10th Annual TN STEM Education Research Conference
February 11-12, 2016
DoubleTree Hotel
Murfreesboro, TN
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Welcome from Director
Tom Cheatham

Tenth Annual Tennessee STEM Education Research Conference
DoubleTree Hotel, Murfreesboro, TN
February 11-12, 2016

We are pleased you have chosen to join us for the 10th Annual Tennessee STEM Education Research Conference hosted by the Tennessee STEM Education Center at Middle Tennessee State University (MTSU). STEM education continues to be an area of great need in our country but of too little interest among students. The courses are tough but the rewards are great. Your attendance indicates that have made the decision to invest in STEM education. Thank you for what you do and for being interested in research about teaching and learning—which is how we improve STEM education. We have a great program for you to enjoy, free food, and an opportunity to renew acquaintances and meet new friends and collaborators.

Keynote speakers include Rich Lehrer, Vanderbilt University, Sheryl Sorby, The Ohio State University, and Dale McCreedy, the Franklin Institute Science Museum in Philadelphia. Dr. Lehrer, the Frank W. Mayborn Professor of Teaching and Learning, studies teaching and learning in K-5 mathematics, focusing on space and measurement. Dr. Sorby has published broadly on the improvement of spatial skills among engineering students. She has a national project to improve spatial skills for middle school females, believing that improved spatial skills will lead additional females into STEM careers. Dr. McCreedy has spent her professional career in informal education and is interested, in particular, in how informal education experiences impact females. Their enthusiasm is contagious and their research experiences are varied and interesting. I hope you will make it a point to hear all three during our sessions on Thursday afternoon and evening, February 11, 2016. We are extremely pleased to hear an update from the TN Commissioner of Education, Dr. Candice McQueen, former Senior VP and Dean of Education at Lipscomb University.

We also have something for everyone in our 20 breakout presentations on Friday morning, ranging from “how coding and dance can help teach K-12 common core mathematics” to “active learning strategies to teach high school biology;” from “how an informal science program impacts science identity of females” to “how interacting with a graduate teaching fellow impacts attitudes toward science;” and from “how discourse varies in traditional and virtual electrochemistry laboratories” to “how to teach next generation physical science and everyday thinking.” We have six K-12 teacher authors, eight PhD student authors, and 35 university faculty authors. This is the first year in my memory that we have had more science focused presentations than math. Several presentations can fit in both areas and many of these are in the STEM education sessions.

We have never charged a registration fee for the conference and we have been able to provide free snacks and meals because of generous support from the Tennessee Space Grant Consortium and the MTSU Office of Research. We have been informed that significant cuts in support are likely for next year. This will likely result in the imposition of a registration fee to pay for at least part of the food cost. We will keep the cost as low as possible. I hope this anticipated change will not impact your participation in the next conference. Without you we have no reason to exist.

Special thanks to the Tennessee Space Grant Consortium MTSU PI, Dr. Henrique Momm, Department of Geosciences, and the MTSU Vice Provost for Research, Dr. Jackie Eller and MTSU Director of the Office of Research, Mr. Jeff Porter. This conference exists because of their financial support over the last decade.
Conference Agenda  
Tennessee STEM Education Research Conference  
February 11-12, 2016  
DoubleTree Hotel  
1850 Old Fort Pkwy  
Murfreesboro, TN 37129

{There is a pre-conference meeting of the STEM Education Leadership Council, 8:30 AM - 10:30 AM}

Thursday, February 11, 2016

10:30 – Registration  
11:30-12:30 Light Lunch  
12:30 – 1:00 Welcome and Announcements (Ballroom) (Facilitator: Tom Cheatham)  
   Dr. Jackie Eller, Vice Provost for Research & Dean Graduate College, MTSU  
   Dr. Robert Fischer, Dean, College of Basic & Applied Sciences, MTSU  
   Dr. Henrique Momm, MTSU PI NASA Space Grant & Professor Geoscience, MTSU

1:00 – 2:05 Mathematics Education Keynote (Facilitator: Sarah Bleiler-Baxter, MTSU)  
Grounding K-5 Mathematics Education in Experience of Space  
Dr. Rich Lehrer, Frank W. Mayborn Professor, Department of Teaching and Learning, Vanderbilt University, Nashville, TN

2:05 – 2:20 Break/Discussion

2:20 – 3:25 Science Education Keynote (Facilitator: Stacy Kline-Gardner, Harpeth Hall School)  
Gateway to STEM: Improving 3-D Spatial Skills  
Dr. Sheryl Sorby, Professor, Teaching and Learning Administration, Engineering Education Innovation Center, The Ohio State University, Columbus, OH

3:25 – 3:40 Break/Discussion

3:40 – 4:45 Tennessee K-12 Education Update (Facilitator: Linda Gilbert, Murfreesboro City Schools)  
Dr. Candice McQueen, Tennessee Commissioner of Education  
Tennessee Department of Education, Nashville, Tennessee

4:45 – 6:00 Setup for Dinner (all leave the ballroom area, please)

6:00 – 8:00 Banquet and Keynote (Introduced by John Hawkins, Discovery Center at Murfree Springs)  
Cascading Influences: Long-term Impacts of Informal STEM Experiences for Girls  
Dr. Dale McCreedy, Director of Gender, Adult Learning, & Community Engagement at the Franklin Institute Science Museum, Philadelphia, PA

Friday, February 12, 2016

7:30 – 8:15 Full Breakfast

8:15 – 10:15 Concurrent Breakout Session 1 (talks are 20 minutes plus 10 minutes for questions)  
Mathematics Education Research 1 (Ballroom A) (Facilitator: Dovie Kimmins, MTSU)  
- Coding for the Core: Computer Programming & Common Core Middle Grades Mathematics, Leslie Suters (Tennessee Technological University)
- Supporting Teacher Learning in Math Content and Pedagogy: Lessons Learned, Gale Stanley, Ann Higginbotham (Campbell County Schools), Michael Lawson, Ashley Walther and Lynn Hodge (University of Tennessee, Knoxville)
- Math Dance: Teaching High School Common Core State Standards of Mathematics through Creative Movement and Concert Dance, Morgan Davis (Middle Tennessee State University)
- Lesson Study as a Means for Supporting the Development of Mathematics Teacher Educators, Angela Barlow, Kristin Hartland, Jeff Pair, Teresa Schmidt, Ameneh Kassaee and Cicely Woodard (Middle Tennessee State University)

(continued on next page)
Science Education Research 1 (Ballroom B) *(Facilitator: Meiko Thompson, Knox Schools)*
- Comparing Discourse in Traditional and Virtual Electrochemistry Laboratories, Vichuda Hunter, Archana Tirumala, Ian Hawkins and Amy Phelps (Middle Tennessee State University)
- Does the Practice of Recall Lead to Increased Retention of Text Material for Introductory Biology Students? Michelle Rogers and Colleen White (Austin Peay State University)
- High School Student Attitudes about Science and Career Choice after Interacting with a TRIAD Graduate Fellow for the School Year, Rachel Lytle, Kim Sadler, Anthony Farone, Mary Farone and Ginger Rowell (Middle Tennessee State University)
- How to Sustain a Freshman-Sophomore Summer Team Research Program, Ginger Rowell, Chris Stephens, Jeff Leblond, Tom Cheatham and Don Nelson (Middle Tennessee State University)

STEM Education Research 1 (Ballroom C) *(Facilitator: Vicki Metzgar, MidTN STEM Hub)*
- Out of School Time Science Programs: Examining a Program’s Impacts on the Science Identities of Middle School Female Participants, Elizabeth MacTavish (University of Tennessee, Knoxville)
- Alignment of an Intensive Nine-Week Science Research Experience with Pre-Service Teacher Career Plans, Mark Abolins, Tom Cheatham (MTSU) and Herschell Parker (Nashville, TN)
- Next Generation Physical Science and Everyday Thinking (Next Gen PET), Steve Robinson (Tennessee Tech University)
- STEM Summer Institute Increases Student and Parent Understanding of Engineering, Stacy Klein-Gardner (Vanderbilt University and Harpeth Hall School)

10:15 – 10:30 Break/Discussions

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

Mathematics Education Research 2 (Ballroom A) *(Facilitator: Kim Williams, UT Martin)*
- Helping Students Who Are at Risk in Pre-calcus and Calculus I, Ginger Rowell, Chris Stephens, Tom Cheatham, Don Nelson, Jeremy Strayer and Jim Hart (Middle Tennessee State University)
- Creating a Course Community to Change the Teaching of Introductory Statistics at Middle Tennessee State University, Lisa Green, Scott McDaniel, Nancy McCormick, Jeremy Strayer and Ginger Rowell (Middle Tennessee State University)
- Mathematics Success for STEM Majors, Holly Anthony, Sally Pardue, Allan Mills, Steve Robinson, Chris Wilson, Anna Litchford (Tennessee Technological University)

Science Education Research 2 (Ballroom B) *(Facilitator: Artenzia Young-Seigler, TN State)*
- Promoting Active Learning Strategies in the High School Biology Classroom, Leigh McNeil, Grant Gardner, Jennifer Parrish and Tom Cheatham (Middle Tennessee State University)
- Integrating Science Learning with Literacy in Grades 6-12, Chih-Che Tai and Karin Keith (East Tennessee State University)
- Comparing the Impact of Two Active Learning Strategies on Epistemological Beliefs of Post-secondary Microbiology Students, Jeff Bonner (The Webb School and Middle Tennessee State University)

STEM Education Research 2 (Ballroom C) *(Facilitator: Jeanetta Jackson, TN State University)*
- Big Orange STEM Saturday: A Successful Model for STEM Career and Outreach, Thura Mack (University of Tennessee Knoxville)
- A Mini-Hyperwall for Teaching, Anatoliy Volkov, Andrienne Friedli, Eric Oslund, Amy Phelps, June Hunter and Tom Cheatham (Middle Tennessee State University)
- Using Digital Metaphors to Improve Student Success in Mathematics and Science, Amenah Kassaee and Ginger Rowell (Middle Tennessee State University)

12:00 - Lunch/Depart
Mathematics Education Keynote

Dr. Richard Lehrer, Frank W. Mayborn Professor
Department of Teaching and Learning, Peabody College
Vanderbilt University

Grounding K-5 Mathematics Education in Experience of Space

Conceptualization and quantification of space have long played a foundational role in mathematical inquiry, perhaps because some of our earliest and most common experiences revolve around the organization of space (Lehrer, Kobiela, & Weinberg, 2013; Nitabach & Lehrer, 1996). Mathematical concepts expressed in space are literally grasppable and indexical and consequentially, broaden the available pathways for making mathematical sense (Lehrer, 2009; Lehrer & Shauble, 2009). Yet these prospective pathways are often not exploited in mathematics education, perhaps because visualization is usually thought of as a fixed individual trait, a spatial ability that is relatively immutable.

We are currently engaged in longitudinal research in K-5 classrooms, working collaboratively with teachers to design learning ecologies intended to foster spatial mathematics and the development of spatial visualization (Lehrer, in press). The context is a public school that serves underrepresented children and their families. Our approach to instruction builds upon children’s intuitions and everyday experiences of space but aims to refine and extend these experiences and intuitions to develop mathematical understandings. We illustrate our approach in two strands of spatial experience: measure and symmetry. Measurement is a linchpin that connects the world of number with the wider world of space. Measuring space (length, area, and volume) provides an alternative metaphor for understanding operations on and with number, and our approach to it emanates from children’s experiences of travel and motion in space. Symmetry is an organizing principle for a wide range of cultural and disciplinary activity. We introduce this powerful tool for construction and analysis by engaging children in the design of artistic patterns (e.g., friezes and quilts) and in the construction of planar figures and three-dimensional structures. Moreover, because geometry and visualization is a way of creating a world that is tangible and visible for children, it is especially useful as a medium for developing mathematical practices, such as those emphasized by the Common Core State Standards in Mathematics.
References:


Science Education Keynote

Dr. Sheryl Sorby, Professor
Teaching and Learning Administration
Engineering Education Innovation Center
The Ohio State University

Gateway to STEM: Improving 3-D Spatial Skills

The ability to visualize in three dimensions is a cognitive skill that has been shown to be important for success in engineering and other technological fields. For engineering, the ability to mentally rotate 3-D objects is especially important. Unfortunately, of all the cognitive skills, 3-D rotation abilities exhibit robust gender differences, favoring males. The assessment of 3-D spatial skills and associated gender differences has been a topic of educational research for nearly a century; however, a great deal of the previous work has been aimed at merely identifying differences. For more than two decades, Sheryl Sorby has been conducting research aimed at identifying practical methods for improving 3-D spatial skills, especially for women engineering students (Sorby, & Baartmans, 1996; Sorby, & Baartmans, 1998; Sorby, & Gorska, 1998; Sorby, 1999; Sorby, & Baartmans, 2000; Sorby, & Wysocki, 2003; Sorby, 2006; Sorby, 2009; Sorby, 2011a; Sorby, 2011b). This presentation details the significant findings obtained over the past several years through this research and identifies strategies that appear to be effective in developing 3-D spatial skills and in contributing to student success.

References:


Tennessee K-12 Education Update

Dr. Candice McQueen
Commissioner of Education
Tennessee Department of Education

Candice McQueen became Commissioner of Education in Tennessee in January 2015 after serving as Senior Vice President and Dean of the College of Education at Lipscomb University. Commissioner McQueen will provide an update on K-12 education in Tennessee. The goals she and her team have set for K-12 education in Tennessee are challenging and will bring continuing improvement in K-12 education across the state. The goals of the Tennessee Department of Education include

<table>
<thead>
<tr>
<th>Number</th>
<th>Goal</th>
<th>Measurement</th>
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<tbody>
<tr>
<td>1</td>
<td>Tennessee will continue rapid improvement and rank in the top half of states on the Report Card.</td>
<td>Tennessee will rank in top half of states on 4th and 8th grade NAEP in 2019</td>
</tr>
<tr>
<td>2</td>
<td>The average ACT score in Tennessee will be a 21, allowing more students to earn HOPE scholarships.</td>
<td>Tennessee will have an average public ACT composite score of 21 by 2020</td>
</tr>
<tr>
<td>3</td>
<td>The majority of Tennessee high school graduates will earn a certificate, diploma, or degree.</td>
<td>The class of 2020 will be on track to achieve 55% postsecondary completion in six years</td>
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References:

Keynote Banquet Speaker

Dr. Dale McCreedy, Director
Gender, Adult Learning, & Community Engagement
Franklin Institute Science Museum in Philadelphia

Cascading Influences:
Long-term Impacts of Informal STEM Experiences for Girls

*Cascading Influences* documents young women’s perceptions of experiences 5-25 years ago in one of six informal, out-of-school time (OST) programs designed specifically for girls, and the ways in which participation influenced their future choices in education, careers, leisure pursuits and ways of thinking about what science is and who does it (McCreedy, 2015; McCreedy & Dierking, 2013). Over the past decade, hundreds of STEM programs for girls have been funded, undertaken, and evaluated. Few, however, have documented impact beyond a few years, usually during the period of a grant, making evidence of long-term impact a critical need. Asking “*What possible influences do informal science experiences play in girls’ interest, engagement, and participation in science communities, hobbies, and careers over the long term?*” provided insights into:

- how participation in such experiences facilitate and lead to additional engagement,
- the role significant adults and peers play, and
- the ways in which girls describe their relationship to science and their sense of themselves (identities) as science-interested learners and advocates.

Findings of this exploratory study not only provide insights into the power of informal OST social contexts and the contributions they can make in supporting STEM learning, science rich lives, and girls’ identity development; they also suggest considerations for learning across the contexts of home, school and community.
References:


Coding for the Core: Computer Programming & Common Core Middle Grades Mathematics

Leslie Suters
Tennessee Tech University

Coding for the Core aimed to address the need for high quality professional development (PD) in CCSS for TN middle school math teachers with the goal of improving their content and pedagogical strategies in the context of computer science (CS). There is a growing need to prepare students for a work force with skills in science, technology, engineering, and mathematics and in particular CS skills (National Research Council, 2012; CSTA, 2012; & TCS, 2013). By 2018 there is an expected shortage of 230,000 STEM workers with more than 70 percent of those in CS (TCS, 2013). Students are often first exposed to CS in high school; however, not all high schools include a CS course. Furthermore, females and minority students are underrepresented in these courses (CSTA, 2012 & Denner, J., 2011). Researchers are proposing that earlier exposure to CS education at the K-8 level can help increase enrollment and lifetime engagement in CS for all students (CSTA, 2012).

Mathematical content and practices from CCSS were aligned with CS and computational thinking practices at the middle school level. Integrating algorithmic and computational thinking can be a meaningful way to emphasize the four C’s needed to meet 21st Century challenges: Critical thinking and problem solving; Communication; Collaboration; and Creativity and innovation (CSTA, 2012). Coding for the Core used a programming package developed by Code.org and Bootstrap (2014) that requires students to write code using algebra and geometry. Additionally, programming robots with the Lego® Mindstorms® allowed for writing code emphasizing ratios and proportions as well as data analysis, statistics, and probability, among other topics (Carnegie Mellon Robotics Academy, 2014).

Coding for the Core provided PD for 22 middle school teachers, from six high-need school districts. The project included a two-week summer institute Summer 2015 and two follow-up Saturdays Fall 2015. Participants received PD aimed to improve their math content and pedagogical knowledge with a focus on best practices for instruction as required by the Tennessee Educator Acceleration Model (TEAM).

Teacher participants received a $75 daily stipend, a Lego® Mindstorms® EV3 Core Set, hands-on manipulatives, and publications geared for middle level teachers on the topics of robotics and hands-on manipulatives. The participants received explicit instruction with the Technological Pedagogical Content Knowledge (TPACK) Framework to engage them intentionally in thinking about the intersection of content, pedagogy, and technology and how this can help them with TEAM evaluations.
Specifically, the following research questions were posed.
   How does participation in Coding for the Core impact participants’:
   1. math content knowledge as measured by a content test?
   2. pedagogical content knowledge as measured by the TPACK and TEAM surveys?
   3. instructional practices as measured by a TEAM observation and survey?

We used a variety of quantitative and qualitative measures to evaluate changes in teacher content knowledge (Content test aligned to CCSS-Math), pedagogical content knowledge (TPACK survey and TEAM Survey), instructional practices (TEAM observation with Instruction Rubric) and perceptions of the project. The final report for this project is currently being written and will be shared at the conference.

References:


Supporting Teacher Learning in Math Content and Pedagogy: Lessons Learned

Gale Stanley
Ann Higginbotham
Campbell County Schools

Michael Lawson
Ashley Walther
Lynn Hodge
University of Tennessee, Knoxville

Two key ideas lay the foundation for our project, the Math Counts Institute (MCI). One is the idea of high leverage practices. The second is the idea of high leverage math content that is critical for both teachers and students to know and understand. High-leverage practices are impactful, core practices in math and science that have significant consequences for students’ learning (Ball & Forzani, 2009; Windschitl, 2012). This expands the focus from “What do teachers need to know?” to “What do teachers need to do?” and involves identifying core practices and decomposing them (Ball & Forzani, 2009; Lampert, & Graziani, 2009) in order to understand these practices in depth and to modify as needed. An example of a high-leverage practice is proactively guiding a whole-class discussion that introduces a complex task (Jackson, Garrison, Wilson, Gibbons, & Shahan, 2013).

This study describes and examines the development, implementation, and initial impact of the Math Counts Institute (MCI), a 10-day professional development (PD) program focused on supporting teachers in the domains of mathematics content and pedagogy. Our central questions were:

a) What did teachers learn?
b) What were teachers’ perspectives on their experiences during the institute?

Participants of the MCI were 68 elementary and middle school teachers and instructional coaches who completed 60 hours of PD. The PD focused on understanding mathematics standards and high-leverage instructional practices that help to make mathematics come to life for students. During the MCI, participants completed pre- and post- measures of mathematics content and pedagogy and a self-report survey of teacher experiences during the institute. The
data were analyzed using mixed methods—quantitatively using mixed factor ANOVA and dependent *t-tests*, and qualitatively using open and *in vivo* coding to produce a thematic analysis. Preliminary analysis indicates that the institute was successful in accomplishing its design goals. Lessons learned and implications for mathematics professional development and future work with the MCI are also discussed.

**References:**


Dance allows students to use movement and the way they experience the world around them to explore aspects of mathematics like shape, number, or graphs (Watson, 2005). It provides a means for mathematical concepts to be “understood mentally, physically, and emotionally” (Schaffer, Stern, & Kim, 2001, p.5), and in so doing, it helps students to form connections between mathematics and the real world. For example, students’ understanding of rotations is improved when they are physically facing different directions rather than manipulating shapes on a graph (Rosenfeld, 2011). Students of various learning styles, especially kinesthetic learners, can be reached through dance as a form of teaching mathematics (Schaffer, Stern, & Kim, 2001; Watson, 2005), and in some cases, dance makes math visible (Rosenfeld, 2011).

In my study, I sought to answer the question: What knowledge of the content within Common Core State Standards for Mathematics (CCSSM) do participants demonstrate before and after engaging in concert modern dance and creative movement used to teach these standards? I chose four high school standards from the CCSSM (2010) document that I perceived were conducive to being taught through concert modern dance and creative movement. Topics included vectors, complex numbers, congruence transformations, and composition of functions. Participants were nine student volunteers from Middle Tennessee State University – most being involved with the university’s Dance Program. Participants were divided into groups based on their availability for weekly lessons. They took pretests and posttests over their standard via group brainstorms and individual concept mapping. The project culminated in a Math Dance Concert where the participants performed dances we had created using movement developed to represent math concepts from the CCSSM.

Participants’ understanding of the standards was evaluated through qualitative observation and questioning during each rehearsal and during the question and answer segment of the Math Dance Concert. Moreover, participants’ pre and posttest concept maps were evaluated quantitatively using a modified scoring method where individual propositions (i.e., connected concepts in the concept map) were evaluated (McClure & Bell, 1990). The use of both qualitative and quantitative analysis provided the means to evaluate not only how much the participants learned but also what they learned and how.

Quantitatively, the participants’ posttest concept maps showed an increase in total number of propositions, number of valid propositions, and score, in comparison with their pretest concept maps. Qualitatively, during instructional rehearsals, I noticed that dance as a form of mathematics instruction seemed to be most useful in leading participants to form their own definitions, clarify mathematical concepts, and kinesthetically form connections to the real world through their own movement.
In this conference session, I will provide content-specific descriptions of the ways participants developed an understanding of their CCSSM standard through movement. Moreover, I will provide implications for teaching mathematics through dance based on lessons learned from this study.

References:


Note: This research study was conducted as partial fulfillment of an undergraduate honors thesis under the direction of Dr. Sarah K. Bleiler-Baxter, Mathematics Education Professor at Middle Tennessee State University.
Educators have recognized that the U.S. needs to improve in mathematics education in order to compete globally (National Research Council, 2013). Many researchers have identified the lack of teachers’ knowledge as one of the major obstacles in the students’ mathematics success (e.g., Ball, 1990; Hill, Sleep, Lewis, & Ball, 2007; Shulman, 1987). Recognizing the potential of doctoral programs in influencing this professional growth, doctoral programs have been specifically called upon to “provide mentored clinical experiences that develop expertise in designing and teaching preservice mathematics content and methods courses and organizing professional development experiences for in-service teachers” (Reys, 2002, p. 1). Although significant progress has been, many doctoral programs are not devoted to the professional development of their students (Austin, 2001; McAlpine & Norton, 2009).

While there are numerous approaches for providing professional development, in this study we examined the potential of lesson study for developing doctoral students as mathematics teacher educators. The concept of lesson study is to collaborate with colleagues in planning, observing, and reflecting on lessons (Takahashi & Yoshida, 2004). This reflection-on-action, which results from the development of the lesson, serves as a means for those participating in the lesson study to experience the connected relationship between the theory and practice (Garcia, Sanchez, & Escudero, 2007). Although lesson study has been used in a variety of settings (e.g., Dotger, 2011; Lampley, 2015; Lewis, Perry, & Hurd, 2009), its use as a means for enhancing the development of mathematics teacher educators has not been documented. Therefore, the purpose of this study was to examine the support that the lesson study process might provide for doctoral students teaching a mathematics content course for preservice elementary teachers. Specifically, our research question was: How does engaging in the lesson study process support doctoral students’ development as mathematics teacher educators, if at all?

One faculty member and six doctoral students engaged in the lesson study process within the context of a mathematics content course for preservice elementary teachers. From this group, we selected two doctoral students to serve as cases for this study. Data from journal writings and interviews were compiled into chronologically ordered case records (Patton, 2002) and then analyzed using a
deductive analysis process (Patton, 2002) in which data were coded according to the different foci of Tzur’s framework (2001).

Results indicated that the majority of participants’ reflections aligned within the Learn Math Teaching focus. Their reflections tended to focus on teacher actions that supported the preservice elementary teachers in developing mathematical understandings. Additional reflections aligned with the Learn Educating Teachers focus, in which the participants focused on activities that support the preservice elementary teachers in learning to teach mathematics. Through their reflections within the Learn Math Teaching focus, it is likely that participation in the lesson study process enhanced the participants’ knowledge and skills with regard to mathematics teaching. Participants gave very little attention to their roles in helping preservice teachers learn how to teach mathematics. Results serve to inform the design of future professional development of doctoral students.

References:
Comparing Discourse in Traditional and Virtual Electrochemistry Laboratories

Vichuda Hunter
Archanal Tirumala
Ian Hawkins
Amy Phelps
Middle Tennessee State University

The goal of this research is to gain an understanding of what experiences students are having in general chemistry laboratory by examining group discourse. Since the formalization of school science, laboratory has been seen as a fundamental element in good science education where students can experience phenomena first hand (Hofstein, 2004). While the usefulness of laboratory is rarely questioned, there is little consensus about the purpose of this time and money intensive activity (Hilosky, et al., 1998; Herrington & Nakhleh, 2003). The purpose of our study is to investigate what is transpiring in the laboratory by analyzing the discourse of group members as they worked through a laboratory on electrochemistry and to compare the experiences of students in traditional hands-on laboratories to those in virtual laboratories.

Using a mixed methods research approach, and grounded theory inquiry framework (Nurren & Robinson, 1994; Phelps, 1994), we will examine the discourse of pairs of students enrolled in four sections of General Chemistry II laboratory (two sections are virtual and two are hands-on). This research is a part of a larger quasi-experimental study with 336 students enrolled in six sections of virtual laboratory, and 10 sections of hands-on laboratory (Hawkins & Phelps, 2013). Students in the virtual lab interacted with concepts in the form of simulations (experimental group) while the students in traditional lab performed experiments on the same concepts in a hands-on laboratory (control group). Data were collected in the form of digital audio recordings which were transcribed, coded and analyzed using constant comparison analysis (Corbin & Strauss, 2008). The original data for the electrochemistry concept laboratories were collected during the Fall 2011 and Spring 2012 semesters. So much of how laboratory is carried at in Universities is based on tradition with little data as to how the laboratory experience impacts the learning of students. The data were sorted into a variety of categories like Activities or Levels of Learning. These big categories were broken down into smaller sub classes. For example, the Levels of Learning category was broken into knowledge (recall), understanding, application and predication. Statements and phrases from the transcripts were sorted into these classes to give a sense of what kinds of activities students were engaged in and what types of learning were being demonstrated. Ultimately each lab type, hands-on and virtual demonstrated advantages and
disadvantages from the student perspective. Whether one type of lab is preferred over another would be directly related to the goals a professor or program wants to accomplish. This enhanced understanding of what laboratory is like from the student perspective will contribute to the discussion about the purpose of laboratory in the teaching and learning of chemistry. Choices about the future of laboratory can be made from a more informed position when we consider the experience from the perspective of the student.

References:


Does the Practice of Recall Lead to Increased Retention of Text Material for Introductory Biology Students?

Michelle Rogers
Colleen White
Austin Peay State University

At Austin Peay State University, the introductory biology courses, BIOL 1010, a general education course, and BIOL 1110, a major’s course, are taken by over one thousand students every year. Both courses historically have a high student failure rate. Since these courses require that students read and retain large amounts of information, we were interested in evaluating the success of three different methods students might use to study introductory biology text.

In a 2009 survey at Washington University, St. Louis, the majority of students chose rereading as their “#1” strategy (Karpicke, et al., 2009), even though recent research suggests that rereading is not an effective approach to studying for long-term retention compared to recall methods. Various studies have been conducted which required the subject to recall information from memory for the purpose of improving long-term information retention. In a 2006 study, students were tested one week after using various study methods, and the more times students had practiced recalling the material, the better their performance (Roediger, & Karpicke, 2006). A 2010 study indicated that approaches that required answering questions yielded better results than rereading only (Weinstein, et al., 2010). In a study by Karpicke and Blunt students who had exercised recall demonstrated better retention of material than those who did not (2011).

A total of 315 undergraduate students enrolled in either BIO 1010 or BIO 1110 participated in this study. Students were randomly assigned to treatment groups that 1) read text – a relatively passive learning method; 2) read and took notes over text; or 3) read, took notes, and practiced active recall from memory to reinforce learning. Exactly one week later, the students were given a short multiple choice test over the previously studied material. A one-way analysis of variance (ANOVA) was conducted to compare the effect of the three different methods on the number of correct answers given. There was no statistical significance between the performance of the treatment groups, $F_{2, 15} = 0.272$, $p = 0.765$. The results were surprising, suggesting additional research questions, including, “Do students correctly identify material to be learned from text?” and “How much do students comprehend from what they read?” as well as questions pertaining to the duration of study for long-term retention.
References:


High School Student Attitudes about Science and Career Choice after Interacting with a TRIAD Graduate Fellow for the School Year

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Middle Tennessee State University received funding for the GK-12 program, Reforming Graduate Education by Integrating Teaching, Research, and Industry Applications to Deepen Scientific Understanding (TRIAD) to create partnerships with selected biomedical and biotechnology companies, local high schools, and MTSU. One purpose of TRIAD is to integrate project-based learning through scientific research in high school biology classes to improve graduate fellow (GF) communication as well as enrich high school science content and instruction. Within the TRIAD program, graduate fellows (GFs) are placed with partner teachers (PTs) to interact with high school science students in the classroom for one year by teaching labs, developing engaging lectures, and mentoring student-led authentic research projects. The year culminates with the secondary students presenting their research at venues such as the annual meeting of Tennessee Junior Academy of Science (TJAS) or the TRIAD Research Symposium.

The purpose of this study was to determine if introducing GFs into high school science classrooms positively influences student attitudes toward science, their interest in science research, and their interest in pursuing a STEM career. The following questions guided the study:

Q1. After interaction with a graduate fellow, what aspects of student attitudes toward science will change?
Q2. After interaction with a graduate fellow, how did student attitudes about pursuing a career as a scientist change?
Q3. After interaction with a graduate fellow, what are student perceptions about their research project experience?
Classes with a fellow (GF group) were paired against a corresponding class taught by the same teacher (comparison group) to account for expected natural growth throughout the school year. The survey included a modified version of the Student Attitude Inventory-II (SAI-II, Moore & Foy, 1997) which was used to determine student attitude toward science and scientists with added demographic and career interest questions.

Although small positive differences were present in GF classes, a repeated measures MANOVA found no significant differences between the treatment groups and SAI-II categories. GF student attitudes increased in C1 (about the ability of science to change), C3 (about the attributes of scientists), and C5 (about the importance of the public understanding science), and decreased in C2 (about the limitations of science) and C4 (about the relationship between science and technology). Misconceptions about scientists’ use of explanations remained in the GF and comparison groups. Both groups decreased in STEM career interest (C6); however, student interviews with GF classes conveyed increased understanding of the scientific process and a desire to continue practicing science. The GF group of students did not have significant increases in their attitudes toward science; yet, they had an increased interest in medical careers, felt they better understood the scientific process, and wanted to continue practicing science.

References:

How to Sustain a Freshman-Sophomore Summer Team Research Program

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When grant funding ends, how do you sustain an expensive component of a program that you are convinced is an important factor in student success? The MTSU FirstSTEP Team (NSF DUE#0969571) is faced with such a question for the summer immersion program (Yantz, et al., 2014). The summer immersion program was designed to immerse at-risk STEM majors in a research team experience for 3-4 week in the summer following their freshman year. By design, a team consists of 4 at-risk rising sophomore STEM majors, an upper-division experienced undergraduate researcher, and a faculty mentor. Each is paid a stipend making the cost of a team around $11,000. We call it immersion because students must commit full-time (40 hours per week) to the project for 3-4 weeks. It is an expensive program because FirstSTEP has run 6-8 of these research teams each summer. Why would you want to continue the immersion program?

Undergraduate research has been identified as a “high-impact” practice for increasing student engagement and retention (Brownell & Swaner, 2010, Kuh, 2008). In their meta-analysis Pascarella and Terenzini (2005) conclude that undergraduate research has a positive effect on minority students’ persistence through to graduation, and that the effect is “strongest for African American and for sophomores.” Ishiyama (2001) concludes that the positive effects of undergraduate research apply equally to first-generation and low-income students. Penrose (2002) found that student self-perceptions are critical to their academic performance and persistence. Wolfram, et al. (2012) says “I am…a daily witness to the transformative power of undergraduate research in students, changing their personal and professional identities throughout this process.” The data we have collected from the students and the observations of the FirstSTEP team agree that the immersion experience, more than any other intervention in the project, helps students mature, helps them imagine themselves as STEM professionals, and builds self-confidence needed for success. Students begin the experience barely able to pronounce the words in the research title and end with their name as a co-author on a professional presentation, publication or both.
Our plan to sustain the immersion program is to create May-term team research classes with a dozen students (3 teams of 4) where the faculty mentor is paid from summer school tuition paid by the students and students receive an invaluable experience, developing strong out-of-class ties with a professor. We will present the data and conclusions from a first iteration of the class and discuss future plans.

References:


Out of School Time Science Programs: Examining a Program’s Impacts on the Science Identities of Middle School Female Participants

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Science education reform efforts emphasize teaching science for all Americans, and identify scientific literacy as the principle goal of science education (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996). Despite the goal of scientific literacy, some students, especially females and minorities, consider science and math irrelevant to their personal interests or career goals. They also lack the understanding that science and math play a significant role in job requirements and career success (Kadlec, Friedman, & Ott, 2007). Additionally, research identifies middle school as a period when students begin to lose interest in science and math (Farenga, 1999; Hill, et al., 2010).

Decades of research have documented the gender achievement gap, yet little research has been focused on the science identity gap (Archer, et al., 2013). We do know girls often do not identify with science regardless of test scores (Archer, et al., 2013; Sadker, Sadker & Zittleman, 2009). This lack of research makes a strong argument that the science identity gap limits girls’ participation in science beyond secondary schooling.

One solution to increasing students’ science involvement and development of science identities is through the implementation of out-of-school time (OST) STEM programs. OST refers to the hours in which school-age children are doing “something other than activities mandated by school attendance” (National Institute on Out-of School Time, 2003; Lauer et al., 2006). Science OST programs have paved the road for early exposure to STEM-related careers especially with underrepresented groups like females. However, there is limited research on how these programs change female participants’ perceptions of their science abilities. This project examines the impacts of an established STEM OST program in an East Tennessee middle school on the identify construction of its females participants. The following research questions guided the project.

1. How do middle school students’ thoughts about and interests in science differ between gender, grade levels, and academic levels?
2. What factors contribute to middle school females’ construction of their science identities?
3. How does participation in a science OST program impact middle school females’ science identity?
An exploratory sequential mixed methods research designed was used to answer the research questions. Initially, the “Science and Me” survey (SMS) instrument was designed and administered to both boys and girls. Survey results guided the development of a focus group discussion guide for Phase 2. Data from four female only focus groups (two groups of OST participants and two groups of non-participants) provided information about the development of middle school females’ science identities and helpful in determining factors impacting females’ science identities. These include parental or home assistance, teachers’ instructional approaches, media outlets, and peer relationships. It was concluded that when girls view these influences as positively supporting their science abilities, they feel confident and interested in pursuing informal STEM programs. Further, the OST program was shown to positively impact the continued construction of their science identities.

References:


Alignment of an Intensive Nine-Week Science Research Experience with Pre-Service Teacher Career Plans

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Does a discipline-based science research experience have a positive impact on pre-service science teachers? During summer 2015, five Earth science, three chemistry, and two biology pre-service teachers from across the country participated in the Geoenvironmental Challenges Research Experience for Undergraduates (REU). Geoenvironmental Challenges was the National Science Foundation (NSF) Geosciences Directorate’s first REU Site specifically designed for pre-service teachers. The participants were involved in discipline-specific Earth science, chemistry, and plant ecology science research for approx. seven of nine weeks, and all were involved in at least some field work. During the first week of the experience, they participated in two days of ranger-led citizen science in Great Smoky Mountains National Park.

Pre-service teachers often have a skeptical view of research. Research in their opinion focuses directly on practice rather than a theory-practice dialectic. One pre-service secondary teacher said, “I think with the class load it just doesn’t allow teachers to engage with research” (Gitlin, et al., 1999). Roth (1998) argues that undergraduate college science courses do not adequately prepare teachers to perform authentic scientific research, and, so, science teachers may not have the competencies needed to teach inquiry (Brown, & Melear, 2007). Yet, it has been common for two decades for state licensure standards to require pre-service teachers to possess the knowledge and skills to “conduct inquiry-based, open-ended investigations” (TN Department of Education, 1997). If it is true that “we teach as we were taught,” then engaging pre-service teachers in original research can have a profound influence on their use of research during their teaching careers. Here, we present data from a group of undergraduate pre-service teachers engaged in original discipline-based research, draw some comparisons with other undergraduate researchers, and suggest some conclusions.

Participants were asked to write a 7-20 page end-of-experience paper describing how they would mentor K-12 research (e.g., science fair projects), lead citizen science, or both after becoming classroom teachers. Seven participants submitted papers, and two submitted paper topics during the third week of the REU experience, although those two did not submit papers. The papers and
paper topics show that, among other things, seven of the participants plan to involve K-12 students in citizen science, field-based learning, or both. Overall, the most common word pair in these papers was “citizen science” (123 instances), and this pair was the most common pair in six papers and the second most common pair in one paper. The second most common word pair overall was “field trip(s)” (49), and this pair was among the five most common pairs in two of the papers. Of the two participants who did not emphasize citizen science, field-based learning, or both, one plans to mentor science fair projects and involve students in research within a classroom setting, and the other plans to implement project-based learning.

References:


The PET, PSET, LPS, and LEP curricula (Goldberg et al., 2010; 2012) were designed as guided inquiry physics and physical science curricula intended for use in courses for pre-service elementary teachers. The design team has now combined these into a new integrated set of modules, called Next Gen PET, that offer flexibility in implementation and which are better aligned with standards that are based on the more recent Framework for K-12 Science Education (NRS, 2012).

Next Gen PET consists of five separate modules, four aligned with the four disciplinary physical science core ideas of energy, force and motion, waves, and properties of matter, and one focusing on building models of magnetism and static electricity. Each module also includes engineering design activities where students apply knowledge learned as they carry out steps in the engineering design process. There are also an extensive set of teaching and learning activities associated with each module that help students make explicit connections between teaching and learning. Almost every activity also includes an online tutorial-style extension that can be assigned for homework. Most of these extensions also include quizzes that can be scored by an institution’s learning management system. There are also two distinct versions of each module: one to be used in small class structures, where the focus is almost entirely on small group laboratory work and discussion; and a second version to be used in lecture-style classes (large or small enrollment), where class sessions are shorter and only limited and simple laboratory materials might be used. An extensive CyberPD site is also being constructed to support instructors who adopt these materials, which will be published by “It’s About Time” later this year.

This presentation will give an overview of Next Gen PET, show preliminary student impact data, and discuss plans for future research and dissemination.

References:


STEM Summer Institute Increases Student and Parent Understanding of Engineering

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The need for more females in the STEM disciplines has been well documented over the years. To accomplish this goal, it is imperative that programs designed for females take into account what the literature has to offer about what females both need and desire in a STEM classroom or program. For example, studies have shown that women are attracted to STEM programs that include civic engagement (Knight, Mappen & Knight, 2011). Similarly, the use of problems that contextualize a topic to girls’ interests is important (Halpern, et al., 2007) and that may include instances where altruism and science overlap (Carlone & Johnson, 2007).

Parents play an extremely important role in their daughters’ choice of whether or not STEM is “for them.” Many studies have shown that adults’ math-gender stereotypes influence both their expectations and attributions of girls’ math achievements, which then influences girls’ own math attitudes and achievements. Specifically, a parent’s own math anxieties may be passed on to their children. Related to this is a parent’s belief that whether or not one’s math ability is stable or not – the growth mindset – and how this is transmitted to a child. Children are then at risk of gender-based stereotype threat which leads to underperformance in STEM-based fields (Beilock, et al., 2010; Eccles, Jacobs, & Harold, 1990; Gunderson, et al., 2012; Mueller & Dweck, 1998; Shapiro & Williams, 2012).

For females, especially females of color, parents play an important role in determining whether or not she will pursue a STEM field in college. Goodman and Cunningham (2002) found that mothers and fathers were highly influential in students’ decisions about her major, with over 70% of study participants citing a parent as the most or second-most influential factor in their decision to pursue engineering. Because parents play such a critical role in determining their daughter’s future major choices, it is also critical that parents understand what engineering is so that they can encourage their daughters to pursue when it is a good fit. Parents must also deem engineering to be an “appropriate” choice for their daughters.

The STEM Summer Institute (SSI) is a non-residential, ten-day summer camp for high school girls held by the STEM Summer Institute. Over the past four summers, eight-one unique girls participated in the program, with some girls participating as many as four years. Two-thirds of the girls were from local public comprehensive high schools, while the other third attended independent schools in the area. The curriculum was based in both service learning and engineering design within a global context. The Lwala Community Alliance of Kenya (2016) "hired" the participants to work on two projects each summer. In one summer, the rising 9th and 10th graders improved the design of the approach to a bridge that floods in the rainy season. The rising 11th and 12th graders designed an oven for the women of Lwala to bake mandazi in large quantities to use as a commodity for trade in one summer. Participants used the engineering design process to manage the designs along with appropriate scientific inquiry, statistical analyses, CAD drawings, and hands-on prototype building to accomplish this task. Each group also prepared an oral presentation and a video. These videos ran while the girls stood in front of the posters, giving their oral presentations, to judges, parents, and teachers from their home schools on the final engineering design competition day. We also did things to make this feel a bit more like a traditional camp - and not just academics – such as making ice cream, making shrink-dinks, going to the playground, etc. We also included topics like college planning and building up the girls’ social capital. Parents were specifically engaged at two points during the program: a homework assignment designed to have parents
and daughters brainstorm about the Lwala design challenges and an invitation to parents to participate in the engineering design project presentations on the last day.

The Parents’ Engineering Awareness Survey (PEAS) (Yun, et. al, 2010) was administered to all consented parents (one per participant) prior to and following the SSI. The PEAS survey includes knowledge, attitude, and behavior aspects; only the knowledge and attitude aspects were hoped to be impacted by this program due to the short intervention time between implementations of this survey. The Draw an Engineer Test (DAET) (Knight and Cunningham, 2004) was administered to all consented student participants prior to and on the last day of the SSI during the first three summers. The PEAS survey indicated a significant increase in parental knowledge of and attitudes toward engineering. Using qualitative analysis, the DAET test indicated an increase in the accuracy of student understanding of what engineering is and what engineers do. The STEM Summer Institute program is an effective model for helping both girls and their parents’ increase their knowledge of what engineering is and should be replicated and emulated in other programs, both academic year and summer, for girls.

References:


Galileo said "The great book of nature can be read only by those who know the language in which it was written. And that language is mathematics." Unfortunately, many students enrolling in freshman mathematics at MTSU cannot read the “great book of nature.” Every STEM discipline depends on mathematics, but many of our STEM majors have serious deficiencies in mathematics that may keep them from achieving their dreams. More than ever, universities across the US are interested in helping students succeed academically. In our NSF-funded STEP project “Mathematics as a First STEP to Success in STEM (FirstSTEP),” MTSU mathematicians have been searching for interventions to help STEM majors who are poorly prepared in mathematics successfully complete their freshman mathematics. We studied the impact of several mathematical interventions during the freshman and sophomore years on cohorts of incoming freshman STEM majors (Raines, 2012; Yantz, et al., 2014), with varying success. In an attempt to broaden our reach, in August 2015, we launched pre-semester readiness workshop for students enrolled in pre-calculus and calculus I. Support continued for the duration of the fall semester for students in the Calculus I readiness workshop and ended with the start of the fall semester for the pre-calculus participants. This talk will describe the readiness workshops, data we have collected and analyzed, conclusions we have drawn, case studies of students with particular deficiencies, and other observations about this intervention.

References:


Creating a Course Community to Change the Teaching of Introductory Statistics at Middle Tennessee State University

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The Modules for Teaching Statistics with Pedagogy using Active Learning (MTStatPAL) research group designed learning modules for an introductory statistics course to improve student success by disseminating best teaching practices across the many sections of this course. During the class-testing by faculty outside the MTStatPAL project, we observed that faculty new to active learning have a hard time implementing the modules without support. Many faculty members do not have formal statistical training in their undergraduate or graduate coursework. Further, many do not have training in using active learning. The MTStatPAL project team then started to create a professional development model to support faculty in effectively integrating active learning in introductory statistics.

The NCTM Professional Development Research Brief guidance for Mathematics Professional Development (2010) gave four areas that professional development should address. Modifying these to address Statistics, rather than Mathematics, yielded the following four goals:

- Build instructors’ statistical knowledge and specifically their statistical knowledge for teaching.
- Build instructors’ capacity to notice, analyze, and respond to students’ thinking.
- Build instructors’ productive habits of mind.
- Build collegial relationships supporting the scholarship of teaching and learning.

Furthermore, successful professional development programs must have a substantial time investment, systemic support for the instructors, opportunities for collaborative and varied learning experiences that result in acquisition of skills and knowledge, and evaluations of both student achievement and the immediate and ongoing impact on professional practice (Ohio Department of Education, 2010).

An Introductory Statistics Course Community was created to incorporate these best practices for professional development and address the professional development goals. Faculty met every
two weeks during the fall 2015 semester, and will continue to meet in the Spring 2016 semester. Faculty in the group share planning, ask and answer each other’s course content and curriculum questions, reflect on their class experiences, and explore pedagogical changes. Additionally, faculty are using student outcome data to make decisions on course content, curriculum, and pedagogical approaches. In the spring semester, faculty will implement the MTStatPAL active learning modules in 20 sections of Introductory Statistics at Middle Tennessee State University.

This presentation will report on the experiences of the faculty members involved in this Course Community using data collected from faculty self-surveys to begin to answer the following questions: Do faculty involved feel a benefit from the community? How do faculty members with different levels of experience in teaching statistics differ in their reactions to the community? Has the community positively affected the teaching of Applied Statistics? Is this a sustainable model of professional development that can continue to function after the current year?

**References:**


Mathematics Success for STEM Majors

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The overall goal of the Math Success for STEM Majors (2010 – 2016) project is to increase the number of STEM graduates annually from Tenn Tech University from a pre-project average of 350 – 400 students to 500 per year by the end date of the grant. To meet this goal, the project has pursued six main strategies based in education research (Twigg, 2005): 1) Math 1730-Precalculus Redesign - incorporating active learning in the redesign of introductory STEM mathematics courses (Hensel, 2006, Klingbeil, 2009); 2) Math Zone - implementing just-in-time academic support for students enrolled in all introductory STEM mathematics courses (Smolinksky, 2006); 3) STEM 1010 - integrating the STEM disciplines through context-driven math applications within a new introduction to university life course for entering STEM freshmen (Cordray, 2007); 4) Placement in Math Courses - implementing a uniform TTU mathematics course placement policy; 5) Student Data Tracking - developing and implementing a data system that tracks individual student performance and status across the STEM disciplines, using information from Banner and additional sources; and 6) Articulation - articulating mathematics skill-level expectations with selected high schools sending large numbers of STEM freshmen to TTU (Blair, 2006, ACT, 2007).

While not designed as a research project (outright), evaluation data related to all of these components are compelling. Evaluation questions include: Is student success as measured by the percent of STEM majors completing a redesigned math course with a grade of C or better and the number and percent of STEM majors completing the next required math course with a grade of C or better greater than in traditional courses? Do students in redesigned mathematics courses show improvement on existing or newly developed instruments in pre/post comparison? Are students in redesigned math courses requiring the use of the Math Zone more likely to complete the course with a grade of C or better? Are students from articulation partner school districts more likely to be placed in Calculus I (rather than pre-calculus) during their first semester, more likely to earn a C or better in their first STEM mathematics course, more successful in mastery of topics within TTU mathematics courses, or more likely to be retained in a STEM major?
In the final stages of the project, we are examining the Student Data Tracking results to extract insights regarding the math completion trajectories of STEM majors guided by these evaluation questions. The emerging findings will be shared during the Conference presentation. The MSSM project is the result of a synergistic approach amongst faculty from the College of Arts and Sciences, the College of Education, and the College of Engineering that utilizes best practices in STEM education to increase the number of STEM graduates. The project has both advanced knowledge in mathematics and the associated comfort level of STEM majors by removing barriers linked to poor performance in STEM math classes and the associated lower retention to graduation in a STEM major (Brachey & Bechard, 2012). Addressing the issue at the pre-college level through articulation with regional feeder high-schools, at the math placement level, and inside and outside the initial mathematics classroom is a holistic and potentially transformative approach.

References:


Promoting Active Learning Strategies in the High School Biology Classroom

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Promoting Active Learning Strategies in Biology (PALS) compared the efficacy of two active learning strategies, originally developed for a university setting in chemistry and physics, in the high school biology classroom: Process Oriented Guided Inquiry (POGIL; Ferrell, Moog and Spencer, 1999) and Peer Instruction (PI; Mazur, 1997). Both strategies have demonstrated success at the high school level (Freeman et al., 2007; Freeman, Haak, and Wenderoth, 2011; Guiliodori, Lujan, & DiCarlo, 2006; Smith, Wood, Krauter, & Knight, 2011). The project proposed to further adapt and evaluate these strategies to determine which showed the most promise for increasing high school students’ achievement (as measured by end-of-course test scores) and attitudes towards science, as well as teacher knowledge, teaching motivation, teacher attitude, implementation fidelity, and context beliefs. Data were collected via survey instruments and observation of classroom teaching.

Biology is taught more frequently than any other science in the United States, constituting 39% of all science courses offered, and it is frequently taught didactically, with an emphasis on memorization of vocabulary and facts (Lyons, 2012). In Tennessee, biology is required of all high school students, yet only 27% of high school graduates are prepared to succeed (as measured by grades of A, B, or C) in freshman biology courses in college (ACT, 2013). High school biology, taught using strategies that emphasize active learning and conceptual understanding, offers an environment with potential to improve science achievement, and attitudes towards science in general.

Beginning in the summer of 2015, the PALS Project provided professional development in one of the identified active learning strategies (either POGIL or PI) to high school biology teachers in Middle Tennessee (n = 46, from 16 school districts and 32 high schools). Teachers attended a summer intensive workshop in which they were introduced to one of the strategies, and given an opportunity to practice the pedagogy by designing and delivering lessons to their peers, using materials that PALS project personnel had designed and/or adapted. Teachers also attended follow-up sessions during the academic year. Two content areas were selected based on their difficulty for student learning: heredity, and cellular structure and function.
Results from the curriculum design and professional development components will be shared, as well as benchmark and preliminary data from the classroom.

References:


With the increasing globalization, and the increasing need for a scientifically literate population, it is essential that secondary school (Grades 6-12) students not only receive meaningful science and literacy instruction, but also see the seamless nature of how each informs the other. According to Yager (2004), “science content must be related to the real world—the world the students know and operate in” (p. 103). In students’ world, they use reading and writing as tools to inquire deeply about science topics. However, students need support to comprehend, compose, understand, and apply what they read in science texts (Goldman, 1997; Ivey, 1999; Lee & Fradd, 1999; Nicholson, 1985). This integration can lead to greater interest and confidence in literacy and scientific endeavors as students move through school and determine future education and career paths (Nichols, 2015).

To that end, the Tennessee Department of Education (TNDOE) Mathematics and Science Partnerships (MSP) Program promotes innovative practices in K-12 Science-Technology-Engineering-Mathematics (STEM) classrooms by bringing together staff from local educational agents (LEA) and faculty from institutes of higher education (IHE) to provide professional development (PD) to K-12 teachers. The project described in this presentation, *Integrating Science Learning with Literacy using Informational and Fictional Texts in Grades 6-12*, sought to enable grades 6-12 Science and English Language Arts (ELA) teachers to reach for excellence in middle and high school Science and ELA through Hands-on, Standards-based, Project-based and Technology-based (HSPT-based) learning. Specifically, teachers developed lessons that integrated science and literacy, reading and writing about HSPT learning. During this project, a Project Management Team (PMT) used feedback from teachers, as well as literature about effective PD and effective science and literacy integration to design meaningful experiences for teachers. The purposes of this presentation are: 1) to describe PD that paired middle school and high school science and ELA teachers for the purposes of developing integrated lessons; and 2) to report preliminary findings about this PD.

References:


Comparing the Impact of Two Active Learning Strategies on Epistemological Beliefs of Post-secondary Microbiology Students

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A research-based instructional strategy was implemented in a post-secondary microbiology course in an attempt to shift students’ novice-like epistemological beliefs toward more expert-like beliefs. Typically, this course is taught in a traditional manner emphasizing rote memorization which is often described as a passive-learning instructional model. Research suggests this model is less effective at fostering conceptual understanding and discipline specific interest when compared to an active-learning model (Brewer & Smith, 2011; Halpern & Hackel 2002). Numerous studies document the benefits of active learning compared to passive learning; however, there is only limited studies that directly compare active learning implementation strategies—a particularly import factor to consider when incorporating active-learning strategies into a traditional lecture course. For this study I compare the impact of two distinct active-learning implementation strategies on students’ epistemological beliefs about biology.

An inquiry based active-learning model was implemented in two sections of an introductory microbiology course taught by the same instructor. The instructor implemented seven inquiry-based exercises over the course of the semester. These exercises were developed utilizing a list of key concepts of microbiology developed by the American Society for Microbiology (ASM) (Merkel, 2012). The exercises were designed to foster meaningful discourse between students and between students and the instructor around key concepts of microbiology identified by ASM. The implementation varied between each section so that students in Section 1 completed a set of inquiry based exercises individually, and students in Section 2 completed the same set of exercises in small groups. Upon completion, both sections participated in an instructor guided debriefing that involved whole class discussion based on student responses to the exercises. The purpose of this study was to compare the impact of distinct active-learning strategies on students’ epistemological beliefs about biology.

Data was collected in both sections at the beginning and end of the semester using the CLASS-Bio (Semsar, et al., 2011) to evaluate student epistemological beliefs about the practice of biology and the learning of biological content as compared to experts in the field of biology. Results indicate no significant differences between treatments. Interestingly, results do contradict previously reported studies on science majors’ epistemological beliefs within specific disciplines. For example, past studies reported novice-like shifts in post-secondary science students’ beliefs after one semester of physics (Adams, et al., 2004), chemistry (Barbera, et al., 2006) and biology (Ding & Mollohan, 2015). However, result here indicated participants did not reveal any novice-like shifts. Furthermore, more than 50% of all participants...
demonstrated shifts toward more expert-like beliefs. This is a notable finding that supports further use of this set of inquiry-based exercises and the implementation strategies utilized in this study to incorporate a student-centered active-learning component in a traditional lecture course.

References:


Big Orange STEM Saturday: A Successful Model for STEM Career and Outreach

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The Big Orange STEM Saturday: A STEM Studies and Career Fair in the Libraries (BOSS), formerly the Big Orange STEM Symposium, is approaching its 4th year as a recognized University of Tennessee, Knoxville event and continues to reinforce student transition from high school to college from year to year. BOSS contributes to the University of Tennessee’s campus-wide mission and has been instrumental in developing academic relationships with local Knoxville and surrounding county schools, such as Anderson, Blount, Sevier, and Union.

BOSS is a one-day mini conference where attendees participate in a Keynote Activity, breakout sessions, and a STEM career fair. The BOSS program helps students identify both college and career resources through interactions with peers, experts, and campus faculty within those fields.

A review of the research shows that a large portion of STEM outreach has mostly been done by university STEM departments, however there is a growing trend that academic libraries are beginning to take a leadership role in planning STEM outreach and engagement which has been reported to help address student retention and success. J. Kuenzi (2008) speaks of the history of the STEM preparedness in her report to Congress saying, “Since the 1990’s, there has been continual improvement in preparing students to succeed in college; however there is a growing concern that these students are not being sufficiently prepared in the STEM areas.” Joan M. Raines, in her article First STEP: A Preliminary Review of the Effects of a Summer Bridge Program on Pre-College STEM Majors (2012), continues this concern stating, “it is essential that we strengthen the science, technology, engineering, and mathematics (STEM) skills of those who will be competing in the workplace.” This idea is agreed upon in the literature, including case studies by Patricia A. S. Ralston (2013), Deidra N. Herring (2015), and Mark F. Engberg (2013).

Adding to the national research, the BOSS team developed its own instrument in order to gather information from participants about their experience. A sampling of the instrument questions include:

   After having attended the symposium, are you now interested in STEM fields that you were not before?
After having attended the Symposium, do you have a better understanding of some local agencies or departments you might like to work for?

The Research feedback showed that participants were less prepared to respond to questions about STEM in a research capacity. There was greater interest in meeting community contacts, professors, and peers. Due to feedback from participants of 2014, the 2015 program was updated to include a Keynote activity that provided a more interactive learning experience rather than a lecture style format.

Interdepartmental outreach initiatives have a role in shaping future STEM professionals. The library setting for the program included a smaller, efficient networking opportunity that allowed the students and parents to look holistically at Science, Technology, Engineering, and Mathematics disciplines instead of attending each program separately.

References:


A small, flexible, affordable, stereoscopic 3D-hyperwall system (Johnson, Leigh, Morin, & Van Keken, 2006; Leigh, et al., 2003, 2004) has been constructed at MTSU to help teach spatial skills alongside discipline content. This talk focuses on the design of the hardware and software systems for laboratory and lecture, the redesign of educational materials, and the research design. The sample size of the preliminary results and the dosage of the training are inconclusive. Further research is planned.

References:


Many educators claim that student learning is not only prompted by subject matter knowledge of teachers but also by their other unique knowledge called pedagogical content knowledge (e.g., Ball, 1990; Shulman, 1986). This pedagogical content knowledge (PCK) allows the teacher to comprehend the subject matter, to discover several ways to represent it, to generate and evaluate analogies, metaphors, and particular examples of subject matter concepts when performing the tasks of teaching. The key component of Shulman’s (1986) PCK is knowledge of content and students (KCS) which can provide a valuable source of pedagogical knowledge by examining students’ thinking and opinions (Hill, Ball & Schiling, 2008). In an effort to gain awareness from assessing students’ thoughts and ideas, we used a tool called Digital Metaphor (Rowelett, 2013). The Greek word, *metaphora*, means to transfer or carry over (Presmeg, 1997). According to Oxford Dictionaries (2015), “A metaphor is a thing regarded as representative or symbolic of something else especially something abstract.” Digital metaphors use images and words in response to a given statement. Using a digital metaphor model (Rowlett, 2013), the students were asked to present a picture (on their cell phone or from online sources like Google Images) which captured their reaction to a given statement. The participants were also asked to write a paragraph describing how the picture they selected was related to the given statement, underlining the words they thought to be the most important. The significance of this study lies in understanding how to use digital metaphor assignments to improve teachers’ knowledge on how students think and feel about issues, and in particular to better understand and recognize student struggles related to learning mathematics and/or science.

This presentation shares lessons learned fusing digital metaphor assignments in three different mathematics/science settings. The first study focused on using digital metaphors written by students who are underprepared in college mathematics to provide insight into their self-determination for college success in science, engineering, technology and mathematics. The second study used digital metaphors from students taking Calculus I and showed how asking the right questions can help students improve their own determination for success. The third study was conducted in an introductory statistics course and provided both lessons learned for the student and the teacher on using digital metaphors to help students overcome their fears and anxieties about learning mathematics/statistics.
Even though different research questions were proposed for the three studies, each revealed the following:

1. How did the students use digital metaphors to portray and describe the given statement?
2. How can mathematics and science teachers use digital metaphors to inform and improve instruction?
3. How did the participants benefit, if at all, from their digital metaphors?

Examining students’ digital metaphors enabled us to understand their perspectives regarding a given statement. It provided insights into the students’ inner feelings and personal struggles to learn mathematics and science. Furthermore, this acquired knowledge helped us support students with improved instruction.

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