7th Annual
STEM Education Research Conference
February 7-8, 2013
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Welcome from Director
Tom Cheatham

Seventh Annual MTSU STEM Education Research Conference
DoubleTree Hotel, Murfreesboro, TN
February 7-8, 2013

Science, Technology, Engineering and Mathematics (STEM) are exciting disciplines to learn and teach. We all know the important role that STEM plays in our world/national/state/local economy. The Tennessee STEM Education Center (TSEC) at Middle Tennessee State University (MTSU) is pleased to organize the Seventh Annual MTSU STEM Education Research Conference focusing on research on teaching and learning in STEM in K-20. As suggested in Rising Above the Gathering Storm the key to a healthier STEM pipeline is “better teachers.” We improve teaching and learning by studying teaching and learning and experimenting with new ways of teaching and learning—by doing research on teaching and learning. This conference is dedicated to such a goal. We will hear from Dr. David Hestenes, Science Modeling Institute and Arizona State University, and Dr. Ling Liang, Lasalle University, about national initiatives to reform science education. Among ideas that Dr. Hestenes will mention is the Modeling Instruction pedagogy that he helped launch for high school physics. Dr. Liang will look at the impact of inverting the order of the high school science curriculum by teaching conceptual physics in 9th grade, chemistry in 10th grade, and molecular biology in 11th grade. Dr. Angela Barlow, Director of the MTSU Ph.D. Program in Mathematics and Science Education, will describe work to improve teaching and learning of mathematics in the elementary grades.

Focusing more on Tennessee, Ms. Jamie Woodson, President and CEO of Tennessee State Collaborative on Reforming Education (SCORE), will provide an update of progress in K-12 education since former Senate Majority Leader Bill Frist launched the SCORE organization. A government panel will highlight new and exciting program underway and update participants on progress from existing programs. The Panel consists of Dr. David Sevier, Tennessee Board of Education, Ms. Linda Jordan, Tennessee Department of Education, Dr. Sally Pardue, Tennessee Technological University on behalf of TSIN, and Ms. Kathryn Meyer, First-to-the-Top. We have 16 great breakout presentations for you to choose from plus Richard Audet’s book discussion on Creating Innovators. There will be great food, time to discuss old projects and new ideas, renew acquaintances and make new friends. We are excited to partner with you in collaborative efforts to improve learning and teaching in STEM from kindergarten to graduate school. The conference is possible because of continuing support from the Tennessee Space Grant Consortium and the MTSU Office of Research Services. Special thanks to Dr. Mark Abolins, the MTSU PI for the Space Grant. Enjoy the conference!
Agenda
MTSU STEM Education Research Conference
February 7-8, 2013
DoubleTree Hotel
1850 Old Fort Pkwy
Murfreesboro, TN 37129

{There is a pre-conference meeting of the STEM Education Leadership Council, 9:30 AM - 12:00 PM}

Thursday, February 7, 2013

12:00 – 1:00  Registration
1:00 – 1:30  Welcome and Announcements
  Dr. Tom Cheatham, Director, Tennessee STEM Education Center, MTSU
  Dr. Mike Allen, Vice Provost for Research & Dean Graduate College, MTSU
  Dr. Mark Abolins, PI NASA Space Grant & Professor Geoscience, MTSU

1:30 – 2:30  Mathematics Education Keynote
  Dr. Angela Barlow
  Facilitator - Diane Miller
  Reform-oriented Mathematics Teaching: The Impact of Observing Practice on Beliefs
  Dr. Angela Barlow, Professor and Director of Math and Science Education Ph.D. Program
  Middle Tennessee State University, Murfreesboro, TN

2:35 – 3:35  Science Education Keynote
  Dr. Ling Liang
  Facilitator: Steve Robinson
  Advantages of Modeling in a Physics-First (Inverted) Curriculum
  Dr. Ling Liang, Associate Professor of Science Education
  School of Arts and Science, Lasalle University, Philadelphia, PA

3:40 – 4:00  Break
4:00 – 4:25  Update on PK-12 Educational Progress in Tennessee
  Facilitator - Leigh Gostowski
  Ms. Jamie Woodson, President and CEO of Tennessee SCORE

4:30 – 5:00  Tennessee Government Panel
  Facilitator - Tom Cheatham
  Ms. Linda Jordan, STEM Coordinator, TN Department of Education
  Dr. David Sevier, Deputy Director, TN Board of Education
  Dr. Sally Pardue (for TSIN), Director, Oakley STEM Center at TN Tech University
  Ms. Kathryn Meyer, STEM Coordinator, First-to-the-Top

5:00 – 6:00  Setup for Dinner (all leave the ballroom area)
6:00 – 7:45  Dinner and Science Education Keynote
  David Hestenes
  Facilitator - Robert Carlton
  An Engine for STEM Education Reform
  Dr. David Hestenes, Director, Science Modeling Institute
  Academy of Science and Arts & Emeritus Professor of Physics
  Arizona State University, Tempe, AZ
Friday, February 8, 2013

7:30 – 8:25  Breakfast
8:30 – 10:00  Concurrent Breakout Session 1 (talks are 20 minutes plus 10 minutes for questions)

**K-12 Research (Ballroom A)**
Facilitator - Kim Sadler
- The NSF GK-12 TRIAD Project: Lessons learned from Bringing Together Higher Education, Industry, and K-12 Communities in Middle Tennessee, Tony Farone
- STEM Summer Institute - A Model Program for STEM Integration for Girls, Crystal Chukwurah and Stacy Klein-Gardner
- Evaluation of Aviation Activities for STEM Development in High School Students, Wendy Beckman

**Science Education Research (Ballroom B)**
Facilitator - Rebecca Seipelt-Thiemann
- Assessing Science Literacy Skills in an Undergraduate Biology Course for Non-Majors, D. Michelle Rogers
- The Impact of Forming a STEM Experiential Learning community and Integrating Science Content in Non-Science and Elementary Education Majors and in high School Science Teachers' Professional Development, Ben Hutchinson, Todd Gary, Leigh Arino de la Rubia
- Questioning As Science and Questioning as Learning, Aydeniz Mehmet

**Math Education Research (Ballroom C)**
Facilitator - Julianna Gregory
- Course Redesign to Deepen Early Mathematical Experiences of Pre-Service K-8 Teachers, Ann Assad, Audrey Bullock, Jennifer Fillingim, Jackie Vogel
- Assisting a Teacher’s Transition to Using Active Learning in Introductory Statistics: An Initial Assessment, Lisa Green, Scott McDaniel, Nancy McCormick, Jeremy Strayer, Ginger Holmes Rowell, Natasha Gerstenschlager, Brandon Hanson
- Using Video as a Stimulus to Reveal Elementary Teachers’ Mathematical Knowledge for Teaching, Angela Barlow, Wesley A. Baxter, Angeline K. Gaddy

10:00 – 10:30  Break/Discussions
10:30 – 12:00  Concurrent Breakout Session 2 (talks are 20 minutes plus 10 minutes for questions)

**K-12 Research (Ballroom A)**
Facilitator - Kim Sadler
- Effectiveness of the Modeling Method Pedagogy in Montgomery County, Tennessee Secondary Biology Classrooms, Kate A. Fields, Willodean D.S. Burton, Sheila Pirkle
- The Impact of the Inverting Curriculum and Modeling Instruction on Student Achievement in Science, Jennifer Dye, Tom Cheatham, Ginger Holmes Rowell, Angela Barlow, Robert Carlton
- Modeling Instruction: The Impact of Professional Development on Instructional Practices, Angela Barlow, Heather L. Barker, Tasha M. Frick

**Science Education Research (Ballroom B)**
Facilitator - Rebecca Seipelt-Thiemann
- Inquiry-based Physics and Physical Science in a Large Lecture-Hall Environment, Steve Robinson
- Learner-centered Environment for Algebra-based Physics, Paula V. Engelhardt
- Using Bloom's Taxonomy to Examine the Depth of a Three-week, Introductory Research Experience for college STEM Undergraduates, Brittany Smith, Jennifer Yantz, Ginger Holmes Rowell, Chris Stephens, Don Nelson, Elaine Tenpenny, Tom Cheatham

**STEM Education Research (Ballroom C)**
Facilitator - Richard Audet
- Enhancing STEM Learning Through an Interdisciplinary Research Centered-Curriculum, Tiffany Farmer, Kimberly Mulligan, Virginia Shepherd
- Book Discussion (one hour, led by Richard Audet)
Creating Innovators by Tony Wagner
[http://www.educationfutures.com/2012/05/18/review-creating-innovators-by-tony-wagner/](http://www.educationfutures.com/2012/05/18/review-creating-innovators-by-tony-wagner/)

12:00 - 12:30  Lunch/Depart
Mathematics Education Keynote

Reform-oriented Mathematics Teaching: The Impact of Observing Practice on Beliefs
Angela Barlow

With the adoption of the Common Core State Standards for Mathematics, the need to improve instructional practices is paramount as all students are expected to develop proficiency in both mathematical content and mathematical practices. For most mathematics teachers, the necessary change in instructional practices is transformative in nature, as opposed to additive. Yet it is well documented in the literature that US teachers do not currently hold beliefs about instruction that will support such a change towards reform-oriented teaching. In this talk, we will examine the instructional shift represented by reform-oriented mathematics teaching along with the results of three research studies that examined the impact of observing reform-oriented teaching on teachers’ beliefs about the teaching and learning of mathematics.
Science Education Keynote

Ling Liang, Associate Professor of Science Education
School of Arts and Science, La Salle University, Philadelphia, PA

The Effects of a Model-Based Physics Curriculum with a Physics First Approach
Ling Liang

This presentation will start with a brief description of the Physics First (PF) approach and its implementation in the schools. Then, the major theoretical frameworks guiding my research study on the model-based physics curriculum in PF and some key findings will be presented. Other PF related research will also be briefly examined and discussed. Finally, the presentation will conclude with some thoughts about future research related to PF and model-based science curriculum and potential collaborations with researchers in the international science education community.
Update on PK-12 Educational Progress in Tennessee

Jamie Woodson
President and CEO of Tennessee SCORE
Nashville, TN

Jamie Woodson guides SCORE’s work as President and CEO and has been a leading figure in spearheading Tennessee’s education reform efforts. Prior to joining SCORE, she served for over twelve years in the Tennessee General Assembly in both the House and Senate (1999-2011). As Chairman of the Senate Education Committee and later as Senate Speaker Pro Tempore, Woodson was a key leader in Tennessee’s First to the Top Act, the largest piece of education reform legislation since 1992. In addition, she sponsored the overhaul of Tennessee’s K-12 education funding formula and led the effort to reform Tennessee’s public charter school laws.

Woodson serves on numerous statewide boards including the First to the Top Advisory Council and the Tennessee Business Roundtable.

Woodson received a Bachelor of Arts and Doctor of Jurisprudence from the University of Tennessee at Knoxville. She was selected as “Torchbearer” which is the highest honor an undergraduate may receive from the University. Woodson attended public schools in Tennessee.
Tennessee Government Panel

Update from First to the Top
Kathryn Meyer, THEC First to the Top Program Coordinator

During this session, an update will be provided on two of the First to the Top STEM programs housed in higher education institutions. The UTeach program is being replicated at four institutions statewide and uses an innovative approach to training future math and science teachers. The STEM Professional Development grant program focuses on using the expertise of higher education faculty in increasing the effectiveness of K-12 STEM teachers.

Update from the Tennessee Board of Education
David Sevier, Deputy Executive Director of the State Board of Education

An update on issues surrounding school reform, curriculum, teacher preparation and licensure, and STEM education will be provided.

Update from the Tennessee STEM Innovation Network
Sally Pardue, Director Millard Oakley STEM Center, TN Tech University

From Memphis to Kingsport, the TSIN's regional STEM Innovation Hubs and associated STEM Platform Schools are working to support local innovation in education by aligning educators, business partners, and civic organizations. Dr. Pardue will share examples from the work of the TSIN hub she directs, the Upper Cumberland Rural STEM Initiative housed at Tennessee Tech’s Oakley STEM Center.

Update from the Tennessee Department of Education
Linda Jordan, Science Specialist Tennessee Dept. of Education

An update on math and science programs and activities from the Tennessee Department of Education will be provided including Common Core State Standards in Mathematics and Next Generation Science Standards.
Dinner Speaker and Science Keynote

David Hestenes, Director, Science Modeling Institute
Academy of Science and Arts & Emeritus Professor of Physics
Arizona State University, Tempe, AZ

An Engine for STEM Education Reform
David Hestenes

Rapid emergence of a global economy driven by science and technology has precipitated a crisis in the U.S. education system. Cries of alarm continue to echo throughout the news media as U.S. education falls further and further behind — not only behind the pace of technological change, but also the educational performance of other countries. In response, a national consensus has emerged calling for comprehensive K-12 STEM education reform.

However, the U.S. education system, with critical functions and responsibilities dispersed among schools, school districts, colleges of education and government agencies, has proven to be too ponderous and unfocussed to enact timely, significant reform. Briefly put, our education system lacks institutional mechanisms for rapid adaptive change.

Ultimately, all reform is local. Therefore, the key to education reform is empowering teachers as agents of change. We discuss how the STEM education crisis can be addressed by incorporating this principle in the design of a robust engine to drive rapid, deep and sustained STEM education reform nationwide.
The 21st Century has been called the “century of the life sciences” because of advances such as the human genome project. Using cellular and molecular biology as the theme, the TRIAD (Teaching, Research, and Industry Applications to Deepen Scientific Understanding) program formed collaborative teams of graduate students (GF), high school biology/chemistry teachers (PT), and biotechnology/biomedical industry partners (IP) to expand GF understanding of how to better apply the knowledge and skill set gained through graduate study to solving current biological challenges. An anticipated outcome of this three-fold partnership is to improve leadership, communication and team-building skills of the GF. This collaborative approach to graduate-level instruction could provide greater depth and understanding for content at all levels, creating greater interest in STEM professions, and result in scientists better prepared to meet the challenges of scientific investigation. Several studies have examined aspects of the GK-12 program as it relates to the GF (Buck et al. 2006; Feldon et al. 2011; McBride 2011; Trautmann 2008). The literature is developing as GK-12 programs share outcomes related to the impact of interacting with a ‘scientist in residence’ on the PT (Baumgartner 2009; Thompson 2002) and K-12 students (Beghetto et al. 2009; Gengarelly 2009).
STEM Summer Institute: A Model Program for STEM Integration for Girls

Stacy S. Klein-Gardner, Crystal Chukwurah
Vanderbilt University

The less than 20 percent of woman and minorities in engineering, and other STEM fields, is well documented (Koebler, 2011). While one cannot force persons into a given field, students ought to be exposed to these disciplines, giving them a vision of their potential futures. Attitudes and perceptions of what individuals want to become develop early in the secondary education process (Burke, R. J., 2007). Recruitment of K-12 students, specifically girls, toward studies and careers in engineering is a challenging task. One of the ways the Center for STEM Education for Girls is working to meet these challenges is through its two-week STEM Summer Institute (SSI) for students who are interested in STEM topics, but whose schools do not meet their needs fully. Over its five-year projection, the program goals are to increase self-efficacy and the understanding of engineering in girls by incorporating STEM into service learning and placing it within a global context. The first summer of the SSI is described and assessed in this paper.

Rising concern about America’s ability to maintain its competitive position in the global economy has renewed interest in Science, Technology, Engineering, and Mathematics (STEM) education (Chen, 2009). The economy of the United States depends upon engineering and technology advancement. While low-skilled jobs are disappearing and highly skilled professionals of developed nations are increasingly filling technical jobs, the growth of jobs in the STEM workforce is outpacing overall job growth by 3:1 (Lam, 2011; National Science Board, 2008). If there is such high rate in job growth, why are there so few people, specifically among women and minorities, entering the STEM field?

The answer to this question may be found at the root of education: K-12 education. Although children are natural engineers, with strong impulses to investigate, construct, create, and share their knowledge with others (Genalo et al., 2000), current curricula does not take advantage of their natural curiosity. Therefore, children’s natural curiosity and their ability to analyze, develop, build, and test as engineers and scientists may be stifled in school. K-12 students tend to shy away from engineering fields simply because they have a limited understanding of engineering (Jeffer, Safferman, and Safferman, 2004). It does not help that many K-12 teachers have just as limited an understanding of engineering as the students do (Fadali et al., 2000). Unless students have family members or friends who are engineers, they are often never introduced to the field (Abbitt and Carroll, 1993).
Evaluation of Aviation Activities for STEM Development in High School Students

Wendy Beckman
Middle Tennessee State University

In June of 2012, a week long aviation camp was conducted by the MTSU Aerospace Department for high school students in the middle Tennessee area. The camp was held primarily at the MTSU flight school at the Murfreesboro Airport, with one day of activities conducted on the MTSU campus. Since aviation is a high-interest area for many students, offering aviation-based experiences to students has proven a good way to incorporate STEM basics in a fun and interesting manner, as evidenced by the number of aviation camps sponsored by various groups across the country. The current national focus on increasing student proficiency and interest in the STEM disciplines offers the opportunity for educators to use aviation to teach students a variety of STEM skills. The purpose of this presentation will be to: 1) explain briefly the aviation activities that were conducted at the camp, 2) share the student responses to the activities, 3) share the impact of these activities on student subject matter knowledge and, 4) discuss the activities that can be conducted in a classroom environment.

Important concepts related to aviation were introduced through the conduct of 20 activities during the camp. Listed below, in order of the average of the student rankings of both how much they enjoyed and how much they learned from each experience, the camp activities included:

- Flight in a Diamondstar aircraft
- Piloting a full scale simulator of a Diamondstar aircraft
- Cockpit familiarization session with Diamondstar aircraft
- Piloting Microsoft Flight Simulator laptop kits
- Experiencing the Air Traffic Control simulator room on campus
- Pre-flighting a Diamondstar aircraft
- Air Traffic Control lesson
- G-1000 (glass cockpit) lesson
- Aviation career session
- Airport operations
- Unmanned aerial systems session
- Determining aircraft performance
- Aerodynamics
- Determining aircraft weight and balance
- Building gliders
- Utilizing aviation charts
- Aircraft systems session
- Introduction to aircraft maintenance session
- Cross country flight planning
- Impact of weather on aviation operations lesson
Assessing Science Literacy Skills in an Undergraduate Biology Course for Non-majors

D. Michelle Rogers
Austin Peay State University

The central questions of this research were 1) whether a core science course for non-majors improves the science reasoning skills of students and 2) whether purposeful teaching of science reasoning skills through active learning pedagogy can produce a greater increase in those skills than the standard curriculum alone.

A number of previous studies with adults and children have shown that purposeful instruction in the skills of science reasoning and inquiry can produce significant, lasting transferable results. (Kuhn, et al. 1995; Chen and Klahr, 1999; Kesselman, 2003; Miri and Uri, 2007).

The specific skills under consideration are variously referred to as “science reasoning skills” or “science literacy skills” and are closely related to skills often called “critical thinking” or “reasoning skills.” The following list of skills based on a review of relevant literature and assessments was developed as a guide for modifications to the course. (American Association for the Advancement of Science, 1990; Brickman, et al., 2009; CAAP Science Test, 2011; Derry, 2000; Keeports, 1994; Meinwald, 2010).

1. Develop testable scientific hypotheses and design simple experiments.
2. Assess whether scientific evidence supports a hypothesis.
3. Evaluate and compare sources of scientific information.
4. Understand basic elements of research design (e.g., correlative vs. experimental research, randomization, sample size, etc.).
5. Interpret various presentations of data: text, tables, graphs and diagrams.
6. Interpret basic statistics in the reporting of scientific research.
7. Construct arguments in support of conclusions and predictions based on data.

The course under study was BIOL 1010 Principles of Life, a course for non-majors which fulfills general education requirements at Austin Peay State University.

The primary assessment instrument used was the Science Literacy Skills Inventory (SLSI) developed by Dr. Peggy Brickman of the University of Georgia. It is a 28-question multiple-choice test. The SLSI was administered to approximately 80 students in one section of the course in fall 2011 as a pre- and post- test to obtain a baseline of student performance and improvements after completion of the course. During the spring 2012 semester, the SLSI was administered to one section of the course as a control and another section of the course taught with an experimentally modified curriculum intended to address science literacy skills.

The results of the study suggest the difficulty of addressing these complex, critical thinking skills at this level. Neither the original nor the modified versions of the course led to significant improvement of students’ SLSI scores. Future studies in this situation might benefit from a more targeted approach addressing a subset of these skills.
The Impact of Forming a STEM Experiential Learning Community and Integrating Science Content in Non-science and Elementary Education Majors and in High School Science Teachers’ Professional Development.

Ben Hutchinson and Todd Gary
Lipscomb University
Leigh Arino de la Rubia
Tennessee State University

There has been a significant focus on science, technology, engineering and mathematics (STEM) education at both the state and national levels (Carke-Midura, et al, 2011; Lavrakas, 2012; National Research Council, 2010 & 2012). This includes focus on increasing college graduate in STEM disciplines, strengthening STEM courses for both non-science and elementary education majors and supporting professional development for practicing teachers. Over the past five year, Lipscomb University (LU) has developed innovative ways to redesign STEM courses, programs, and professional development for teachers. This has resulted in tremendous growth in STEM majors, programs and degrees. This growth includes the establishment of seven new STEM programs, a 75% increase in undergraduate STEM majors and 100% increase in STEM degrees in the past five years.

The innovations for non-science and elementary education majors involved the development of integrated science courses funded by an NSF Science Education for New Civic Engagements and Responsibilities (SENCER) award and supported by LU’s SALT (Service and Learning Together) program. The LU Integrated Science Course sequence consisted of a year-long trans-disciplinary team-taught science course with a strong service learning component. A community of learners is developed, and science is modeled in a way that is supportive of the development of elementary teachers. The content is taught in modules focused on the physical and life science content of the PRAXIS. The content is delivered in a trans-disciplinary manner. This is different from a inter-disciplinary approach in that faculty from several disciplines (biology, chemistry, nutrition, and physics) are brought together to illustrate how their combined disciplines function together to approach current scientific problems (Domik & Fischer, 2011; Park & Son, 2010). This model was used with high school teachers involved in professional development that supported forming STEM experiential learning communities between teacher teams and within their classrooms.

The following research questions were posed. 1) Is there a difference in student’s content knowledge and attitude between student’s attending traditional undergraduate science course vs. integrated science course? 2) Is there an appropriate way to integrate science and the arts to future teachers? 3) Will methods be introduced and sustained in the classroom of practicing teachers?

Assessment instruments were developed and given to students in both the traditional and integrated science courses and to high school teachers involved in professional development. The results are guiding LU’s efforts to sustain these innovations and support the STEM development of both pre-service and practicing teachers. We have begun to examine how students’ content knowledge changes and collecting quantitative feedback on the effectiveness of the course, while combining this with student views of the nature of science gives a more complete picture of the science these teachers intend to teach in their future classrooms.
Questioning As Science and Questioning As Learning: Enhancing Science Teachers’ Questioning Practices

Mehmet Aydeniz
The University of Tennessee, Knoxville

The purpose of this presentation is to highlight the importance of questions and questioning in science and in education of children in science classrooms. This presentation will provide an overview of questioning from a cognitive complexity perspective and highlight the importance of teachers’ questioning practices in shaping classroom discourse and in students’ understanding of core scientific ideas and processes. Finally, the implications for teacher professional development and educational research will be discussed.
Course Redesign to Deepen Early Mathematical Experiences of Pre-Service K-8 Teachers

Ann Assad, Audrey Bullock, Jennifer Fillingim, Jackie Vogel
Austin Peay State University

Two pilot projects are described. In fall 2011 and fall 2012, the researchers aimed to redesign and revitalize freshman level courses for pre-service K-8 teachers.

The projects had the following goals.
1. Increase student success rates.
2. Improve students' perceptions of the usefulness of course content and its implementation in the K-8 classroom.
3. Deepen students' understanding of the role of problem solving in the teaching and learning of mathematics.

The Conference Board of the Mathematical Sciences (CBMS) recommends that mathematics courses for pre-service teachers should, “...develop the habits of mind of a mathematical thinker, such as reasoning and explaining, modeling, seeing structure, and generalizing.” (2012, p. 8).

Traditional college mathematics courses may not provide opportunities to develop these habits. For example, for mathematicians, algorithms and theorems provide means to move on to increasingly sophisticated structures of mathematics. According to the National Research Council (NRC), “Teaching, however, entails reversing the direction followed in learning advanced mathematics. In helping students learn, teachers must take abstract ideas and unpack them in ways that make the basic underlying concepts visible.” (2001, p. 376)
The American Statistical Association endorses the Guidelines for Assessment and Instruction in Statistics Education (GAISE) (Aliaga, et. al., 2005), which include using active learning to effectively teach statistical concepts. However, many professors in college introductory statistics courses still use lecture as the primary method of instruction. Faculty at Middle Tennessee State University are working to develop learning modules that help instructors make a successful transition to using active teaching methods to teach introductory statistics. This project, called Modules for Teaching Statistics with Pedagogies using Active Learning (MTStatPAL), is developing a series of technology-facilitated learning modules that support the implementation of activities designed to teach specific statistical topics.

Each module includes both a pre-class activity and an in-class activity for students. Each module also contains instructor materials including an activity description with a script, a video of an experienced professor completing the activity with a class, and assessment questions and solutions.

MTStatPAL investigates the effectiveness of the modules in this ongoing project using design experiment methodology (Cobb, diSessa, Lehrer, & Schauble, 2003). The project collects both quantitative and qualitative data and empirically analyzes that data to learn: 1) How the elements of the introductory statistics learning ecology (tasks students solve, kinds of classroom discourse, norms of participation, tools used for learning, and the practical ways the teacher orchestrates relations between these elements) are impacted by the implementation of MTStatPAL modules. 2) How student statistical reasoning changes as a result of completing MTStatPAL modules. 3) How faculty adapt to teaching with MTStatPAL modules.

This presentation reports findings that address goals 1 and 3 above. Faculty and students who completed an MTStatPAL module in the fall of 2012 completed surveys to measure their perceptions of how well they were able to teach and learn, respectively, with the modules. The MTStatPAL team also used the Reformed Teaching Observation Protocol (RTOP) to observe classroom instruction for MTStatPAL module and non-module lessons in two different classrooms. The RTOP measures how well classroom instruction aligns with the type of reform-based teaching endorsed in the GAISE report.
Educators recognize that mathematical knowledge is essential to effective teaching (Darling-Hammond, 2005; Hill, Sleep, Lewis, & Ball, 2007; Howard & Aleman, 2008). Yet, mathematical knowledge alone may be insufficient (Hill et al., 2007). Therefore, the Mathematical Knowledge for Teaching (MKT) framework (Ball, Thames, & Phelps, 2008) was developed to address “the mathematical knowledge needed to carry out the work of teaching mathematics” (p. 395). Research has indicated that a teacher’s MKT contributes to the quality of mathematics instruction (Hill et al., 2007) and student achievement gains (Hill, Rowan, & Ball, 2005).

Coupled with this work is increased attention to measuring teacher knowledge (Hill et al., 2007; Howard & Aleman, 2008). There are challenges, however, involved in assessing teachers’ knowledge via traditional methods (Hill et al., 2007; Kersting, Givvin, Sotelo, & Stigler, 2010; Schoenfeld, 2007). Teachers may demonstrate knowledge through a pencil-and-paper examination, yet “be unable to activate and apply that knowledge in a real teaching situation” (Kersting et al., 2010, p. 179).

One potential solution for measuring teachers’ knowledge in an applied setting involves the use of video. Video is a valuable tool as it allows teachers to analyze classroom interactions (Sherin, Linsenmeier, & van Es, 2009). Therefore, the purpose of this qualitative study was to examine the utility of a video-based tool featuring a mathematical disagreement for accessing teachers’ MKT. Given the need for context-based assessments (Hill et al., 2007), the significance of this work lies in its demonstration of the potential for using classroom video of students engaged in mathematical disagreements as a stimulus for revealing teachers’ MKT.

Our video-based tool included two short videos taken from a single lesson occurring in a third grade classroom. The videos highlighted the occurrence and resolution of a mathematical disagreement featuring a triangle and its rotated image. Six elementary teachers accessed the video via a secure online site. Participants responded to a set of questions after each video. To analyze participants’ responses, we utilized content analysis (Patton, 2002), using three questions to guide our analysis. First, what did participants perceive as the mathematical misunderstanding(s) that formed the basis of this disagreement? Second, what instructional strategies would participants use to resolve the disagreement? Third, what were participants’ ideas related to the teacher’s resolution of the mathematical disagreement in the video?
Effectiveness of the Modeling Method Pedagogy in Montgomery County, Tennessee Secondary Biology Classrooms

Kate A. Fields, Willodean D.S. Burton, Sheila Pirkle
Austin Peay State University

Physics, chemistry, and biology are traditionally viewed as difficult subjects to teach and to comprehend. It is vital to research and implement the most effective method(s) to teach these subjects. High school is a critical time for students to progress from concrete thought to formal thought; it is also a time for students to develop not only an appreciation for science, but also the ability to think critically and engage in intelligent debate and discourse (Jackson, 2008). A physicist at Arizona State University, Dr. David Hestenes, developed the Modeling Instruction Program as alternative physics pedagogy to the traditional lab/lecture classroom; his student, Malcolm Wells adapted the Modeling Instruction Program to high school physics (Wells, 1995). After teaching, testing, and revision, the present-day modeling method is centered around the development of reasoning skills, which lead to formal thought. Educational studies have shown that a lecture is the most time efficient avenue to impart information to students; however, it can be inefficient in establishing a firm understanding of the concepts delivered (DeHaan, 2005). Additionally, research conducted in 2002 found a strong correlation between conceptual gains and the degree of which the students were actively engaged (Novak, 2002). The foundation of modeling rests in the idea that humans learn by recognizing patterns and then forming analogies that allow for the construction of mental models; these models become a regular part of classroom curriculum, evaluation, and discourse. The models are created to represent a system, and they focus on particular aspects of the system in order to explain phenomena, while also developing the conceptual knowledge required. Students are actively engaged in identifying variables and relationships within the model, then testing those ideas. This fosters a critical thought process and a well-developed conceptual understanding of the topic (Wu, 2010).

In Clarksville high schools, an inverted curriculum has been introduced in conjunction with modeling instruction. In six of the seven Clarksville-Montgomery County (CMCSS) high schools, there is at least one secondary classroom in each biology department that implements modeling pedagogy; the remaining classrooms adhere to the traditional lecture and lab structure. The Modeling Instruction Program was introduced to the CMCSS biology department in the 2010-2011 school year where it was piloted in one high school; by the next school year, six of the seven CMCSS high schools contained one modeling biology class.

The 2010/2011 and 2011/2012 TCAP EOC predicted and observed biology scores of six Montgomery County high schools were analyzed to determine if the Modeling Instruction Program has made a significant impact on the scores. For each school, one modeling and one non-modeling teacher provided EOC scores to be compared. In addition to EOC scores, attendance records of the 2011/2012 participating classes were provided. Each modeling and traditional class was observed for the purpose of confirming instructional differences and fidelity of the Modeling Instruction Program. During each observation, a checklist was completed and notes taken to reflect the content, instructional strategies, and student responses of the observation.
The Impact of the Inverting Curriculum and Modeling Instruction on Student Achievement in Science

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Nationally, the focus of K-12 education has shifted to student outcomes and career and college readiness (CPRE, 2009). The major testing organizations have tests that predict college-readiness. In 2012, nationally only 31% of all students tested across the U.S. using the ACT were college-ready in science (ACT, 2009), the lowest rate of all disciplines. Science is critical to the health and welfare of the nation. Two strategies, the inverted curriculum (IC) and modeling instruction (MI), for improving high school student’s achievement in science have been piloted in districts across the U.S. In IC students complete a conceptual physics course in 9th grade, chemistry in 10th grade, and molecular biology in 11th grade (Lederman, 1995 & 2000; Glasser, 2012; Liang et al., 2012; Goodman & Etkina, 2008). MI was created by physics teachers and researchers at Arizona State University in the mid-90s as a better way to teach high school physics (Hestenes, 1987; Baker 2012). In MI, the teacher becomes a guide posing real-world like problem, motivation the need for a solution and allowing students in small groups to collect data, prepare solution models (often using small white boards), and explain and defend their model to the rest of the class. MI has proven successful in teaching high school physics and has spread to chemistry and, recently, to biology. Some recent studies have examined the effectiveness of IC and MI in chemistry for improves student achievement. This study describes eight years of data collected and analyzed for a small, private high school located near a large metropolitan area in the south. The data includes four years of graduates taught traditionally (no IC or MI), two years of graduates with IC alone (no MI), and two years with IC and MI in chemistry and biology, allowing us to look at the impact of the IC alone and MI in chemistry and biology within the IC. Data for these 800+ students has been analyzed by treatment group. There is a steady increase in average ACT science subscores across the treatment groups reaching the point that the average student graduates college-ready in science (a science subscore of 24 or more, a statistically significant increase). Impact of the treatments on the percentage of students graduating college-ready in science (ACT, 2009) and the impact on enrollment in optional, advanced-level 4th year science are also presented.
Modeling Instruction: The Impact of Professional Development on Instructional Practices

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Modeling Instruction is a research-based curriculum that supports students’ engagement in scientific processes (Jackson, Dukerich, & Hestenes, 2008). When implemented with fidelity, physics teachers utilizing the Modeling Instruction curriculum demonstrated significant gains in student achievement (Hestenes, 2000). Given the positive results in physics, modeling curriculums have been developed in chemistry (Dye, Cheatham, Rowell, Barlow & Carlton, under review; Barker, 2012; Dugger, Principe, & Rudolph, 2012; Farrell, Moog, & Spencer, 1999; Lewis & Lewis, 2005) and biology (Dye, et al., under review; Dye, Nolan, Rudolph, 2012; McDaniel, Lister, Hana, & Roy, 2007).

In the final report of the NSF-funded project, Modeling Instruction in High School Physics, Hestenes (2000) reported on the success of the project, including the increase in both teachers’ content knowledge and student achievement. He noted, however, that differences in student achievement could only be explained by the fidelity of implementation of Modeling Instruction. Therefore, Modeling Instruction emphasizes effective professional development, in which teachers participate as both students and teachers within the Modeling Instruction curriculum. In doing so, teachers strengthen their understanding of the content and modeling pedagogy (Jackson et al., 2008).

The purpose of this qualitative research was to examine the impact of Modeling Instruction professional development on instructional practices. The following research questions were posed. 1) How does participation in a two-week professional development focused on Modeling Instruction impact teachers’ instructional practices? 2) What factors influence the fidelity of implementation of Modeling Instruction?

The significance of this research is its examination of instructional practices before and after modeling workshop participation. Through this process, the documentation of issues surrounding the implementation fidelity aids individuals supporting teachers in implementing Modeling Instruction.

The Modeling Instruction professional development occurred within a two-week summer workshop. We selected nine participating teachers for inclusion in this research. We observed participants’ instructional practices both before and after the workshop. Observation instruments included the Reformed Teaching Observation Protocol (RTOP) (Arizona Board of Regents, 2002) and an observational checklist. In addition, we interviewed participants after post-observations. RTOP data were examined for trends. Interview transcripts were analyzed using content analysis (Patton, 2002). Observational checklist data were utilized to enhance the interview findings.

Data analyses provided insight into the challenges that impact implementation fidelity.
Inquiry-based Physics and Physical Science in a Large Lecture Hall Environment

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It has long been recognized that engaging students in the processes of science results in improved learning (NRC, 2011). This is especially important in courses for prospective elementary teachers, who will be expected to engage their own students in the future. Most efforts in this regard have taken the form of curricula in which students work in small collaborative groups in studio-style settings, working through guided-inquiry hands-on and minds-on activities. Two such curricula, on which this work is based, are *Physics and Everyday Thinking (PET)* (Goldberg, Robinson, & Otero, 2005) and *Physical Science and Everyday Thinking (PSET)* (Goldberg et al. 2007). However, the intensive resources necessary to implement such curricula often prohibit their adoption, especially when enrollments are large and class time is limited. To address this issue our group first developed the *Learning Physical Science (LEPS)* curriculum (Goldberg et al., 2012a) and are now currently developing the *Learning Physics (LEP)* curriculum. (Both with NSF support.)

LEPS and LEP take the research-based design-principles on which PET and PSET were built (Goldberg, Otero, & Robinson, 2011) and attempt to implement them in a way that is still inquiry-based, but is compatible with having a high number of students in a large lecture-hall setting. One difference is that in some content areas observations are made from movies of experiments shown by the instructor. However, in other content areas observations are made ‘in-seat’ using readily available materials and/or computer simulations. Another major difference between the two styles of class is that of pacing. In PET and PSET the pacing is set by how quickly individual groups work through the activities. In LEPS and LEP the instructor guides the whole class through a lesson together via powerpoint slides that highlight guiding questions and serve to focus discussions. A major focus of PET and PSET was on students writing and evaluating conceptual explanations of phenomena. This was largely abandoned in LEPS, but in LEP we are currently experimenting with the process of Calibrated Peer Review (CPR) (Russell, 2004) to fill this role.

In this presentation I will describe the structure of LEPS and LEP in more detail and present our latest results of the assessment of both content learning and student attitudes. I gratefully acknowledge my collaborators in this project, Fred Goldberg and Mike McKean (SDSU), Ed Price (UC San Marcos), and Danielle Harlow (UC Santa Barbara) as well as the support of the NSF via DUE grants 0717791 and 1044172. For more information on PET, PSET, and LEPS visit the website of the Physics Learning Research Group at SDSU: http://cipstrends.sdsu.edu/.
Learner-centered Environment for Algebra-based Physics
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The Learner-centered Environment for Algebra-based Physics (LEAP) is a two semester physics curriculum for algebra-based physics appropriate for both university and high school settings. The course pedagogy and activity sequence is guided by research on student learning of physics and builds on the work of the NSF supported project, Physics for Everyday Thinking (PET). Students work in groups to develop their understanding of various physics phenomena including forces, energy, electricity and magnetism, light and optics. Students utilize hands-on experiments and computer simulations to provide evidence to support their conceptual understanding. Traditional problem solving is scaffolded by using the S.E.N.S.E. problem solving strategy. This talk describes the LEAP curriculum and discusses evidence of its effectiveness. *Supported in part by NSF CCLI grant #DUE-0737324.

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Using Bloom’s Taxonomy to Examine the Depth of a three-week, Introductory Research Experience for College STEM Undergraduates

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Universities across the nation are working to increase the number of STEM graduates. Middle Tennessee State University’s *Mathematics as a FirstSTEP to Success in STEM* project is a 5 year, $2 million NSF-funded exploration of interventions to address mathematics deficiencies in STEM majors. MTSU first-time, full-time freshman STEM majors, who are at-risk based on mathematics ACT test scores between 19 and 23, inclusive, participate in an intensive two-year program that includes a mathematics bridge program, academic support, and an intense, introductory research experience at the end of their freshman year.

The inclusion of an early introduction to research is based on research by Schwartz, et al. (2008) which found that students who covered one science topic in-depth in high school experienced greater success in college science courses. FirstSTEP hypothesized that an in-depth introduction to research early in a student’s academic career in college would lead to greater success in future science courses, and thus increased STEM retention. The FirstSTEP introductory research immersion consists of a three-week, intensive, inquiry-based exploration of a specific science topic connected to students’ major field of study. Small teams of students work with a STEM faculty member and an upper division or graduate student to complete a research project.

The purpose of this study is to answer the question: *Will at-risk STEM majors who complete a three-week, introductory, science research program at the end of their freshman year experience greater success in their future science courses?* In this study, we follow six teams through the research program and ask students and faculty to use a new instrument based on Bloom’s Taxonomy to determine the extent the students had an in-depth experience in one area of science.
Enhancing STEM Learning Through an Interdisciplinary Research Centered Curriculum

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In the past decade there has been an increased demand for university scientists to become intimately involved in reforming how children in grades K-12 learn science which in turn prepares them for the rigor of college science majors and careers in STEM disciplines [1, 2]. In response to this call, a number of universities have dramatically increased partnerships with their local public school districts. In 2007, the Vanderbilt Center for Science Outreach (CSO) in partnership with Metropolitan Nashville Public Schools (MNPS), implemented a unique one-day on-campus science and math school (School for Science and Math at Vanderbilt, SSMV) for highly motivated, exceptionally capable students. The SSMV provides a rigorous and demanding research-centered interdisciplinary curriculum focusing on enhancing critical thinking skills while developing scientific research experiences for 9-12th grade students. However, the student population is limited to those MNPS students who can not only excel in their traditional high school courses, but also add an additional seven science elective credits and one full day to their high school curriculum. In an effort to provide this learning opportunity to more students, the Interdisciplinary Science & Research (ISR) program was implemented in 2010. The first student cohorts were at Stratford STEM Magnet High School, followed in 2011 by an expansion to Hillsboro High School. ISR courses are co-taught within the school schedule and on the high school campus by a scientist and MNPS science teacher with a focus on unique interdisciplinary research-centered STEM curriculum. As with the SSMV, the objective is to provide a rigorous program of study that will increase students’ research understanding and skills; strengthen their basic science knowledge; and increase their critical thinking skills. Anticipated outcomes include:

- Increased student scores on end of course (EOC) tests, overall grade point average (GPA), and standardized test scores (Plan, ACT)
- Increased numbers of students who are prepared to conduct projects in university research laboratories
- Increased numbers of students who are college-ready
- Increased numbers of students who pursue STEM majors in college and ultimately enter careers in STEM-related fields
Here’s what Jonathan Wai in *Psychology Today* said about Harvard professor, Tony Wagner’s book, *Creating Innovator’s: The Making of Young People Who Will Change The World*: “(this) important book emphasizes developing the talent of students who are essential to the future of America and profiles some extremely bright minds and their parents, teachers, and mentors to provide some insights into ways to develop intellectual and creative talent.” Please join me for an open discussion of Wagner’s ideas about creativity and how efforts to promote innovation can transform STEM education.
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