a-Glance

Wednesday, June 20, 2012 – Wells Pre-Function Area, and Rms 1&2

Time	Event	Location
7:30 AM – 9:00 AM	Registration and Continental Breakfast	Wells (Pre-Function Area)
8:30 – 8:45 AM	**Welcoming Remarks**	Wells (Room 1)
8:45 – 9:45 AM	**Opening Keynote – Karen King**	Wells (Room 1)
9:50– 10:50PM Sessions 1 & 2	**Session 1:** ***Teacher Knowledge of Student Ideas in Physical Science***	Wells (Room 1)
	Session 2: ***Community Connections in STEM Education***	Wells (Room 2)
10:50 – 11:00 AM	Break	Wells (Pre-function Area)
11:00 AM – 12:00 PM Sessions 3 & 4	**Session 3:** ***Teaching Energy in K-12***	Wells (Room 1)
	Session 4: ***STEM-Related Project-Based Learning***	Wells (Room 2)
12:00 – 1:30 PM	**LUNCH**	Memorial Union Marketplace
1:30 – 3:30 PM	**Workshops (1-9 concurrent)**	(see page 16)
3:30 – 4:30 PM	Poster Session Set-Up	Wells Room 2
4:30 PM – 6:00 PM	**Poster Session and Reception** (Hors d'oeuvres & Cash Bar)	Wells Rooms 2
6:00 PM – 7:00 PM	Dinner Banquet	Wells (Room 1 & 2)
7:00 PM – 8:00 PM	**Keynote – Marianne Wiser**	Wells (Room 1 & 2)

Thursday, June 21, 2012 – Donald P. Corbett Business Building (DPC)

Time	Event	Location
7:45 – 10:30 AM	Registration, Information Table and Continental Breakfast	DP Corbett Atrium
8:30 – 10:30 PM Sessions 5 & 6	**Session 5:** ***Teaching and Learning in Chemistry and Engineering***	DP Corbett 107
	Session 6: ***Strengthening STEM Education: Broadening Participation, and Next Generation Science Standards***	DP Corbett 115
10:30 – 10:45 AM	15 minute Break	DP Corbett Atrium
10:45 AM – 12:25 PM Sessions 7 & 8	**Session 7:** ***Earth Science and Climate Change***	DP Corbett 107
	Session 8: ***Project-Based Learning and Student Thinking in STEM***	DP Corbett 115
12:25– 1:45 PM	**Lunch on your Own**	Memorial Union Marketplace
1:45 – 3:45PM	**Workshops (10-17 concurrent)**	(See page 17)
4:00 – 7:00 PM	Break and Dinner on your own	
7:00 – 9:30 PM	**Challenger Mission**	Challenger Center
	Gathering place on campus	Great Rooms in Doris Twitchell Allen Village

Friday, June 22, 2012 – Donald P. Corbett Business Building (DPC)

Time	Event	Location
7:45 AM – 10:30 AM	Information Table & Continental Breakfast	DP Corbett Atrium
8:40 AM – 10:00 AM Sessions 9 & 10	**Session 9: Teaching and Learning Evolution**	DP Corbett 107
	Session 10: Teaching and Learning Physics and Mathematics	DP Corbett 115
10:00 – 10:15 AM	Break	
10:15 AM – 12:00 PM	Start of Open Space Session	DP Corbett 100
	Open Space Break-Out Conversations	DP Corbett 100, 105, 107, 109, 111, 113 and 115
	Open Space Reports and Conference Wrap-Up	DP Corbett 100
	EVALUATIONS	DP Corbett 100
12:00 PM	**LUNCH**	Memorial Union Marketplace

Open Space Session

Susan R. McKay, Professor of Physics
and Director, Maine Center for Research in STEM Education (RiSE Center)
Natasha Speer, Assistant Professor of Mathematics Education and RiSE Center
University of Maine

Question: How can we use what we have learned at this conference to collaborate to improve STEM education?

This session is designed for participants to seize the moment; to begin a conversation that combines imagination and practicality, and that leads to unique ideas to answer the question.

Open Space Session is simple, self-directed, and focused. Participants create the agendas for simultaneous small-group meetings. After all the sessions are completed, we will gather for a follow-up discussion.

As the first step, some participants decide to present ideas for which they have a passion and are willing to take responsibility for convening a conversation. Conveners will ask someone in the group to write a summary of the key points to be shared with the larger group.

The Law of Two Feet:

If participants are not learning or contributing they must use their two feet to join another discussion; all are responsible for their participation. Open Space Session works if people care about the issue, the issue is complex, there is a sense of urgency, and people represent diverse points of view.

We hope the OSS session will lead to:

1. *High learning.* Participants change how they think, enabling them to create new ideas and linkages.
2. *High play.* A convivial, open atmosphere is developed where participants can question dogma.
3. *Formation of a genuine community.* Participants develop deeper bonds with their peers and expand their networks by talking with people they don’t know but who share their passion.
4. *Tangible output.* Participants generate worthwhile ideas (as measured by group consensus), express them clearly in reports, and create plans to move these ideas forward.

Detailed Presentation Schedule

Wednesday, June 20th · Morning Sessions Overview

Session Title	Teacher Knowledge of Student Ideas in Physical Science (S1)	Community Connections in STEM Education (S2)
Session Chairs	*MacKenzie Stetzer*	*Erik DaSilva*
Location	**Wells Room 1**	**Wells Room 2**
9:45-10:25 am	**Physics Pedagogical Content Knowledge (S1-1)** *Eugenia Etkina*	**Connecting Community with STEM Education (S2-1)** *Ruth Kermish-Allen*
10:25-10:45 am	**Knowledge for Assessment (K4A): How Do Teachers Use Knowledge When They Design Written Assessments for their Classrooms and Interpret Students' Responses? (S1-2)** *Laura Millay*	**Who Do You Turn To? How Teachers Support Each Other in the Maine Physical Sciences Partnership Project (S2-2)** *Bill Zoellick*
10:45-11:00 am	**Break**	
	Teaching Energy in K-12 (S3)	**STEM-related Project-based Learning (S4)**
Session Chairs	*Jonathan Shemwell*	*Daniel Capps*
11:00-11:40 am	**How Elementary Curricula on Matter and Energy Based on Learning Progressions can Prepare Students to Learn Science Effectively in Middle School (S3-1)** *Marianne Wiser*	**Service Learning in an Undergraduate Introductory Environmental Science Course: Getting Students Involved with the Community (S4-1)** *Grace Eason*
11:40am -12:00pm	**Student-Teacher Interactions for Bringing Out Student Ideas About Energy (S3-2)** *Benedikt Harrer*	**The Battle of the Electric Marimba Bands – A Pilot Project-Based STEAM Project (S4-2)** *Dave Harmon and Richard St. Pierre*
12:00-1:30 pm	**Lunch at Memorial Union Marketplace**	

Thursday, June 21st · Morning Sessions Overview

Session Title	**Teaching and Learning Chemistry and Engineering (S5)**	**Strengthening STEM Education (S6)**
Session Chairs	***Erika Allison***	***Joanna Meyer***
Location	**DP Corbett 107**	**DP Corbett 100**
8:30-9:10 am	**Enhancing the Effectiveness of Chemistry Lectures through the Use of Guided-Discovery Activities (S5-1)** *Dawn Rickey*	**On the Ground with the Next Generation Science Standards: How Teachers Grapple with the Re-Prioritization (S6-1)** *Jonathan Shemwell*
9:10-9:50 am	**Refinement of a Learning Progression about Structure of Matter (S5-2)** *Hannah Sevian*	**Strategies to Build Participation in STEM (S6-2)** *Moderator – Sharon Barker* *Panelists: Chris Cash, Shelly Chasse-Johndro, Kelly Ilseman*
9:50-10:30 am	**US Engineering Education in the Middle East: First Year Challenges (S5-3)** *Wilhelm Alexander Friess*	**Science Leadership – What the Framework and Next Generation Science Standards will Demand (K-12) (S6-3)** *Anita Bernhardt*
10:30-10:45 am	**Break**	
	Earth Science and Climate Change (S7)	**Student Thinking in STEM (S8)**
Session Chairs	***Elizabeth Burroughs***	***Wilhelm Alexander Friess***
10:45-11:25 am	**Spatial Thinking in High School Earth Science (S7-1)** *Kim Kastens*	**De-Criminalizing High Stakes Exams Through Effective Teaching, Using Project-Based Learning Modules (S8-1)** *Timothy Conner*
11:25am-12:05pm	**Students' Conceptions of the Greenhouse Effect, Global Warming, Climate Change, and the Earth's Climate System (S7-2)** *Dan Shepardson*	**Which is Better: Fast and "Thoughtless", or Slow and Reasoned? (S8-2)** *Andrew Heckler*
12:05-12:25 pm	**Using a NetLogo Model to Understand the Greenhouse Effect (S7-3)** *Lisa Schultz*	**Using Lab-Based Analogies for Meaningful Understanding (S8-3)** *Mitchell Bruce*
12:25-1:45	**Lunch on your own**	

Friday, June 22nd · Morning Sessions Overview

Session Title	**Teaching and Learning Evolution (S9)**	**Teaching and Learning Physics and Mathematics (S10)**
Session Chairs	***Michelle Smith***	***John Thompson***
Location	DP Corbett 107	DP Corbett 115
8:40-9:20 am	**The Impact of Avida-ED Digital Evolution Software on Student Understanding of Natural Selection (S9-1)** *Amy Lark & Wendy Johnson*	**Shaping the Mathematical Storyline: Leveraging Student Thinking through Rich Classroom Discussions (S10-1)** *Michael Steele*
9:20-9:40 am	**Good Question! Using Students' Prior Knowledge to Teach Evolution (S9-2)** *Rebecca Price*	**Calculus Students' Understanding of Area and Volume in Non-Calculus Contexts (S10-2)** *Allison Dorko*
9:40-10:00 am		**New Ways of Investigating the Canonical Ball Toss Problem (S10-3)** *Michael Wittmann*
10:00-10:15 am	**Break**	
Co-Moderators	***Susan McKay & Natasha Speer***	
Location	**DPC 100**	
10:15am - 12:00pm	**OPEN SPACE SESSION** **DP Corbett, Rm. 100**	
	Open Space Break-Out Conversations	
	DP Corbett Rms. 100, 105, 107, 109, 111, 113 & 115	
	Open Space Reports and Conference Wrap Up **DP Corbett Rm. 100**	
12:00 pm	**Lunch at Memorial Union Marketplace**	

Wednesday Afternoon Workshops (1:30-3:30pm)

***NOTE**: Although workshops do not require pre-registration, we request that you sign up for Wednesday and Thursday afternoon workshops at the registration desk when picking up your registration material.

Workshop Title	Facilitator	Building & Rm.
W1: Community Projects and Involvement in STEM education	***Bill Zoellick, Moderator*** SERC Institute ***Beth Bisson, Panelist*** University of Maine ***Grace Eason, Panelist*** University of Maine – Farmington ***Ruth Kermish-Allen, Panelist*** Island Institute ***Sarah Nelson, Panelist*** University of Maine	DPC 100
W2: Looking for and Expressing Regularity in Repeated Reasoning: Math Magic Tricks as an Entry to Algebra	***Karen King*** National Council of Teachers of Mathematics	DPC 105
W3: Using a Learning Progression Framework to Investigate Thinking about Benefits, Costs and Risks in Chemical Design	***Hannah Sevian*** University of Massachusetts - Boston	DPC 109
W4: Fostering Spatial Thinking in High School Earth & Space Science Students	***Kim Kastens*** Lamont-Doherty Earth Observatory of Columbia University	DPC 113
W5: A Place-Based Project-Based Learning Unit for Rural Schools – School Yard Project-Based Learning Modules	***Timothy Conner*** SUNY Cortland	DPC 115
W6: Experimenting with Natural Selection in the Classroom Using Avida-ED Software	***Amy Lark*** Michigan State University ***Wendy Johnson*** Lansing Catholic High School	DPC 111
W7: Low-Cost Electronics for STEM Education	***Dave Harmon and Richard St.-Pierre*** Make it Science, and IBM Systems and Technology	FFA Rm Memorial Union
W8: A Method for Constructing Good Questions for Use in Class, Homework and Tests: the Dissection of a Scientific Concept into its Relevant and Irrelevant Dimensions	***Andrew Heckler*** Ohio State University	Bumps Room Memorial Union
W9: Helping Your Students Learn Physics and Think Like Scientists	***Eugenia Etkina*** Rutgers University	Coe Room Memorial Union

Thursday Afternoon Workshops (1:30-3:30pm)

Workshop Title	Facilitator	Building & Rm #
W10: Crosscutting Concepts in the Next Generation Science Standards (K-12)	***Anita Bernhardt*** Maine Department of Education	Bumps Room Memorial Union
W11: Designing Learning Progressions and Translating Them Into Curricula	***Marianne Wiser*** Clark University	FFA Room Memorial Union
W12: Creating the Mathematical Storyline and Planning for Rich Discourse	***Michael Steele*** Michigan State University	Coe Room
W13: Designing and Implementing Guided-Discovery Activities to Enhance Students' Understanding	***Dawn Rickey*** Colorado State University	DPC 115
W14: Teaching and Learning about the Earth's Changing Climate System	***Dan Shepardson*** Purdue University	DPC 109
W15: You've Almost Got It…Assessing and Improving How Students Understand Evolution	***Rebecca Price*** University of Washington - Bothell	DPC 113
W16: Using Free-Response Questions to Probe Student Thinking	***MacKenzie Stetzer*** University of Maine	MultiPurpose Rm Memorial Union
W17: Stop Sneering at Engineering: Strategies for Exciting and Engaging Your Students	***Erika Allison*** University of Maine	DPC 107

Abstracts of Talks

In Order By Session

S1-1 Physics Pedagogical Content Knowledge

Eugenia Etkina
Professor of Science Education and Chair, Department of Learning and Teaching
Graduate School of Education, Rutgers, The State University of New Jersey

Targeted Audience: High school physics teachers and undergraduate physics students and post-secondary physics teacher educators

In my talk I will describe the concept of pedagogical content knowledge (PCK) and how this concept relates to physics teacher practice. PCK is what distinguishes a content expert from an expert teacher of that content. Some elements of physics PCK include knowledge of student ideas in different areas of physics, knowledge of effective instructional methods that help students master fundamental physics ideas and ways of reasoning, and knowledge of assessment of student learning. I will show examples of these elements relevant to physics instruction and focus on the most important element that determines the teacher's choices and decisions in every lesson.

S1-2 Knowledge for Assessment (K4A): How Do Teachers Use Knowledge When They Design Written Assessments for their Classrooms and Interpret Students' Responses?

Laura Millay
Master of Science in Teaching Student, RiSE Center
University of Maine

Targeted Audience: Middle and high school teachers and post-secondary level teacher educators

What do teachers know about assessment and how do they use that knowledge as they make assessment choices and interpret results? How does other knowledge (of content, pedagogy, student ideas, or other) interact with teachers' classroom assessment?

Knowledge of assessment (or assessment knowledge) is a construct situated within PCK literature. According to Abell (2007) "More studies are needed to better understand what teachers know about assessment, and how they design, enact, and score assessments in their science classes." The K4A project seeks at this point to contribute to a practical understanding of assessment knowledge through three case studies. Research participants are 6^{th} and 7^{th} grade science teachers who piloted in the 2011-12 school year, with support from the Maine Physical Sciences Partnership, a research-based curriculum developed by Science Education for Public Understanding Program (SEPUP). The curricular materials are intended to teach and assess not only for students' recall of content, but also for their abilities to apply the content, to work with a variety of representations, and to use scientific skills.

This research uses a triangulated approach to explore teachers' uses of knowledge as they choose, administer, and evaluate written assessments in their classrooms during their first year of using SEPUP.

S2-1 Connecting Community with STEM Education

Ruth Kermish-Allen
Education Director, Island Institute

Targeted Audience: Middle and high school science teachers and post-secondary level science teacher educators

Through a variety of National Science Foundation and Environmental Protection Agency funded projects, including CREST, STORMS, and now Energy for ME and WeatherBlur, the model for STEM education developed by staff at the Island Institute has had extremely high levels of success due to a strong focus on integrating community concerns with STEM learning in the classroom.

This presentation will discuss the model and highlight the new Energy for ME project, which provides teachers and students in grades 6-12 – and their families – with an opportunity to learn how to better understand their communities' energy-consumption habits, and implications, as well as how to develop effective strategies to increase energy efficiency. We will also discuss the evaluation metrologies being used including embedded assessments, performance based assessments, and the incorporation of validated instruments.

S2-2 Who Do You Turn To? How Teachers Support Each Other in the Maine PSP Project

Bill Zoellick
Director of Education Research and Chief Financial Officer
Schoodic Education and Research Center (SERC) Institute

Targeted Audience: Middle school teachers and 9th grade teachers of physical science

Interactions between teachers are an important component of Professional Development (PD) for teachers in the Maine Physical Sciences Partnership project. The “Collaboratives,” cohort meetings, summer academies, and other PD elements all create opportunities for teachers to work with teachers. Maine PSP’s design intent is that, once working relationships between teachers are initiated, they will continue to grow and serve the day-to-day needs of teachers without depending on a Maine PSP event to make interactions happen. How do we know that such growth in teacher-to-teacher support is taking place?

Researchers working with the Maine PSP seek to answer this question by surveying teachers each spring, asking them whom they turn to for advice. We ask about different kinds of advice, including advice on subject matter, planning of lessons, assessment, and so on. We also ask whether a teacher’s reliance on colleagues is increasing or decreasing and how they are interacting (e.g., at school, at PSP events, or virtually).

We use these responses to create diagrams that show how richly connected the teachers are to each other: each teacher is a dot connected by lines to other dots. By coloring the dots according to different attributes such as membership in a school district we can see whether there are more connections between teachers in different school districts over time.

This presentation reviews what we have found about teachers connections over the first two years of Maine PSP. It concludes with questions to stimulate discussion about what else teachers and others want to find out through this research.

S3-1 How Elementary Curricula on Matter and Energy Based on Learning Progressions Can Prepare Students to Learn Science Effectively in Middle School

Marianne Wiser
Associate Professor and Chair, Hiatt School of Psychology
Department of Psychology, Clark University

Targeted Audience: Middle school science teachers

I will use a K-2 matter curriculum, a grade 3-5 energy curriculum, the Inquiry Curriculum (grade 3-5 matter curriculum), and the IQWST Curriculum (middle school science curriculum) to illustrate the processes behind designing learning progressions and the dynamic links between learning progressions and curricula.

S3-2 Student-Teacher Interactions for Bringing Out Student Ideas About Energy

Benedikt Harrer
Ph.D. candidate, Department of Physics and Astronomy
University of Maine

Targeted Audience: Middle school science teachers

Modern middle school science curricula use group activities to help students express their thinking and enable them to work together like scientists. We are studying rural 8th grade science classrooms using materials on energy. Even after spending several months with the same curriculum on other physics topics, students’ engagement in group activities seems to be restricted to creating lists of words that are associated with energy. Though research suggests that children have rich and potentially valuable ideas about energy, our students don’t seem to spontaneously use and express their ideas in the classroom. Only within or after certain interactions with a teacher do students begin to explore and share these ideas. We present and characterize examples of student-teacher interactions resulting in students’ deeper engagement with their ideas about energy. This preliminary analysis of video-recorded classroom dialogue is a step toward helping teachers improve their students’ learning about energy.

S4-1 Service Learning in an Undergraduate Introductory Environmental Science Course: Getting Students Involved with the Community

Grace Eason
Associate Professor of Science and Science Education
University of Maine – Farmington

Targeted Audience: Science professors teaching undergraduate non-science majors, and grade 7-12 teachers who would like to try service learning in their classes.

I will discuss how to incorporate service-learning projects in an undergraduate introductory environmental science course. These projects influence students' views regarding environmental activism on a local level and connect community involvement with the main themes covered in the course. There are two main project paths from which students may choose. The first path involves Unit Lab Journal Reflections, where students discuss how the course field trips are connected to the scientific issues discussed in class. The second path involves working with the Sustainable Campus Coalition (SCC), a coalition of students, faculty, staff, and community members that promotes environmental sustainability on campus and in the regional community. Service-learning combines campus service with course learning objectives, and promotes civic engagement, self-reflection, and self-discovery. Some project examples include helping campus food service incorporate local and organic foods and composting, campus energy reduction in the dorms, and inviting K-12 students to participate in tours of our LEED certified education center. Student reflections, video footage, and lessons learned while implementing these projects will also be discussed.

S4-2 The Battle of the Electric Marimba Bands – A Pilot Project-based STEAM Program

Dave Harmon & Richard St.-Pierre
Make It Science and IBM Systems and Technology

Targeted Audience: Middle and high school STEM teachers and post-secondary level science students and teacher educators

When introducing new educational topics in a classroom environment, it is a primary goal to engage a complete cross-section of the students and energize them to apply their knowledge and gain new skills. The *Battle of the Electric Marimba Bands* was a pilot project-based STEAM (Science, Technology, Engineering, Arts, and Mathematics) unit jointly developed by *Essex Middle School* and *Make It Science*, working in conjunction with the *IBM Technical Education Outreach* program. This poster presentation provides an overview of the design sessions, processes, and results. The project combined the science and math behind electric marimba instruments with the *Design Cycle* version of the *Scientific Method* and various construction techniques to allow diverse student teams to build operational electric marimbas. Each team was required to (1) fabricate a set of alto, tenor, and bass marimbas that incorporated artistic and cultural designs, (2) pick and perform a musical selection requiring all three marimbas, and (3) present their project to an independent panel of judges. Awards were given out based on meeting the goals of a STEAM-centric rubric. The application of science and mathematics to marimba construction was found to be an effective educational tool, which successfully engaged the students.

S5-1 Enhancing the Effectiveness of Chemistry Lectures through the Use of Guided-Discovery Activities

Dawn Rickey
Associate Professor, Department of Chemistry
Colorado State University

Targeted Audience: High school chemistry teachers and undergraduate chemistry students and teacher educators

Our research group investigates how to facilitate learning with a depth of understanding that empowers students to apply scientific models in new contexts. Here we report on what we have learned about how guided-discovery activities can be employed to enhance students' understanding of chemistry lectures. Two specific types of guided-discovery activities – one designed for laboratory settings and the other designed for regular classroom settings – will be discussed. These activities share common instructional design elements, including (1) students' work with data sets that highlight contrasting cases to construct scientific models and/or invent general rules, and (2) expert solutions that are presented only after students have worked to understand the chemical systems on their own. The presentation will include a summary of research supporting the instructional design; the development and implementation of our guided-discovery activities in general chemistry; and results of our research on student learning. The general instructional design and associated research results presented are expected to be of interest to all science teachers and science education researchers, with most examples drawn from first-semester general chemistry.

S5-2 Refinement of a Learning Progression about Structure of Matter

Hannah Sevian
Associate Professor, Department of Chemistry
University of Massachusetts - Boston

Targeted Audience: High school science teachers and post-secondary level science students and teacher educators

Learning progressions describe learning over extended periods of time, usually several years. They are of increasing interest in institutional and policy contexts because they hold promise for guiding the coordination of curriculum, instruction, and assessment in order to provide sustained opportunities over many years for students to engage with core ideas and develop connections between them. The structures of most learning progressions includes descriptions of levels of achievement by students, variables along which progress can be measured, and assessments that enable describing how students understand and think about ideas within this framework. The process of validation of a learning progression involves iterative cycles of refinement including the development of measures, studies of how students demonstrate their understanding and thinking, and studies of how curriculum and instructional interventions influence students' learning.

To illustrate part of this process, one iteration in the refinement of a learning progression of the structure of matter will be described. The initial, hypothetical learning progression described likely pathways in the development of implicit assumptions (common underlying presuppositions about the nature of entities and phenomena in the world) that learners make about the particle nature of matter, specifically characterizing how the implicit assumptions guide and constrain learners' explanations and predictions about the behavior of matter. The refinement of the learning progression involved measuring and examining implicit assumptions about the structure and motion of matter in students aged 13 to graduation from university.

Measurement of implicit assumptions involved developing and administering an open-ended survey that used questions about the phenomenon of diffusion of a gas solute in a gaseous solvent to prompt students to generate mental models, which served as cognitive resources in the students' written and drawn explanations of the structure and motion of matter. The development of the instrument served as a process for refining the learning progression, fine tuning the characterization of various implicit assumptions, and substantially clarifying one of the progress variables of the learning progression. The instrument consistently measured implicit assumptions along three progress variables: structure of the gaseous solvent, origin of motion of gaseous solute particles, and trajectories of motion of solute particles.

Using a large sample of students (N=485) ranging from grade 8 through upper-level undergraduate, a cluster analysis revealed five distinct mental models held by students, each one characterized by a specific combination of implicit assumptions in the three progress variables. The mental models are considered as levels of achievement, representing intermediate understandings reached by students in the sample. Some of the mental models uncovered by this method may be useful 'stepping stone' intermediate understandings along a learning progression, through which appropriate curriculum and instruction can deliberately facilitate students' growth in knowledge.

S5-3 US Engineering Education in the Middle East: First Year Challenges

Wilhelm Alexander Friess
Associate Professor of Mechanical Engineering Education (University of Maine)
and Director of Brunswick Engineering Program and Discovery Center (Brunswick, Maine)

Targeted Audience: High school science teachers, undergraduate science and engineering students, and post-secondary teacher educators

The presentation discusses the author’s experiences establishing engineering programs at two US universities in the Middle East. Typical inaugural year challenges are addressed, and in particular the difficulties arising from establishing a US campus and teaching a US engineering curriculum in this environment. US education values, such as independent thinking and personal initiative, often represent a completely new approach to learning for the local and regional students, who originate from school systems that stress other approaches. In addition, the Middle East is an environment where family ties and social hierarchies are strong, and where authority is not questioned. As a result, very different motivations to attain a University degree develop, that in turn directly manifest in the academic success of the student.

The Institute and the individual professor are challenged at all levels, starting with the difficulty to objectively assess the student’s educational background and readiness in the admissions process, weak and very non-homogeneous academic backgrounds, and the need to develop an appropriate level of independence and independent thinking for university level work.

The presentation reviews observations and lessons learned, as well as some of the initiatives undertaken to enable the students to succeed in a US Engineering curriculum.

S6-1 On the Ground with the Next Generation Science Standards: How Teachers Grapple with the Re-Prioritization

Jonathan Shemwell
Assistant Professor of Education & Cooperating Professor of Physics
University of Maine

Targeted Audience: All science education audiences

The Next Generation Science Standards (NGSS) place a high priority on engaging students in science practices such as asking questions, planning and carrying out investigations, constructing arguments, and communicating. The NGSS vision is radical. It proposes that science practices should be so tightly bound to other aspects of science knowing (e.g., concepts, principles) as to be inextricable from them. Questions abound as to how science teachers will respond to this vision. For instance, how will teachers respond to the increased emphasis on learning science practices? This question and others are now being addressed in ongoing research which is the subject of the talk. Data will be presented from analysis of journals and interviews from a group of experienced middle school science teachers in central Maine who are in their first year of using NGSS-inspired curriculum materials. The data reveal a tension between appreciation for authentic learning of science practices and "traditional" values such as the need to make progress and meet state content standards. This tension suggests several ways in which teachers should be supported in reconstructing their practice to meet NGSS. Important among these are transitional changes to existing state standards and professional development addressing the tensions that arise from re-prioritization. This talk is suitable for all science education audiences.

S6-2 Strategies to Build Participation in STEM

Sharon Barker (Moderator)
Director, Women's Resource Center, University of Maine

Chris Cash
Institute of Broader Participation

Shelly Chasse-Johndro
Project Reach & Project Opportunity, University Diversity Leadership Institute

Kelly Ilseman
Upward Bound, University of Maine

Targeted Audience: Middle, high school, and post-secondary STEM educators

Engaging underrepresented groups with STEM education topics or future STEM-related careers is an ongoing challenge that needs to be addressed and better understood. Each panelist will describe the project that they have implemented to broaden participation in STEM. Panelists' work spans middle, high school, and post-secondary grade levels. Each panelist will outline their strategies and lessons learned related to this important topic. A discussion will follow emphasizing proven practices and ways to build awareness of them and their effectiveness, in order to increase participation in STEM. Strategies will include program development, mentoring, and available resources for this work.

S6-3 Science Leadership – What the Framework and Next Generation Science Standards will Demand (K-12)

Anita Bernhardt
Science & Technology Specialist
Maine Department of Education

Targeted Audience: Middle, high school science teachers and post-secondary teacher educators

A Framework for K-12 Science Education presents a different picture of instruction in science classrooms. This vision has implications for the skill set needed to make this vision a reality. This talk will explore the demands that Framework and Next Generation Science Standards present to science leaders.

S7-1 Spatial Thinking in High School Earth Science

Kim Kastens
Lamont-Doherty Earth Observatory
Columbia University

Targeted Audience: High school earth science teachers and post-secondary teacher educators

Each year, approximately 166,000 students in New York State take "Regents Earth Science" and are assessed by a state-set end-of-year exam. Building on research showing that spatial thinking is important in Earth Science and can be improved through instruction and practice, we have designed and implemented a spatial thinking professional development program for teachers of this course. “Spatial thinking” in this context involves envisioning, manipulating, or drawing meaning from the position, shape, orientation, trajectory, or configuration of objects or phenomena.

In the first stage of our project, we analyzed all items from 12 recent exams to quantify the extent and type of spatial thinking being assessed. Our coding system identifies spatial concepts, spatial representations, spatial skills, and sub-categories within these. Our findings confirm that the exam is rich in spatial thinking opportunities, with 65% of all items either requiring or benefitting from use of spatial thinking. The most commonly tested spatial representations are maps (31%) and profiles (17%), expressed as percentage of the spatially-coded items, allowing multiple codes per item. The most common spatial concepts are configuration (55%), position (51%), motion (42%) and direction (37%). The most common spatial skills are mental animation (26%) and representational correspondence (14%). Visual penetrative ability, although prominent in other Earth Science curricula, plays a minor role (~1%) on this exam. Based on a limited data set, the spatial elements on which students are performing most poorly are: concepts: trajectory and gradient; representation: solar system; skills: describe a spatial phenomenon and perspective taking.

This analysis informed the design of a pilot PD program which was tested during the 2011-2012 school year. Currently, most teachers receive little instruction on what spatial thinking is or how to foster it during their pre-service or in-service training. Our long term vision is that school districts committed to data-driven improvement will be able to identify teachers and students who are doing poorly on spatially-demanding items and then use our spatial thinking PD techniques. Although improved test scores are the “hook,” the real goal is to foster higher order thinking skills. After inspecting hundreds of test items, we consider that the spatial thinking demanded by the Regent exam is a faithful representation of practices used by geoscientists in research and practical applications.

S7-2 Students’ Conceptions of the Greenhouse Effect, Global Warming, Climate Change, and the Earth’s Climate System

Dan Shepardson
Professor of geo-environmental & science education
Departments of Curriculum and Instruction, and Earth and Atmospheric Sciences, Purdue University

Targeted Audience: High school science teachers and post-secondary level science students and teacher educators

The presentation will summarize the research literature and our own work investigating secondary students’ conceptions of the greenhouse effect, global warming, and climate change, and will provide preliminary results from our new research program investigating students’ conceptions of the Earth’s climate system.

S7-3 Using a NetLogo Model to Understand the Greenhouse Effect

Lisa Schultz
Master of Science in Teaching Graduate and 9th Grade Science Teacher
Old Town High School

Targeted Audience: High school science teachers and post-secondary teacher educators

I will be summarizing my MST research of common student ideas about the greenhouse effect and the effectiveness of a computer modeling program as a learning tool to understand the greenhouse effect. This study was conducted at two Maine middle-schools with 136 seventh-grade students and 11 eighth-grade students in eight classes. Results indicate middle-school students partially increased in their understanding about how the greenhouse effect influences the Earth's temperature after using the computer model, although they held on to their misconceptions from the pre- to post-tests. Since completing my thesis, I have included a modified NetLogo model into the 9th grade curriculum with a guided inquiry activity. I will be sharing the modifications to the model and activities students do with the model to investigate the greenhouse effect.

S8-1 De-Criminalizing High Stakes Exams, Through Effective Teaching, Using Project-Based Learning Modules

Timothy Conner
SUNY - Cortland

Targeted Audience: Teachers of environmental science, earth science, biology, and outdoor education at any level

Fearing the results of “high stakes exams”, teachers often resort to “teaching to the test” or trying to force feed curriculum to resistant students. After many years of teaching I found that project-based modules that focused on issues relevant to my students were much more effective than teaching to the test. I used project-based modules in my teaching in New York, a state with a long history of high stakes end of the year assessments. Project-based learning helped engage my students in science and supported them in learning the content they needed to know for state exams. In my presentation I will demonstrate how I used project-based modules in my classroom.

S8-2 Which is Better: Fast and "Thoughtless" or Slow and Reasoned?

Andrew Heckler
Associate Professor, Department of Physics
Ohio State University

Targeted Audience: High school science teachers and post-secondary level science students and teacher educators

Should instructors teach and test for "mindless" rote memorization and basic skills or deeper critical thinking and complex problem solving? An examination of patterns of student responses to simple physical science questions can offer insight into this issue. Taking cues from a century of cognitive psychology, it can be useful to categorize student responses into two paths: a fast, automatic and intuitive path and a slow, deliberate and explicitly reasoned path. In this talk several examples will be shown demonstrating these two paths at work when students respond to science questions. A student's prior knowledge and experience plays a big role in which path is used, and each path has its pros and cons. We will discuss how making thoughtful instructional decisions that take advantage of both paths can help to achieve a teacher's instructional goals.

S8-3 Using Lab-Based Analogies for Meaningful Understanding

Mitchell Bruce
Associate Professor, Department of Chemistry
University of Maine

Targeted Audience: High school chemistry teachers and post-secondary level chemistry students and post-secondary teacher educators

The nature of using analogies in a comparative way results a meaningful learning that can help learners relate to a concept from a different view and refine their mental models to be more adequate to the conceptual model shared by the scientific community. In this paper, we will describe how analogies can be integrated to an introductory lab course using the Analogy/Learning Cycle (A/LC) curriculum we developed. Our approach is aimed at constructing conceptual understanding and minimizing student misunderstanding through a "just in time" structured analogy activity after conducting a lab experiment. We encourage students during and after the lab to construct the correspondence and consider the limitations of an analogy. Anchoring analogical reasoning to experimental observations permits students to think about the chemistry they cannot see while giving them a way to understand the inherent limits of a model. The project includes the interrelated pieces of curriculum, assessment, and research on student ideas. We present an overview of the A/LC curriculum, pre- and post-assessment results, a tool for eliciting students' answers for analogy reasoning and students' answers content analysis from fall 2011 and spring 2012 (n = 502).

S9-1 The Impact of Avida-ED Digital Evolution Software on Student Understanding of Natural Selection

Amy Lark
Doctoral Student, Science Education
College of Education, Michigan State University

Wendy Johnson
Biology Teacher, Lansing Catholic High School

Targeted Audience: High school biology teachers and post-secondary level biology students and post-secondary teacher educators

Evolutionary theory unites all domains of biological inquiry and is a powerful paradigm for understanding the living world, yet the basic premise of natural selection is poorly understood by students and their misconceptions are highly resistant to change. The evolution education literature suggests many potential reasons and possible solutions to this problem including the proposition that student understanding and acceptance of evolutionary theory is intimately linked to their understanding of the nature of science. The process of biological natural selection is difficult to observe in the classroom for a number of reasons, but digital organisms can provide an instance of evolution in a modeled software environment that is readily observable and testable in the classroom.

Researchers at Michigan State University are studying evolutionary processes using self-replicating digital organisms that resemble computer viruses. Their research platform, Avida, has been simplified into an educational version for use in undergraduate and high school biology classes. Avida-ED provides a user-friendly interface that likens the digital organisms to bacteria growing in a virtual petri dish. Investigating the evolution of digital organisms allows students to participate in authentic scientific inquiry and study the process of natural selection in engaging and relevant ways, overcoming time and resource barriers traditionally associated with the study of biological natural selection in the classroom. We have developed introductory lessons utilizing Avida-ED that provide opportunities for guided inquiry, highlighting the concepts of random mutation, fitness, and selection, and which allow students to examine variation at both the organismal and population levels while they learn to use the software. The introductory lessons include collecting and analyzing data from different lineages, culminating in an activity that asks students to propose and test hypotheses for evolving a particular phenotype.

The lessons were used in Advanced Placement Biology and molecular biology courses for high school juniors during the 2011-2012 school year at Lansing Catholic High School (Lansing, MI). Pre and post-tests were administered and the results are currently being analyzed to determine the effects of the Avida-ED lessons on student understanding of evolution by natural selection. This session will introduce Avida-ED and highlight the conclusions of the paper that will be presented as a master's thesis in June 2012. We will also discuss our future plans for our research with Avida-ED.

S9-2 Good Question! Using Students' Prior Knowledge to Teach Evolution

Rebecca Price
Assistant Professor, Interdisciplinary Arts and Sciences
University of Washington – Bothell

Targeted Audience: High school biology teachers and post-secondary level biology students and post-secondary teacher educators

Students enter biology classrooms with dogmatic attitudes toward evolution: they are proponents or opponents. This talk addresses the strategies that instructors can use to change the classroom environment from one that is dogmatic to one that fosters critical thinking. We will begin by discussing an approach for using students' questions to engage the whole class in inquiry. Class starts with students completing an anonymous survey in which they answer three questions: (1) What is evolution? (2) What is natural selection? and (3) Does evolution make sense to you? Why? The students' responses, which often take the form of additional questions, launch an opportunity to explore evolution scientifically. The questions that students raise are questions that scientists have raised, too. Scientists have used rigorous evidence to answer the questions.

To illustrate, I will walk through an example of how I draw on many lines of scientific evidence to answer the kind of question that appears on the survey responses: why did fish start walking? I will also discuss other strategies for uncovering students' prior knowledge about evolution, such as the AAAS Science Assessment site that helps instructors diagnose where to focus their instruction to meet the Next Generation Science Standards. We conclude by discussing some of the resources that help teachers learn about both evolution and the evolutionary concepts that challenge students.

S10-1 Shaping the Mathematical Storyline: Leveraging Student Thinking through Rich Classroom Discussions

Michael Steele
Assistant Professor, Department of Teacher Education
Michigan State University

Targeted Audience: Middle and high school mathematics teachers, and post-secondary level mathematics students and post-secondary teacher educators

In this talk, I articulate the use of two tools - the Mathematical Storyline, and the Five Practices for Orchestrating Productive Discussions (Stein & Smith, 2011) - as a means to elicit and make use of students' thinking in a discourse-based mathematics classroom. Specifically, I focus on the ways in which mapping a mathematical storyline for a mathematical task can support teachers in anticipating student thinking, monitoring students as they work, selecting and sequencing responses to share, and connecting mathematical ideas.

S10-2 Calculus Students' Understanding of Area and Volume in Non-Calculus Contexts

Allison Dorko
Master of Science in Teaching Graduate, RiSE Center
University of Maine

Targeted Audience: Middle School Teachers

Researchers have documented difficulties that elementary school students have in understanding area and volume. Although area and volume show up in various ways later in the curriculum, we know very little about older students' understanding of these concepts. The goal of this study is to develop descriptions of calculus students' understanding of area and volume concepts in non-calculus contexts. Participants included 255 introductory calculus students and 43 multivariable calculus students. Clinical interview transcripts and students' written responses to area and volume problems (computational and short answer) were analyzed. Findings from the study indicate that multivariable calculus students struggle with neither the computations nor the units of area and volume problems. In contrast, some differential calculus students struggle with the units associated with various spatial measures. In addition, some differential calculus students mistakenly find surface area when directed to find volume.

S10-3 New Ways of Investigating the Canonical Ball Toss Problem

Michael Wittmann
Associate Professor, Department of Physics & Astronomy and RiSE Center, and Cooperative Associate Professor, College of Education and Human Development
University of Maine

Targeted Audience: Middle and high school physical science teachers and post-secondary level physics students and post-secondary teacher educators

Asking students about the acceleration of a tossed object is a well-studied problem in physics education research. Students frequently respond using reasoning that describes the velocity of the ball, in particular that acceleration is zero at the top. We created new versions of the canonical multiple-choice Force and Motion Conceptual Evaluation ball-toss questions to investigate what other reasoning students might use. Some students were asked "is the acceleration zero at the top?" These students were half as likely to give a velocity-like response (that a=0) as were students answering the canonical form. Other students were told "the acceleration is not zero" and asked to explain. Roughly 75% of these students could explain why acceleration is not zero. This is in contrast to the 60% who say it is zero at the top.

Workshop Abstracts

In Order By Session

W1 Community Projects and Involvement in STEM Education

Bill Zoellick, Moderator
Director of Education Research and Chief Financial Officer
SERC Institute

Beth Bisson
Assistant Director for Outreach and Education
University of Maine Sea Grant

Grace Eason
Associate Professor of Science and Science Education
University of Maine – Farmington

Ruth Kermish-Allen
Education Director
Island Institute

Sarah Nelson
Assistant Research Professor, Water Research Institute
University of Maine

Targeted Audience: All levels of STEM students and educators

Community-based projects can provide engaging, relevant service and/or experiential learning opportunities for students. At the beginning of this workshop, each panelist will present a description of how they have integrated community projects and classroom learning, and the lessons that they have learned about involving students effectively in community work. A discussion will follow about how service and/or experiential learning can meet student needs, align with required learning and project outcomes, and ensure that all members of the project team (students, teachers, other community participants) benefit.

W2 Looking for and Expressing Regularity in Repeated Reasoning: Mathematics Magic Tricks as an Entry to Algebra

Karen King
Director of Research
National Council of Teachers of Mathematics

Targeted Audience: Middle and high school teachers

Everyone has seen the math magic tricks that float around. Take a number, do some list of computations, and I can predict the number you started with or you ended up with the number you started with. I am usually the person who is unimpressed with these tricks because I know how they work, but middle and high school students often wonder, "How did you do that?" Using a series of tasks adapted from Miriam Leiva (2012) and Peg Smith and Mary Kay Stein's framework for productive discussions (2011), this workshop will focus on ways to use math magic tricks to introduce ideas of variable as an unknown while supporting students in looking for and expressing regularity in repeated reasoning.

W3 Using a Learning Progression Framework to Investigate Thinking about Benefits, Costs and Risks in Chemical Design

Hannah Sevian
Associate Professor, Department of Chemistry
University of Massachusetts – Boston

Targeted Audience: Middle and high school teachers

Both the *Framework for K-12 Science Education* and the *Next Generation Science Standards* emphasize learning progressions as an important strategy for evidence-based instructional decisions, assessment design and interpretation, and school and district science program planning. This workshop will introduce participants to how we are investigating ways that students reason about the benefits, costs, and risks associated with the design and use of chemicals, in the context of individual, social, economic and political considerations. We will discuss how these methods are used to uncover implicit assumptions and reasoning heuristics that shape how reasoning occurs by constraining students' thinking about chemistry. Participants will practice interpreting expert data, collected during the workshop, from an assessment designed to measure progress along a learning progression describing how students develop understanding of chemical design as the central practice of the discipline of chemistry. We will consider ways to position instruction so that it targets learning for students at the levels where they currently are along a learning progression.

W4 Fostering Spatial Thinking in High School Earth & Space Science Students

Kim Kastens
Lamont-Doherty Earth Observatory
Columbia University

Targeted Audience: High school teachers and post-secondary teacher educators

Spatial thinking involves envisioning, manipulating, or drawing meaning from the position, shape, orientation, trajectory, or configuration of objects or phenomena. Earth and space science students use spatial thinking when they envision how a body of rock has been folded and faulted over time, when they make inferences from the distribution of earth phenomena on a map, and when they envision the trajectory of the moon relative to the Earth and sun. Research has shown that (a) spatial thinking is important for success in science in general and geosciences in particular, and (b) that it can be improved through instruction and practice.

This workshop will share techniques that we developed and tested during a workshop series conducted at Lamont-Doherty Earth Observatory during the 2011-2012 school year, in association with the Earth2Class series of workshops for Earth Science teachers (www.earth2class.org). The skills practiced were identified as important for earth science students through an analysis of spatial thinking elements in the New York State Earth & Space Science Regents exam, and prior work on spatial thinking in geosciences.

To foster students’ attention to significant details in spatial representations, while at the same time enhancing their ability to speak and write with spatial vocabulary, we have developed a set of “spot the differences” puzzles. Students view several similar drawings or diagrams of geo-scientifically significant phenomena, and have to either say or write what are the similarities and differences between the pictures.

To foster students’ ability to make inferences about earth processes from map patterns, we advocate a data-first approach, in which students first use their native human pattern-detection ability to detect and describe map patterns. When the teacher then introduces the normative explanatory model, students find it to be a rewarding solution to a phenomenon demanding explanation.

To foster students’ perspective-taking ability, we begin with sketching everyday objects and spaces from different vantage points. We offer several strategies to make more salient the connection between map views and cross-section (profile) view of the same space. Finally, we suggest ways to use physical models in which the models are used as cognitive tools in support of student problem solving, rather than simply as visual aids for demonstration.

To foster students’ ability to combine spatial and temporal thinking, we have developed a sequencing activity, in which students “reverse-engineer” the sequence of steps by which the rocks revealed in a geological cross-section were deposited/emplaced/deformed. Using a series of overlays, students sketch the cross-section as it would have looked at a series of time slices.

W5 A Place-Based Project-Based Learning Unit for Rural Schools – School Yard Project-Based Learning Modules

Timothy Conner
Lecturer, Department of Geology
SUNY – Cortland

Targeted Audience: Middle and high school teachers and post-secondary teacher educators

Participants will be engaged in working with some Project Based Learning activities that can be adapted to any schools grounds. These activities are inexpensive, rich, rigorous and relevant and are guaranteed to engage students along with the added bonus of improving student achievement.

W6 Experimenting with Natural Selection in the Classroom using Avida-ED Software

Amy Lark
Doctoral Student, Science Education, College of Education
Michigan State University

Wendy Johnson
Biology Teacher
Lansing Catholic High School

Targeted Audience: High school teachers and post-secondary teacher educators

Evolutionary theory unites all domains of biological inquiry and is a powerful paradigm for understanding the living world, yet the basic premise of natural selection is poorly understood by students and their misconceptions are highly resistant to change. The evolution education literature suggests many potential reasons and possible solutions to this problem including the proposition that student understanding and acceptance of evolutionary theory is intimately linked to their understanding of the nature of science. The process of biological natural selection is difficult to observe in the classroom for a number of reasons, but digital organisms can provide an instance of evolution in a modeled software environment that is readily observable and testable in the classroom.

Researchers at Michigan State University are studying evolutionary processes using self-replicating digital organisms that resemble computer viruses. Their research platform, Avida, has been simplified into an educational version for use in undergraduate and high school biology classes. Avida-ED provides a user-friendly interface that likens the digital organisms to bacteria growing in a virtual petri dish. Investigating the evolution of digital organisms allows students to participate in authentic scientific inquiry and study the process of natural selection in engaging and relevant ways, overcoming time and resource barriers traditionally associated with the study of biological natural selection in the classroom. We have developed introductory lessons utilizing Avida-ED that provide opportunities for guided inquiry, highlighting the concepts of random mutation, fitness, and selection, and which allow students to examine variation at both the organismal and population levels while they learn to use the software. The introductory lessons include collecting and analyzing data from different lineages, culminating in an activity that asks students to propose and test hypotheses for evolving a particular phenotype.

This workshop will introduce the Avida-ED software and offers participants the opportunity to gain hands-on experience using it with the lessons that we have developed. We will discuss benefits of the inquiry approach as well as how each lesson can be easily adapted to meet the needs of varied student populations and learning goals.

W7 Low-Cost Electronics for STEM Education

Dave Harmon & Richard St. Pierre
Make It Science and IBM Systems and Technology

Targeted Audience: Middle and high school STEM teachers

Hands-on science projects that allow students to see, touch or feel the effects of scientific principles can be very effective teaching tools. Benefits include increased motivation and deeper understanding of scientific concepts and associated measurement and modeling techniques. Often these projects can be constructed at low cost and require low-tech equipment. However, many students are embedded in an electronic world and are motivated by the complex functions that electronics provides. Electronics also enhances scientific learning since the sensitivity of electronics is often greater than human senses. Furthermore, the inclusion of small electronic circuits in science demonstrations and STEM projects allows the teaching of electricity in parallel with the science being demonstrated. Simple circuits demystify the realm of electronics; extend the range of physical senses; and enable time-critical phenomena to be observed, measured and modeled. This workshop describes numerous projects that have been piloted in Vermont schools. The workshop will show examples of relatively simple, low-cost circuits and the accompanying equipment that have been used for teaching electrostatics; electromagnetics; forces and motion; and waves, vibration and sound. Participants in the workshop will build a simple electronic circuit, gaining the knowledge, experience and confidence to carry such projects into their own classrooms.

W8 A Method for Constructing Good Questions for Use in Class, Homework and Tests: the Dissection of a Scientific Concept into its Relevant and Irrelevant Dimensions

Andrew Heckler
Associate Professor, Department of Physics
Ohio State University

Targeted Audience: High school and post-secondary level science teachers and post-secondary teacher educators

We will examine a simple method to construct qualitative, conceptual questions that can generate good discussion in class, can be used on tests, and can be used to generate a number of homework practice questions. The method consists of identifying and isolating important dimensions in a natural phenomenon, including those that student incorrectly believe are relevant, and making specific variations in these dimensions to generate questions. For example, when determining the time of flight of a projectile launched on level ground, some of the pedagogically important dimensions are maximum height, range, and mass. Of these dimensions, only maximum height determines the time of flight, though many students believe that range and mass matter. Therefore, asking student to compare trajectories with different ranges but the same maximum height is a productive question. Such examples, often including several dimensions, are plentiful in science. In the first part of the workshop, after an introduction, participants will examine a number of examples in the physical sciences, and practice dissecting them and constructing questions. In the second part of the workshop, the participants will try their hand at coming up with concepts and phenomena relevant to their instruction, and generate a suite of useful questions using this method.

W9 Helping Your Students Learn Physics and Think Like Scientists

Eugenia Etkina
Professor of Science Education and Chair, Department of Learning and Teaching
Graduate School of Education
Rutgers University

Targeted Audience: Middle and high school science teachers and post-secondary teacher educators

We often spend the first week of classes teaching our students how science works and then switch to our traditional delivery mode telling them what the laws of physics are and how to use them to solve back-of-the-chapter problems. Is it possible for our students to learn physics concepts and laws by actually practicing science? What does it mean to practice science in a high school classroom? In this workshop the participants will learn the foundations of a teaching philosophy “Investigative Science Learning Environment” (ISLE) and get a taste of the middle school/high school curriculum continuum Physics Union Mathematics (PUM) that is based on the ISLE philosophy. ISLE and PUM engage your students in the processes mirroring scientific practice when they are learning physics and help them experience physics first hand as their own creation. Students construct their understanding of physics concepts by collecting and analyzing data, devising their own explanations, testing them with new experiments, and making meaningful connections to mathematics.

W10 Crosscutting Concepts in the Next Generation Science Standards (K-12)

Anita Bernhardt
Science & Technology Specialist
Maine Department of Education

Targeted Audience: Middle and high school teachers

The Framework for K-12 Science Education requires that practices, crosscutting concepts and disciplinary core ideas are combined to generate the Next Generation Science Standards. These standards will guide future instruction and assessment. This workshop explores the Crosscutting Concepts in depth and examines examples of lessons for their integration of crosscutting concepts.

W11 Designing Learning Progressions and Translating Them into Curricula

Marianne Wiser
Associate Professor and Chair, Hiatt School of Psychology, Department of Psychology
Clark University

Targeted Audience: Middle and high school science teachers and post-secondary teacher educators

Building off of my keynote presentation, I will explore with the workshop participants some of the research methods involved in designing learning progressions and translating them into curricula. We will also discuss some of the practices embedded in learning progression based curricula.

W12 Creating the Mathematical Storyline and Planning for Rich Discourse

Michael Steele
Assistant Professor, Department of Teacher Education
Michigan State University

Targeted Audience: High school mathematics teachers and post-secondary teacher educators

This workshop will provide teachers and post-secondary teacher educators with opportunities to map mathematical storylines for rich mathematical tasks. Using the storyline maps, we will discuss and practice ways in which teachers might plan that support student-centered discussions of the tasks. These practices include planning for the use of specific teacher discourse moves to elicit student thinking, the sequencing of students' mathematical responses in ways that build mathematical ideas, and the connecting of students' mathematical ideas.

W13 Designing and Implementing Guided-Discovery Activities to Enhance Students' Understanding

Dawn Rickey
Associate Professor, Department of Chemistry
Colorado State University

Targeted Audience: High school chemistry teachers and post-secondary post-secondary teacher educators

Based on an instructional model that has been demonstrated to enhance students' abilities to apply scientific models effectively in new contexts, we have designed and implemented a series of guided-discovery activities for general chemistry. During these activities, students work with data sets that highlight contrasting cases to invent formulas, procedures, and other general rules that describe the cases presented. Later, once students are more prepared to learn, the expert solutions are presented. This workshop will focus on how to design and implement guided-inquiry activities to enhance students' understanding of scientific models. The workshop and general principles of instructional design discussed are expected to be of interest to all science teachers and science education researchers, with most examples and materials drawn from first-semester general chemistry.

W14 Teaching and Learning about the Earth's Changing Climate System

Dan Shepardson
Professor, Geo-environmental & Science Education
Department of Curriculum and Instruction and Earth and Atmospheric Sciences
College of Education, Purdue University

Targeted Audience: High school science teachers and post-secondary level post-secondary teacher educators

Strategies for teaching about climate change within the context of the Earth's climate system will be presented. Participants will explore their own understandings about the Earth's climate system and engage in a number of data driven and visualization activities appropriate for teaching secondary students about how the Earth's climate system is changing. Linkages to the new framework for k-12 science education will be addressed. Resource materials will be provided.

W15 You've Almost Got It…Assessing and Improving How Students Understand Evolution

Rebecca Price
Assistant Professor, Interdisciplinary Arts and Sciences
University of Washington – Bothell

Targeted Audience: High school biology teachers and post-secondary level post-secondary teacher educators

A challenging aspect of teaching evolution is that students' misconceptions are notoriously difficult to change. This makes formative assessment particularly necessary to include, so that we are constantly aware of the conceptual difficulties that our students face. In this workshop, we will participate in three different activities that help assess what our students understand—and do not understand—about evolution: (1) a role play that simulates natural selection and other mechanisms of evolution, (2) a brief activity that uses analogy to explore what experts mean when they say that natural selection is a sorting process, and (3) a survey that is useful for identifying students' questions about evolution. We evaluate the activities, discuss the common conceptual difficulties that they help students confront, and brainstorm about how to implement them in the classroom. We conclude by sharing activities that participants have used successfully in their own classrooms and discussing additional resources available to teachers.

W16 Using Free-Response Questions to Probe Student Thinking

MacKenzie Stetzer
Assistant Professor, Department of Physics and Astronomy and the RiSE Center
University of Maine

Targeted Audience: All levels

Instructors at all levels can gain valuable insight into student ideas by carefully examining written student work. While most of us have experience grading student responses to written questions, the use of the same written responses for formative assessment poses its own unique challenges. In this workshop, we will use actual student responses to an optics question in order to explore a variety of issues related to the role of free-response questions in formative assessment.

W17 Stop Sneering at Engineering: Strategies for Exciting & Engaging Your Students

Erika Allison
Project Operations Director, Maine Physical Sciences Partnership
University of Maine

Targeted Audience: Middle and high school science and engineering teachers and post-secondary level post-secondary teacher educators

This hands-on workshop shares research-supported strategies and messages to open up the world of engineering to all students. Come join us as we break down stereotypes and show how creative, collaborative and accessible engineering can be. Participants will discuss videos following student teams through various phases of the engineering design process, and then participate in two hands-on engineering design challenges. This workshop specifically targets participants who feel like they don't know enough about engineering to properly share the field with students, but the workshop would also be fun and suitable for all levels of experience with engineering opportunities.

Poster Abstracts

P1 Examples of Research on Teaching and Learning in the Maine Physical Sciences Partnership

François G. Amar, Associate Professor of Chemistry, and the RiSE Center, University of Maine
Shirly Avargil, Postdoctoral Research Fellow, Maine Physical Sciences Partnership, University of Maine
Mitchell A. Bruce, Associate Professor of Chemistry, and the RiSE Center, University of Maine
Daniel K. Capps, Assistant Professor of Earth Sciences, and the RiSE Center, University of Maine
Jonathan T. Shemwell, Assistant Professor of Science Education, and the RiSE Center, University of Maine
Michelle K. Smith, Assistant Professor of Biology, and the RiSE Center, University of Maine
Natasha M. Speer, Assistant Professor of Mathematics Education, and the RiSE Center, University of Maine
MacKenzie R.Stetzer, Assistant Professor of Physics, and the RiSE Center, University of Maine
John R. Thompson, Associate Professor of Physics, and the RiSE Center, University of Maine
Michael C. Wittmann, Associate Professor of Physics, and the RiSE Center, University of Maine
Bill Zoellick, Director of Education Research and Chief Financial Officer, SERC Institute

The Maine Physical Sciences Partnership (Maine PSP) brings together nearly 50 rural Maine schools, the University of Maine, three Maine non-profits with expertise in science education, and the Maine Department of Education. The focus of the Maine PSP is the professional development (PD) of physical science instructors, both in grades 6-9 and at the University. The mechanisms are curriculum renewal (6-9) and course reform (University). The Maine PSP serves as a context for research on practice, content knowledge, knowledge for teaching, beliefs, epistemology, attitudes, and communities of practice. A team of education researchers in the Maine Center for Research in STEM Education – spanning 5 STEM departments and the College of Education and Human Development – and partner institutions allows for multidisciplinary investigations and multiple perspectives.

P2 Solving Problems Using Recursion: When Students Use Recursion and Why?

Adi Levy Conlogue
Master of Science in Teaching Graduate Student
RiSE Center, University of Maine

Recursion is a key concept in Computer Science. Recursion is the process of repeating items in a self-similar way. Problems can be solved using recursion if one can define the problem into sub-problems. For example, factorial can be solve iteratively and recursively. When defined iteratively, factorial is n • (n-1) • (n-2) • …1. When defined recursively, factorial is n • (n-1)! Students learn and practice this concept during the first programming course, data structures, algorithm design and various other courses throughout the curriculum. Research has shown that recursion can be a very difficult concept to teach as an educator and to learn as a student. Previous studies revealed difficulties of first year students with understanding the concept and applying it in order to solve problems. The goal of this research is to examine when college students choose to use recursion as a strategy to solve algorithmic tasks while programming, and why they choose to use it. The participants in this study were 15 undergraduate students majoring in Computer Science, five undergraduate students majoring in Computer Engineering and three graduate students in Computer Science. Findings indicate that students do not turn to recursion as a strategy to solve algorithmic programming tasks and the analysis sheds some light on the reason why. Implication of these results for teaching purposes will be discussed.

P3 Calculus Students' Understanding of Area and Volume in Non-Calculus Contexts

Allison J. Dorko
Master of Science in Teaching Student
RiSE Center, University of Maine

Researchers have documented difficulties that elementary school students have in understanding area and volume. Although area and volume show up in various ways later in the curriculum, we know very little about older students' understanding of these concepts. The goal of this study is to develop descriptions of calculus students' understanding of area and volume concepts in non-calculus contexts. Participants included 255 introductory calculus students and 43 multivariable calculus students. Clinical interview transcripts and students' written responses to area and volume problems (computational and short answer) were analyzed. Findings from the study indicate that multivariable calculus students struggle with neither the computations nor the units of area and volume problems. In contrast, some differential calculus students struggle with the units associated with various spatial measures. In addition, some differential calculus students mistakenly find surface area when directed to find volume.

P4 The Role of Gesture and the Body in Molecular Geometry

Virginia J. Flood, Master of Science in Teaching student
RiSE Center, University of Maine

François G. Amar, Associate Professor of Chemistry
Department of Chemistry and the RiSE Center, University of Maine

Michael C. Wittmann, Associate Professor of Physics
Department of Physics and Astronomy, and the RiSE Center, University of Maine

Ricardo Nemirovsky, Director, CRMSE (Center for Research in Mathematics and Science Education)
San Diego State University

Mitchell R. M. Bruce, Associate Professor of Chemistry
Department of Chemistry and the RiSE Center, University of Maine

Gesture is inherently linked to how people think and talk about spatial relationships. An important skill in STEM disciplines is the ability to reason and solve problems about complex three-dimensional phenomena. We examine the role of general chemistry students' spontaneously produced body motion as they predict the three-dimensional molecular geometry of the molecule PF5. During descriptions, gesture conveys molecular shape in the absence of technical language, carrying complex spatial information unmentioned in speech. Furthermore, students use their bodies to solve problems in three dimensions. We present the case of a student who cannot recall the particular molecular shape of PF5 and uses his hands as resources to generate and revise a solution and the case of a student who repairs an idea in three-dimensions. Our findings illustrate that our students demonstrate valid body-based nonpropositional forms of knowing and problem solving that are irreducible to other modalities. Successful knowing and problem solving, in the context of molecular geometry, is enacted by the body.

P5 The Battle of the Electric Marimba Bands - A Pilot Project-based STEAM Program

David Harmon[1], Shawn Willis[2], Richard St.-Pierre[1], Nick Caiano[3], Charles Griffin[1]
[1]Make It Science and IBM Systems & Technology
[2]Essex Middle School
[3]NickTheGuitarTeacher.com

When introducing new educational topics in a classroom environment, it is a primary goal to engage a complete cross-section of the students and energize them to apply their knowledge and gain new skills. The *Battle of the Electric Marimba Bands* was a pilot project-based STEAM unit jointly developed by *Essex Middle School* and *Make It Science*, working in conjunction with the *IBM Technical Education Outreach* program. This poster presentation provides an overview of the design sessions, processes and results. The project combined the science and math behind electric marimba instruments with the *Design Cycle* version of the *Scientific Method* and various construction techniques to allow diverse student teams to build operational electric marimbas. Each team was required to (1) fabricate a set of alto, tenor and bass marimbas that incorporated artistic and cultural designs, (2) pick and perform a musical selection requiring all three marimbas, and (3) present their project to an independent panel of judges. Awards were given out based on meeting the goals of a STEAM-centric rubric. The application of science and math to marimba construction was found to be an effective educational tool, which successfully engaged the students.

P6 Student-Teacher Interactions for Bringing out Student Ideas About Energy

Benedikt Harrer[1], Michael Wittmann[2], Rachel Scherr[3]
[1]PhD student, Department of Physics and Astronomy, University of Maine
[2]Associate Professor of Physics, Department of Physics and Astronomy and RiSE Center, University of Maine
[3]Research Assistant Professor, University of Maryland

Modern middle school science curricula use group activities to help students express their thinking and enable them to work together like scientists. We are studying rural 8th grade science classrooms using materials on energy. Even after spending several months with the same curriculum on other physics topics, students' engagement in group activities seems to be restricted to creating lists of words that are associated with energy. Though research suggests that children have rich and potentially valuable ideas about energy, our students don't seem to spontaneously use and express their ideas in the classroom. Only within or after certain interactions with a teacher do students begin to explore and share these ideas. We present and characterize examples of student-teacher interactions resulting in students' deeper engagement with their ideas about energy. This preliminary analysis of video-recorded classroom dialog is a step toward helping teachers improve their students' learning about energy.

P7 Students' Response Patterns to Research Tasks With Alternative Questioning Formats

Jeffrey M. Hawkins[1], Brian W. Frank[2], Michael C. Wittmann[3], John R. Thompson[4]
[1]Ph.D. Student, Department of Physics and Astronomy, University of Maine
[2]Middle Tennessee State University
[3, 4] Associate Professor of Physics, Department of Physics and Astronomy and RiSE Center, University of Maine

Teachers, researchers, and curriculum developers utilize the results of formative assessment to elicit students' pre-instruction physics ideas. In canonical physics education research tasks, students are asked to identify a correct answer and justify their answer choice. However, we find that students often know more than is revealed by their answers to these question formats. In two research tasks, students were either given the correct answer and asked to justify it, or they were asked which response they would eliminate and to provide a justification for why that response is incorrect. These tasks were randomly administered, online, to students in the first semester of an introductory calculus-based physics course. We present results from these pretests, comparing the types of reasoning and frequency of responses across question types. We find that the variations in responses given by students are context dependent.

P8 Student Expectations in a Group Problem-Solving Activity

Adam Kaczynski[1], Michael C. Wittmann[2]
[1]Ph.D. Student, Department of Physics and Astronomy, University of Maine
[2]Associate Professor of Physics, Department of Physics & Astronomy, University of Maine

Students come to any physics course with expectations about the world and about science. Those expectations have an influence on the way that students make observations, reason about phenomena, and draw conclusions. In certain situations, those expectations may be inconsistent with those of the physics community and lead to results that are inconsistent with the body of knowledge in physics. We designed a new group problem solving activity on damped harmonic motion which supports students in finding coherence between multiple representations through discussion of their known models and observations of an under-damped oscillating system. During the activity, students typically showed appropriate expectations when finding coherence between symbolic, graphical, and qualitative representations, but showed inappropriate expectations about problem solving. We will discuss how students' expectations about the starting point of physics problem solving affect their attempts to achieve coherence and draw conclusions.

P9 Avida-ED – Technology for Teaching Evolution and the Nature of Science using Digital Organisms

Amy M. Lark
Doctoral Student, Science Education
College of Education, Michigan State University

Wendy Johnson
Biology Teacher
Lansing Catholic High School

Avida-ED is a program developed at Michigan State University for undergraduate biology courses to help students learn about evolution and scientific method by allowing them to design and perform experiments to test hypotheses about evolutionary mechanisms using evolving digital organisms.

P10 Preliminary Investigations of Physical Science Teacher Content Knowledge and PCK

Daniel P. Laverty[1], John R. Thompson [2], MacKenzie R. Stetzer[3]
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[2]Associate Professor of Physics, and member of the RiSE Center, University of Maine
[3]Assistant Professor of Physics, and member of the RiSE Center, University of Maine

There is ongoing discussion of the extent to which specific strands of teacher professional development influence student learning. We describe research efforts exploring the roles of teacher content knowledge and pedagogical content knowledge, particularly teacher knowledge of student ideas (KSI), in the context of the Maine Physical Sciences Partnership (MainePSP). The primary focus of the MainePSP is the professional development of physical science instructors in grades 6-9 via curriculum renewal using common instructional resources across multiple school districts. This particular study looks to assess teacher content knowledge and KSI in order to explore their respective effects on student learning in specific contexts, including density and mechanics. We will describe our methods, present preliminary results, and outline recommendations for further investigation.

P11 When an Arrow is not A Force: Students' Cognitive Representations of Force Vectors in Introductory Physics

Savannah Lodge-Scharff
Master of Science in Teaching Student
RiSE Center, University of Maine

A significant challenge in learning science and mathematics is building a set of cognitive representations for ideas, which are not initially familiar to the learner. For example, physics students learning about forces must build and coordinate a set of cognitive representations for pushes and pulls, vector arrows, right triangles, and so on. We investigated characteristics of such force representations for eight college physics students who participated in a hands-on laboratory exercise. The data were developed from video analysis of the students' speech and gestures at three key points in the lab. One finding was that significant reasoning stemmed from depictive (i.e., non-lexical) representations such as imagined vector arrows or imagined pulls along particular directions. A second finding was that representations of vector components as arrows were often decoupled from representations of force as pushes or pulls. These findings imply that instruction in forces and their interactions should place greater emphasis on building representations of pushes and pulls, and coordinating these with representations of vector arrows and their components. More broadly, instruction in science stands to benefit from increased understanding of depictive representations as contributors to essential understandings of phenomena.

P12 Investigating Students' Affective Experience in Introductory Physics Courses

Jayson M. Nissen[1], MacKenzie R. Stetzer[2], Jonathan T. Shemwell[3]
[1]PhD Student, Department of Physics and Astronomy, University of Maine
[2]Assistant Professor, Department of Physics and Astronomy, and RiSE Center, University of Maine
[3]Assistant Professor, College of Education and Human Development, University of Maine

Improving non-cognitive outcomes such as attitudes, efficacy, and persistence in physics courses is an important goal in physics education. This investigation implemented an in-the-moment surveying technique called the Experience Sampling Method (ESM) [1] to measure students' affective experience in physics. Measurements included: self esteem, cognitive efficiency, activation, intrinsic motivation and affect. Data are presented showing contrasts in students' experiences, (e.g., in physics vs. non-physics courses).

1) R. Larson, & M. Csikszentmihalyi, (1987). "Validity and Reliability of the Experience-Sampling Method". J Nerv Ment Dis.,175(9):526-36.

P13 Teachers' Experiences Enacting the Next Generation Science Framework: Coming to Terms with New Priorities for Science Learning.

Jonathan Shemwell[1], Shirly Avargil[2], Daniel Capps[3], and Bill Zoellick[4]
[1]Assistant Professor of Education & Cooperating Professor of Physics, University of Maine
[2]Post-doctoral Research Fellow, Physical Sciences Partnership, University of Maine
[3]Assistant Professor of Earth Science, University of Maine
[4] Director of Education Research and Chief Financial Officer, SERC Institute

The Next Generation Science Standards (NGSS) place a high priority on engaging students in science practices such as asking questions, planning and carrying out investigations, constructing arguments, and communicating. The NGSS vision is radical. It proposes that science practices should be so tightly bound to other aspects of science knowing (e.g., concepts, principles) as to be inextricable from them. Questions abound as to how science teachers will respond to this vision. For instance, how will teachers respond to the increased emphasis on learning science practices? This question and others are now being addressed in ongoing research which is the subject of the talk. Data will be presented from analysis of journals and interviews from a group of experienced middle school science teachers in central Maine who are in their first year of using NGSS-inspired curriculum materials. The data reveal a tension between appreciation for authentic learning of science practices and "traditional" values such as the need to make progress and meet state content standards. This tension suggests several ways in which teachers should be supported in reconstructing their practice to meet NGSS. Important among these are transitional changes to existing state standards and professional development addressing the tensions that arise from re-prioritization. This talk is suitable for all science education audiences.

P14 Assessing and Enhancing Student Understanding of Carbon Cycling in the Biosphere: A Case Study

Kara M. Soule[1], Molly Schauffler[2], C. Gerbi[3], F. Dastoor[4] and K. Pelletreau[5]

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[4]School of Biology and Ecology, University of Maine
[5]Department of Molecular and Biomedical Sciences, University of Maine

Encouraging and scaffolding student understanding of the dynamic systems and processes that transform carbon within the biosphere is an important step in preparing them to make informed and proactive decisions pertaining to global climate change. The goals of this research are to: 1. Assess students' understanding of carbon flow through these dynamic systems and processes; and 2. Implement and evaluate a pedagogically based laboratory that is designed to enhance student understanding by building upon their conceptual strengths and weaknesses identified in the initial assessment. The pilot portion of this study conducted in spring 2011 assessed what first-year Introductory Biology students understand about the interrelated roles photosynthesis, cellular respiration, ingestion and biosynthesis play in moving carbon through living organisms and the biosphere. The results from the pilot-study were then used to inform the generation of two pedagogically based laboratories that cover both photosynthesis and cellular respiration. These labs were then implemented in the fall 2011 semester in the inquiry-based laboratories of the Introductory Biology course at the University of Maine. Student understanding was assessed at four different points in the semester: 1. Pre-semester, 2. Pre-unit, 3. Post-unit, and 4. Post- semester. Questions were identical for the first three assessments, but differed on the post-semester assessment. The intent was to see if the strategies used in the two generated laboratories elicited different responses from students than the traditional *Photosynthesis* laboratory. This poster explores the findings from this study and makes general suggestions for instructional strategies in teaching these concepts.

P15 Understanding Natural Selection

Emily L. Spaulding

Jax Sabbatical Research Internship Program
University of Maine

As the oft quoted geneticist, Theodosius Dobzhansky famously stated in 1973, "nothing in biology makes sense except in the light of evolution." This statement still holds great truth today, yet in many classrooms students receive little instruction on the subject, and what they do receive leaves them riddled with misconceptions. Here an inquiry-based, case study approach is used as an alternative to the traditional ways of teaching this essential piece of the biology curriculum. This three week unit, developed as part of the Research Internship Sabbatical supported by the URiSE Center and the Jackson Laboratory, focuses on introducing students to the key components of evolutionary biology with a strong emphasis on Darwin's model of natural selection. The classroom will model a community of evolutionary scientists in which students solve realistic problems and engage in public debate and communication of their work. Inquiry settings are designed so that students will gain experience creating and justifying explanations of natural phenomena in the context of Darwin's theory of natural selection, naturally leading them to a fuller, more realistic understanding of the nature of science. This poster reports the learning results of implementing the unit in May 2012 to 10th grade Biology students.

P16 Opportunities for Student Achievement through Outreach and "Upreach" with UMaine's Mainely Physics

David E G Sturm
Instructional Lab & Lecture Demonstration Specialist, Department of Physics and Astronomy
University of Maine

For over seven years (and longer in previous incarnations) the Mainely Physics Road Show has provided physics outreach to a number of PSP participant schools. This poster includes a summary of that history. Adding "upreach" opportunities for student achievement, Mainely Physics has become the statewide host/organizer for the Maine Middle School State Science Olympiad (M^2S^3O). Also, a new outreach variation called Mainely Physics: P.S.I. (Physics Scene Investigation) alters the Road Show concept into a 'physics hands-on event' with multiple "content learning unit environments" (CLUEs) with 50 or so stations of a variety of experiments in the fashion of Colorado State University's Little Shop of Physics. Opportunities exist for studies of the impact on the impact on student achievement with all these events, and the poster suggests a CLASS-type survey for pre- and post-events to study further the impact of such outreach and upreach. Studies such as Abernaty and Vineyard's in _The Clearing

House_Vol. 74, No. 5, pp. 269-276 http://www.jstor.org/stable/30189679 strongly suggest this is a potential area for further research.

P17 Assessment of Undergraduate Content Knowledge and Relationships to Self-Reported Confidence

Ryan Weatherbee
Master of Science in Teaching Graduate Student
RiSE Center, University of Maine

This project involves developing and piloting a content knowledge assessment tool that will be used to track changes in understanding throughout an undergraduate marine sciences program. The assessment development involved several steps including: interviews with faculty to determine the implemented curriculum, identification of common misconceptions from student writings, drafting of the assessment questions, feedback from faculty about the scientific accuracy of the questions, deploying the assessment to a pilot group, refining questions based on pilot-group responses and interviews and finally deployment of the final version of the assessment to the entire population of students. Following each of the 15 questions on the assessment, students were asked the rate how sure they were of their response to the question on a Likert-type scale ranging from “I guessed” to “Extremely sure”. This poster will focus on the relationships we found between student achievement on the content knowledge questions and how they self-reported their confidence with the material.

P18 Development and Implementation of a High School Meiosis Curriculum

Ashley Young[1], Molly Schauffler[2], and Michelle Smith[3]
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[2]Assistant Professor, Department of Earth Sciences
[3]Assistant Professor, School of Biology and Ecology
RiSE Center, University of Maine

During spring 2012, I worked 30 hours/week in the Handel lab at the Jackson Laboratory in Bar Harbor, Maine as part of a research internship program sponsored by the University of RiSE Center and the Jackson Laboratory. As part of the associated MST course *Research-related Curriculum Development in Science and Mathematics* offered to the interns, I developed a 5-day inquiry-based lesson plan on meiosis that I implemented in a 12th grade Anatomy and Physiology class at Bangor Christian School. The unit was designed using research-based literature on student understanding of meiosis and targets both national and State (Maine) learning standards. The poster presents results of student learning during implementation of the curriculum based on pre/post surveys of understanding as well as performance on an activity modeling meiosis using pipe cleaners. After completing the unit, students had a deeper understanding of the importance of meiosis, the steps of meiosis, the role of independent assortment of chromosomes in the creation of genetic diversity, and causes/consequences of errors in meiosis, but they still had trouble connecting the process with alleles of genes on chromosomes.

P19 Who Do You Turn To? How Teachers Support Each Other in the Maine PSP Project

Bill Zoellick[1], Dan Capps[2], Jon Shemwell[3], Shirly Avargil[4]
[1]Director of Education Research and Chief Financial Officer, SERC Institute
[2]Assistant Professor, Department of Earth Sciences, University of Maine
[3]Assistant Professor, College of Education and Human Development, University of Maine
[4]Postdoctoral Research Fellow, Maine Physical Sciences Partnership, University of Maine

Interactions between teachers are an important component of Professional Development (PD) for teachers in the MainePSP project. The “Collaboratives,” cohort meetings, summer academies, and other PD elements all create opportunities for teachers to work with teachers. MainePSP’s design intent is that, once working relationships between teachers are initiated, they will continue to grow and serve the day-to-day needs of teachers without depending on a MainePSP event to make interactions happen. How do we know that such growth in teacher-to-teacher support is taking place?

Researchers working with the MainePSP seek to answer this question by surveying teachers each spring, asking them whom they turn to for advice. We ask about different kinds of advice, including advice on subject matter, planning of lessons, assessment, and so on. We also ask whether a teacher’s reliance on colleagues is increasing or decreasing and how they are interacting (e.g., at school, at PSP events, or virtually).

We use these responses to create diagrams that show how richly connected the teachers are to each other: each teacher is a dot connected by lines to other dots. By coloring the dots according to different attributes such as membership in a school district we can see whether there are more connections between teachers in different school districts over time.

Continuing Education Unit (CEU) Information
Conference Services Division
The University of Maine

The CEU Application Process

The CEU application should be completed by the sponsor or agency overseeing both the educational activity and instruction. The completed form should be returned to: Conference Services Division, Third Floor Chadbourne Hall, Orono, Maine 04469-5713 along with a $10.00 application fee. The form may also be faxed to: 207/581-4097. Applications not accompanied with the proper payment cannot be processed. Checks should be payable to the University of Maine. The approval process generally takes a minimum of 10 working days. All CEU applications **must be pre-approved**. Approval of educational activities after-the-fact is NOT an option.

Upon completing the CEU application process, the Conference Services Division will assign a CEU number to the application and return the original form to the originator along with a CEU Participant Form. The CEU Participant Form may be copied and distributed to each participant. The participant should be responsible for sending back the completed CEU Participant Form. BOTH the participant's biographical information section and the CEU sponsor's or the sponsor's representative's signature verifying the attendance and participation of the participant must be filled out. A $10.00 processing fee must also accompany the completed CEU Participant Form.

The CEU Participant Form has no expiration timeline and therefore is valid whenever the participant chooses to return it to the Conference Services Division. The form must be completed in full with the signature of the original sponsor.

The Conference Services Division will then issue an official University of Maine transcript to the participant. All participants' CEU activities taken under the auspices of the University of Maine is comprehensively archived, i.e., each participant's CEU activity will be added to any previous CEU activities. CEU credit is **<u>not</u>** transferable to academic credit.

Further inquiries about the CEU application process should be directed to: Bruce Stinson, Director, Conference Services Division at 207/581-4091.

About the Continuing Education Unit (CEU)

The Continuing Education Unit (CEU) has been designed as a uniform unit of measurement to facilitate the accumulation and exchange of standardized information about individual participation in non-academic credit continuing education programs. The CEU permits the individual to participate in many different kinds of programs while accumulating a uniform record available for future reference.

One Continuing Education Unit is defined as ten contact hours of participation in an organized continuing education experience under responsible sponsorship, capable direction, and qualified instruction.
Examples:

- 5 hour workshop would award 0.5 CEU
- 10 hour workshop would award 1.0 CEU
- 22 hour workshop would award 2.2 CEU
- 45 hour workshop would award 4.5 CEU

Recertification: Since Continuing Education Units are based on ten hours of participation for each unit and recertification credits are based on 15 hours of participation for each credit, recertification CEUs are awarded on a 2/3 ratio.
Examples:

- 1.5 CEU is equal to 1 recertification credit
- 3.0 CEU is equal to 2 recertification credit
- 4.5 CEU is equal to 3 recertification credit
- 9.0 CEU is equal to 6 recertification credit