Proceedings and Abstracts

8th Annual MTSU STEM Education Research Conference

February 6-7, 2014

DoubleTree Hotel
Murfreesboro, TN

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Tennessee Space Grant Consortium
Middle Tennessee State University Office of Research
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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 Eight 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. Thomas Smith, Director of the National Center on Scaling Up Effective Schools (NCSU) and Associate Professor of Public Policy and Education in the Department of Leadership, Public Policy and Education, College of Education in Peabody College at Vanderbilt. He will describe his work on an NSF-funded longitudinal study of beginning middle school math teachers. Dr. Jennifer Lewis, a chemist whose research focus is in chemistry education, will describe her experience with and related research on Process-Oriented Guided Inquiry Learning (POGL), an active learning strategy that has spread from introductory college chemistry to many other disciplines at many educational levels from K-20. We will have a treat after the evening banquet on Thursday when we hear from Mr. Tod Fethering, an entrepreneur, who is Founder and CEO of Stratasan, a leading health-care informatics company in Nashville, Tennessee. Mr. Fethering has had an amazing career that includes several “firsts” in technology and health care. He also served as President of the Nashville Technology Council. He will be introduced by Mr. David Hanna, Microsoft Enterprise Executive Leader for Tennessee, one of our conference sponsors through Mind2MarketPlace.

Focusing more on Tennessee, a government panel will highlight new and exciting programs underway or being discussed and update participants on their progress. The Panel consists of Dr. David Sevier, Deputy Director of the Tennessee Board of Education, Mr. David Williams, Mathematics Coordinator for the Tennessee Department of Education, and Mr. Wesley Hall, Director of Client Engagement for the Tennessee STEM Innovation Network (TSIN). We have 12 great breakout presentations for you to choose from on Friday morning. 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, the MTSU Office of Research Services and, new this year, Mind2MarketPlace including their sponsors Microsoft Corporation, University of Tennessee Center for Public Outreach, and Middle Tennessee State University. Special thanks to Dr. Mark Abolins, the MTSU PI for the Space Grant, Mike Allen, Vice Provost for Research & Dean of the College of Graduate Studies at MTSU, and Mr. Tim Choate, Founder and CEO of Bondware and President of Mind2MarketPlace. I hope you enjoy the conference and come back next year to present your research on teaching and learning in STEM!
Conference Agenda
MTSU STEM Education Research Conference
February 6-7, 2014
DoubleTree Hotel
1850 Old Fort Pkwy
Murfreesboro, TN 37129

(There is a pre-conference meeting of the STEM Education Leadership Council, 8:00 AM - 10:00 AM)

Thursday, February 6, 2014
12:00 – 1:00 Registration

1:00 – 1:30 Welcome and Announcements (Ballroom), (Facilitator: Tom Cheatham)
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
Mr. Brian Robertson, Mind2MarketPlace vice-chair & CIO Rutherford County

1:35 – 2:35 Mathematics Education Keynote, (Facilitator: Stephen Bartos, MTSU)
How can we improve the teaching quality of beginning middle school mathematics teachers?
Dr. Thomas Smith, Director of the National Center on Scaling Up Effective Schools (NCSU) and Associate Professor of Public Policy and Education
Peabody College at Vanderbilt University, Nashville, TN

2:40 – 3:40 Science Education Keynote, (Facilitator: Amy Phelps, MTSU)
Process-Oriented Guided Inquiry Learning: What is it, and can it work?
Dr. Jennifer Lewis, Associate Professor of Chemistry Education
University of South Florida, Tampa, FL

3:40 – 4:00 Break

4:00 – 4:45 Tennessee Government Panel, (Facilitator: Tom Cheatham, MTSU)
Mr. David Williams, Mathematics Coordinator, TN Department of Education
Dr. David Sevier, Deputy Director, TN Board of Education
Mr. Wesley Hall, Director of Engagement, Tennessee STEM Innovation Network

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

6:00 – 7:45 Dinner and STEM Business Keynote
Educate to Innovate, (Introduced by David Hanna, Microsoft)
Mr. J. Tod Fethering, Chairman and Founder of Stratasan
Nashville, TN

(continued on next page)
Friday, February 7, 2014

7:45 – 8:25  Breakfast

8:30 – 10:00  Concurrent Breakout Session 1 (talks are 25 minutes plus 15 minutes for questions)

**Active Learning Research (Ballroom C), (Facilitator, Robert Carlton, MTSU)**
- Faculty Use of Personal Response Devices to Promote Active Learning in University Learning Environments: A Comparative Study
  Grant E. Gardner (Middle Tennessee State University), Subodh Dutta, Karen Mulcahy, Vera Tabakova, Diane J. Majewski (East Carolina University)
- Flipped Instruction and Mathematical Task Engagement
  Jeremy Strayer (Middle Tennessee State University)

**NSF GK-12 Research (Ballroom B), (Facilitator, Elizabeth Linville, Knowledge Associates)**
- Assessing Attitudes: A Preliminary Analysis of the Impact of GK-12 Graduate Fellow Classroom Interactions on Secondary Students’ Perceptions of Science
  Kim Sadler, Rachel Lytle, Anthony Farone, Mary Farone, Ginger Rowell (Middle Tennessee State University), Jennifer Dye (Pope John Paul II High School)
- STEM Partnerships: The Barriers and Successes of Implementing a National Science Foundation Grant at One Elementary School
  Sharon Pickering, Yencenia Cigarroa, Nancy McDonald, Reneé Wood (North Side Elementary School), Elizabeth Linville (Knowledge Academies)

**Teaching Teachers (Ballroom A), (Facilitator: Jennifer “Filly” Fillingim)**
- Reaching for Excellence in Grade 3-5 School Science - Experiences and Results from a THEC-ETSU STEM PD Project
  Chih-Che Tai (East Tennessee State University)
- Technological and Pedagogical Content Knowledge with In-service and Pre-service Teachers in STEM Settings
  Leslie Suters, Melissa Comer (Tennessee Technological University)

10:00 – 10:30  Break/Discussions

10:30 – 12:00  Concurrent Breakout Session 2 (talks are 25 minutes plus 15 minutes for questions)

**Diversity in STEM Education (Ballroom A), (Facilitator: Holly Anthony, TTU)**
- Questioning Selves, Questioning Minds: Women’s Persistence in Doctoral Programs
  Holly Anthony, Martha Howard (Tennessee Technological University)
- The Memphis Virtual STEM Academy at East High School
  Alfred Hall (University of Memphis)

**Integrated Curriculum for Teachers (Ballroom B), (Facilitator: Sarah Jessie, Rutherford Co.)**
- Lessons Learned Integrating Nutrition and Physics into a Course Serving Elementary Education Majors and Degree-Seeking Inmates at the Tennessee Prison for Women
  Ben Hutchinson, Autumn Marshall, Richard Goode (Lipscomb University), Todd Gary (Lipscomb University and Middle Tennessee State University)
- Momentum: Building Capacity for Change through Connections
  Ann Assad, Lauren Wells (Austin Peay State University)

**Mathematics Education Research (Ballroom C), (Facilitator: Donald Nelson, MTSU)**
- Impact of Modeling Instruction and the Inverted Curriculum in Science on Math Achievement
  Jennifer Dye (Pope John Paul II High School), Tom Cheatham, Ginger Rowell (Middle Tennessee State University)
- A Pre-calculus Preparation Program Makes a Difference for At-risk STEM Majors
  Brittany Smith, Chris Stephens, Elaine Tenpenny, Don Nelson, Ginger Holmes Rowell, Tom Cheatham (Middle Tennessee State University); Jennifer Yantz (CTB McGraw-Hill)

12:00 - Lunch/Depart
Dr. Thomas Smith, Director of the National Center on Scaling Up Effective Schools (NCSU) and Associate Professor of Public Policy and Education

Peabody College at Vanderbilt University, Nashville, TN

How can we improve the teaching quality of beginning middle school mathematics teachers?

While for decades many have believed that teachers are the most important ingredient to students receiving a quality K-12 educational experience, only recently has research been able to document the large and persistent effects that teachers have on value added to student achievement. Concomitant with the increased recognition of the importance of teacher effectiveness is an unprecedented interest in teacher preparation and teacher learning.

While induction of new teachers in K-12 schools is but one piece of the teacher education continuum that typically starts in pre-service teacher education programs and continues through in-service professional development, there has been a growing interest among policy makers in figuring out how to best support beginning teachers. Although induction has increased in popularity, supporting only 4 in 10 beginning teachers in twenty five years ago compared to nearly all beginning teachers today, research has yet to identify which components of induction have the greatest impact.

In this talk I will describe findings from a five year study of beginning middle school mathematics teachers in 11 districts. We investigated the relationship between a range of induction supports—including mentorship, professional development, collaboration with other math teachers, and leadership support—provided to beginning middle school mathematics teachers and the extent to which teachers implement forms of instruction advocated by National Council of Teachers of Mathematics (NCTM) standards and required in the new Common Core State Standards. Results suggest little improvement in the instructional quality of mathematics lessons during the first 3 years of teaching and that induction supports, as they are currently delivered, do not appear to help most beginning middle school mathematics teachers improve their instructional quality. While our findings suggest that current methods of mentoring and PD are likely not robust enough to support the type of teacher improvement demanded by new math standards, our research suggests ideas for structuring the supports to improve their effectiveness, and they also emphasize the critical role the principal plays.
Science Education Keynote

Dr. Jennifer Lewis, Professor of Chemistry and Interim Chair Women’s & Gender Studies

College of Arts and Sciences
University of South Florida

Process-Oriented Guided Inquiry Learning: What is it, and can it work?

Process-oriented guided inquiry learning (POGIL) has emerged as one of several high profile promising practices for STEM education in recent years. The POGIL approach combines a cooperative learning structure with specially designed paper-and-pencil activities to support students working in self-managed teams during class time. The goal is for students to develop or deepen conceptual understanding while simultaneously practicing valuable process skills such as scientific argumentation. This talk will provide a description of the basic features of a POGIL implementation and an introduction to some of the research associated with process-oriented guided inquiry learning (POGIL) in chemistry, including both efficacy studies and investigations of student argumentation.

The POGIL Project, a 501(c)3 non-profit organization, offers faculty professional development workshops and published curricular materials in several STEM disciplines. Over the past ten years, the speaker has been part of the leadership team for projects funded by the National Science Foundation involving the development and dissemination of POGIL activities for biochemistry, calculus, chemistry, and climate change, and she has also served as a consultant evaluator to The POGIL Project. Her POGIL-related work has focused on the evaluation of student outcomes and the investigation of student interactions in POGIL groups.
Tennessee Government Panel

Update from Tennessee Department of Education
David Williams, Math Specialist Tennessee Department of Education

An update on math programs and activities from the Tennessee Department of Education will be provided including an update on the Common Core State Standards in Mathematics.

Update from 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 Tennessee STEM Innovation Network
Wes Hall, Director of Client Engagement for TSIN

Conference attendees will be updated on news from the Tennessee STEM Innovation Network and efforts to sustain the network after Race-to-the-Top ends. News from the TSIN Hubs (Metro Nashville, Knoxville, East Tennessee State University, University of Memphis, and Chattanooga) and corresponding Platform Schools across Tennessee will be shared.
Mr. J. Tod Fethering, Chairman and Founder of Stratasan  
Nashville, TN

Educate to Innovate

This talk will discuss the opportunities in today’s workforce for STEM careers. All areas of STEM are growing in demand, but the pipeline of qualified candidates is limited. We will discuss three ways communities and our education system can transform the workforce before 2020.
Call for education reform in undergraduate STEM courses revolve around the idea that teaching should be built on the same principles as scientific practice that “involve(s) active learning strategies to engage students in the process of science and teaching methods that have been systematically tested and shown to reach diverse students” (Handelsman et al., 2004, pg. 521). One means in which scientific teaching has been enacted is through the use of educational technologies. One such pedagogical tool that has seen prolific growth in use over that past decade are personal response devices (“clickers”) (Burnstein & Lederman, 2006; Caldwell, 2007) that are envisioned as a tool to increase active learning especially in larger undergraduate STEM classrooms (Bruff, 2009; Caldwell, 2007; Feis & Marshall, 2006). The most typical use of clickers has been to poll students with multiple choice questions and then utilize the results to promote discussion and allow both the instructor and students to formatively assess their learning (Bruff, 2009).

Clickers engage students, increasing student classroom interactions, enhancing student motivation and interest, promote student argumentation and reasoning, and increasing attendance (Crossgrove & Curran, 2008; Feis & Marshall, 2006; Fitch, 2004; Hansen, 2007; Knight et al., 2013; Preszler et al., 2007; Sharma et al., 2005) although evidence is still somewhat contradictory (Chen & Lan, 2013; Crossgrove & Curran, 2008). As with any technology it is largely how the instructor chooses to use it and not merely that it is used that determines its impact on learning outcomes. Out study examines if and how faculty are using clickers.

Studies note that the use of clickers in the classroom varies greatly among faculty and between disciplines (Freeman et al., 2007). Faculty may choose to never adopt the technology or discontinue use due to various constraints (Freeman et al., 2007; Henderson, 2005). For our initial exploration in this study the authors wished to examine faculty use of clickers and their awareness of the benefits of clickers in a UDL framework (CAST, 2011).

A survey was constructed and distributed to University faculty at a large southeastern University that asked if and how they used clickers to engage students, their satisfaction levels with the technology, supports and frustrations associated with the technology, typical course sections taught, as well as their awareness with
clicker alignment to UDL principles. 201 faculty responses were logged with a range of demographics, faculty designations and instructional responsibilities.

Results demonstrated that overall the majority of the participants were not utilizing clickers in their classrooms and small percentage had discontinued use after trying clickers. There were no significant correlations found between demographic variables and clicker use. It is clear that clicker use is most prevalent in the basic and applied sciences (and associated fields), with many faculty in the humanities and social sciences never having used them. Reasons for faculty adoption and faculty discontinued use are discussed as well from qualitative data collected on open-ended questions. Results are discussed in the context of faculty development and integration of technology in the STEM classroom.

References:


The flipped classroom has garnered vast amounts of attention as a viable instructional strategy in mathematics classrooms from the popular and educational media alike – including NCTM’s SmartBrief news updates (Gojak, 2012). Flipping a classroom is described in The Flipped Class Manifest (Bennett et al., 2011) as transferring information to students outside of class in order to actively engage students in class. If “transferring information” to students means posting video lectures online and nothing more, then it is impossible to reconcile the flip with the process standards and the general vision of mathematics teaching and learning cast by the Principles and Standards for School Mathematics (NCTM, 2000) and Standards for Mathematical Practice (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). However, if the flip strategy can be leveraged to provide increased meaningful interaction between student-teacher, student-student, student-content, and student-outside resources (Dziuban, Hartman, & Moskal, 2004), then it may provide affordances for advancing mathematics learning.

This mixed methods study of the learning environment of a flipped introductory statistics classroom sought to better understand the ways a flipped environment can support meaningful mathematics learning. Twenty three students participated in this study. Students learned course content using the ALEKS intelligent tutoring system outside the classroom and completing active learning tasks in class. Data were collected using surveys, interviews, focus groups, and classroom observation.

Results showed that students in the flipped environment had a greater affinity for collaborative learning, but were less satisfied with how the environment oriented them to the learning tasks in the course. These exploratory results informed the search (using grounded theory methods) for a controlling theme that tells the story of the data. This theme is described elsewhere from a learning environments research perspective as comfortability with classroom activity (Strayer, 2007) and is used to analyze the nuanced unsettledness that students in the flipped learning environment exhibited. Here, in an effort to provide a framework for understanding the ways students learned mathematics in this flipped classroom, I present a modified version of comfortability as the task engagement (TE) framework (see Figure 1). This framework includes three components (communication structure, task approach, and task mindset), each with a dimensional range. Teachers and students both act to determine the manner in which tasks are engaged in the classroom, and the TE framework components conceptualize elements that influence those actions. Since students and teachers act multiple times during the completion of a task, engagement with a task will most often fall somewhere on a continuum between the sides of each component in the framework.
Analysis revealed that students in the flipped classroom engaged out-of-class tasks primarily along the left side of the TE framework and in-class tasks primarily along the right side of the framework. This result provided a viable explanation for the lack of support students felt when completing course tasks. It also leads us to consider whether aligning both in-class and out-of-class tasks along the right side of the TE framework may help meet the challenge of supporting flipped classroom students’ successful mathematical task completion.

References:


Assessing Attitudes: A Preliminary Analysis of the Impact of GK-12 Graduate Fellow Classroom Interactions on Secondary Students’ Perceptions of Science

Kim Sadler
Rachel Lytle
Anthony Farone
Mary Farone
Ginger Rowell
Middle Tennessee State University

Jennifer Dye
Pope John Paul II High School

The NSF GK-12 program at MTSU partners graduate students and high school teachers with biotechnology companies to promote STEM learning opportunities. Graduate Fellows spend one year in high school biology classrooms facilitating learning and mentoring student research projects. Fellows broaden high school student’s views of scientific careers as Fellows share their laboratory experiences gained by visiting partner biotechnology companies and by engaging high school students interactively in research the Fellow conducts as part of graduate school requirements. The year culminates with high school student research presentations at the Tennessee Junior Academy of Sciences or the TRIAD Research Symposium.

Research shows that the most crucial years to developing attitudes are during adolescence. A noted decline in secondary students’ attitude toward science presents the need for intervention at this age (Bennett & Hogarth, 2009; Osborne, Simon, & Collins, 2003; George, 2000). With over 200 GK-12 programs in existence in the United States and Puerto Rico, few to none have researched the impact of the program on high school students (About NSF GK-12, 2013). Studies have shown the countries with more scientists and engineers have better economies than those with less (Osborne et al., 2003). Possibly related to the decrease in secondary students’ attitudes toward science is the decrease in college STEM majors over the past 20 years (Wyss & Tai, 2012). With a predicted increase in the number of STEM careers available, there will not be enough qualified people to fill the positions (Wyss & Tai, 2012). This may have a negative effect on our economy and our country’s scientific standing. Therefore, implementing programs such as the GK-12 which brings young scientists to high schools may generate a positive perception of science and increase interest in pursuing a science career.
The demonstrated need for attention to this topic made us seek the answer to the following research question: Does introducing Graduate Fellows into high school science classrooms to interactively engage with students and develop student research projects influence the secondary students’ attitudes toward science?

To answer the research question, our multi-method approach includes a student perception survey, interviews, and student artifacts for analysis. Using a pre- and post-survey design, classes with a Fellow are compared with a corresponding control class with the same teacher. The Student Attitude Inventory-II (Moore & Hill, 1997) is being used to determine student perception of science and scientists. Attitude statements from the survey are sorted into six categories: (1) laws of science may change; (2) science is limited in what it can answer; (3) scientists must be honest, objective, and willing to change their minds; (4) the value of science is in its theoretical aspects; (5) it is important for the public to be aware of the nature of science; and, (6) interest in pursuing a science career. Student responses give a better picture of which areas of science perception and attitude become more positive, more negative, or stay the same. At this time, the study is in early stages of pre-survey analysis and therefore subject to broad interpretation. Predictions are that preliminary results will show similar trends in Fellow classes and control classes. Interviews and post-surveys data will be collected and analyzed at the end of the academic year.

References:


STEM Partnerships: The Barriers and Successes of Implementing a National Science Foundation Grant at One Elementary School

Sharon Pickering,
Yencenia Cigarroa
Nancy McDonald
Reneé Wood
North Side Elementary School Teachers

Elizabeth Linville
Knowledge Academies

The barriers and successes of implementing a multiyear National Science Foundation (NSF) GK-12 grant with a high poverty elementary school and university graduate students were studied by Dr. Sharon Pickering, Principal of North Side Elementary School (NSE) and Co-PI of the NSF GK-12 “Science First!” grant. East Tennessee State University graduate students implemented their expertise in a STEM discipline to work at NSE to support students and teachers. Both grade level teachers and those in related arts were involved in the project. The partnership afforded fellows the opportunity to teach and receive feedback in order to improve teaching skills, to communicate with nonscientific audiences, to adjust lessons based on understanding, and to work collaboratively with teachers (Page et al., 2011). In classes with rigid curricular requirements, the fellows redesigned traditional lessons to teach required topics using a more inquiry-based approach (Trautman, 2008). Graduate fellows helped teachers expand their curriculum with in-depth planning. This collaboration built lessons that required students to use more research, analytical, and critical thinking skills. Working with partner teachers, fellows determined where and how inquiry projects could help meet class-specific needs and enhance established curricula.

To analyze the success and barriers to this project, Co-PI, Sharon Pickering posed the following research questions:

1. What were the successes for teachers and graduate fellows of the 5 year NSF GK-12 “Science First!” Grant?
2. What were the barriers for teachers and graduate fellows of the 5 year NSF GK-12 “Science First!” Grant?

The benefit of this study was to identify challenges and opportunities in implementing such a grant at one elementary school so that successful partnerships could be created and sustained. Qualitative method was used to determine the participants’ perceptions of the barriers and successes in science and math instruction during the duration of the grant. The researcher used
individual interviews with participants to gather data. Because the data were based on the personal experiences of a small number of participants, a case study design was used. Coding sessions using the constant comparison method occurred after the interviews were completed (Strauss & Corbin, 1997). Each set of questions was analyzed individually after completing interviews to identify patterns and categories in the data. Themes were established, interviewer’s observations noted, and case records established for access (Patton, 1990). The researcher looked for themes leading to pictures of barriers and successes in the grant. Eight themes were found with successes identified as: relationships, mutual appreciation, increased academic depth, and professional growth. Barriers to the project included: communication, time, expectations, and preparation. Results showed that the grant did provide STEM support and academic rigor for the teachers and students. Positive relationships and open communication between graduate fellows, teachers, and the two participating institutions were critical in fostering successful partnerships. The quality of materials and the amount of time fellows spent in the classroom could be affected by these relationships. Through participation in the grant, teachers and fellows obtained professional growth and mutual respect and appreciation for each others’ roles and responsibilities.

References:


Reaching for Excellence in Grade 3-5 School Science- Experiences and Results from a THEC-ETSU STEM PD Project

Chih-Che Tai
East Tennessee State University

This professional development (PD) project seeks to enable elementary teachers to reach for excellence in elementary school science through Inquiry-based, Standards-based, Problem-based and Cloud Computing Technology-based (ISPT-based) learning environments. The project represents a partnership between scientists and science educators at East Tennessee State University (ETSU) and 20 Grade 3-5 elementary teachers from five nearby school districts: Bristol City, Greene County, Hawkins County, Kingsport City, and Sullivan County. It intended to build up two instructional infrastructures under the ETSU Northeast Innovation STEM Hub: (1) A Bank of Human Resource: educating and creating a cadre of knowledgeable and skillful science lead teachers; (2) A Virtual Instructional Network: building up a web-based instructional resource network in the region.

In compliance with THEC STEM PD requirements- Core Conceptual Framework for Effective Professional Development (Desmione, 2009), this project included five effective PD activities (Garet et al., 2001, Johnson et al, 2007a, b): (1) content focus, (2) active learning, (3) coherence, (4) duration of the activity and (5) collective participation. It provided a total of 102 hours of ISPT-based PD by sponsoring 5 Saturday workshops (30 hrs) and 1 summer institute (72 hrs) from August 2011 to December 2012. The principal investigator (PI) had 3 school visits to strengthen the PI-teacher partnerships and support classroom implementation.

Three research questions were investigated and conducted by the Tennessee Consortium on Research, Evaluation and Development: (1) What impact, if any, does this program have on teachers’ pedagogical skills and STEM content knowledge? (2) What impact, if any, does this program have on teachers’ opinions regarding the teaching of STEM? (3) Does this program demonstrate significant growth in Teacher Quality (pedagogical skills and content) and should be considered for inclusion as best practice for Tennessee?

Various summative and formative assessment instruments were used to evaluate the effectiveness of the project including: Teacher Content Surveys, Teacher Pedagogy Surveys, Teacher Classroom Observations and Teacher Interviews (evaluated by the Tennessee Consortium on Research, Evaluation and Development) and Teacher Content Assessments, Teacher Learning Reflections and Teacher TVAAS Reports (evaluated by the program). The findings from three classroom observations indicated there was significant growth for participants in the ETSU program participants in all four measured areas: design, implementation, classroom culture, and content knowledge. The findings from surveys showed a mix of informative results including teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. Also, twenty participants completed both the pre/post assessment that was developed by ETSU. On the pre-test, the teachers answered 80 percent of the items correctly.
then the correct percentage increased to 85 percent on the post-test. This was determined to be statistically significant growth (t = 2.37, df = 19, p < 0.05). Overall, this program demonstrated significant gains in all areas, including teacher quality, teacher opinions, preparedness, and content knowledge and was considered one of best practices in THEC STEM PD Round I programs.

**References:**


Technological and Pedagogical Content Knowledge with In-service and Pre-service Teachers in STEM Settings

Leslie Suters
Melissa Comer
Tennessee Technological University

Research indicates many teachers are not knowledgeable regarding the use of technology in the classroom, even when resources are readily available. For example, Li (2007) states “Although fully aware that the students love technology and technology is students’ preferred way of gaining information, these teachers appear to have little appreciation of advanced technology in teaching practices and are reluctant to consider the idea of engaging students in computer-supported activities” (p. 391). Reynolds, Treharne, and Tripp’s (2003) assert that training gaps leave teachers unaware of how to use technology materials properly. Johnston and Cooley (2001) stress that “integrating technology into the curriculum . . . should not mean finding ways that computers can help us teach the same old things in the same old ways. Instead, [educators] have the opportunity to combine technology with engaging models of teaching and learning to transform education.” (p. 163).

We designed several research projects to develop preservice and inservice teachers Technological Pedagogical and Content Knowledge (TPACK) with the TPACK survey (Schmidt and Gurbo, 2008). Education methods courses typically focus on developing student’s knowledge and application of pedagogy and content in isolation; however, our goal was to develop competency in using various forms of technology connected to pedagogy and content through the use of the iPad and Web 2.0 technologies. We implemented a QEP Research Project in all methods courses with a strong emphasis on the use of technology, Fall 2012-Spring 2013. An additional QEP project was implemented Spring 2013 with a different population of students in 2 different instructional technology classes.

Both researchers also observed change as measured by the TPACK survey with participants in a Race to the Top STEM grant, From Earth to Space with STEM, Fall 2012-Fall 2013. Many of the project activities incorporated technology for collecting and analyzing data. This approach had a strong emphasis on the use of the iPad, Vernier Labquest, and Web 2.0 interactive technologies. Teachers created and produced actual artifacts and uploaded them to the project wiki.

Specifically the following research questions were posed:

1. How does participation in methods courses that incorporate a strong emphasis on the use of technology in context impact pre-service teachers’ TPACK?
2. How does participation in inquiry-and technology-based PD impact math and science in-service teachers’ TPACK?
Participants’ responses to TPACK questions were scored with a value of one assigned to strongly disagree, all the way to five for strongly agree. For each construct, the participants’ responses were averaged. Results for the preservice teachers showed an increase in their perceived ability to integrate technology across the curriculum. Both QEP projects were recognized with the QEP Award for Excellence in Innovative Instruction for the 2012-2013 academic year. Based on analysis of the QEP surveys which will be shared as well, the projects were in the top three out of 20 projects at TTU in which students showed relative gains in 21 out of the 22 objectives measured. Results of the TPACK survey for inservice teachers are currently being analyzed.

References:


Questioning Selves, Questioning Minds: Women’s Persistence in Doctoral Programs

Holly Anthony, Ph.D.
Martha Howard, Ph.D.
Tennessee Technological University

While retention and attrition among undergraduate students has long been an issue in higher education, the issue of attrition among graduate students has received relatively little attention. Women’s attrition in doctoral programs has been well documented, but few studies have examined women’s persistence in these programs. In other words, we know why some leave, but we do not know why others stay.

Participants in this study were 13 women who have completed doctoral programs within the last five years, but who may have doubted themselves or considered quitting at some point in the process. These 13 women (ages: 32–73) were representative of 8 Ph.D. programs, 7 universities, 5 States, and varied in terms of time in their Ph.D. program from 3–16 years.

Research questions included: (1) What kinds of experiences lead women doctoral students to question themselves and their abilities? (2) What motivates women to persist in doctoral programs? How do they persist?

An interpretivist theoretical framework was used in this qualitative interview study to explore the “meanings” that exist in the experiences of women within a Ph.D. journey of persistence. Participants were interviewed either in person or via telephone for 90-120 minutes. The audiotaped interviews were later transcribed verbatim and analyzed using a combination of inductive analysis coding techniques and narrative analysis.

Analysis revealed 11 key themes that were important in women’s persistence in doctoral programs despite self doubts that stemmed from a variety of sources. Analysis further revealed that Ph.D. programs that seek to improve the retention of women should consider (1) being proactive in cohort development, (2) designing social activities to keep students “connected,” (3) think carefully about advisor/advisee “matching,” and (4) acknowledge that the doctoral journey for women differs from that of their male peers.

Via dissemination of this research, other researchers and doctoral students may gain insights into how to lessen the attrition of women doctoral students and better retain them in programs, particularly in highly competitive disciplines (e.g. math, engineering, etc.) in which women are underrepresented. Fellow doctoral students may also find motivation to persist in their programs if faced with doubts.

As a part of a larger set of inquiries, this study will contribute to the effort to understand what it means to persist and succeed in doctoral programs. Thus the study plays a role in rethinking attrition and retention of women in doctoral programs. It may also impact higher education retention strategies due to the recent shift in funding models, which are now dependent on student retention.
The role of STEM education has evolved from providing students with STEM content knowledge and understanding to also preparing students to be interested in and committed to pursuing careers in the STEM and ICT workforce. According to the President’s Council of Advisors on Science and Technology, “We must prepare all students, including girls and minorities, who are underrepresented in these fields, to be proficient in STEM subjects. And we must inspire all students to learn STEM and, in the process, motivate many of them to pursue STEM careers” (PCAST, 2010). To fulfill this role, new strategies and practices must be developed. In addition, STEM teachers, school and district administrators, college faculty and researchers, and STEM professionals must collaborate to develop, implement, study, and evaluate interventions that encourage K-12 students to develop interest in and be prepared for such careers.

STEM-focused curriculum programs and projects have been developed, implemented, and researched for their effectiveness in improving student achievement and understanding of STEM concepts, as well as increasing student awareness of and interest in STEM careers. Burghardt, Hecht, Russo, Lauckhardt, & Hacker (2010) found that introducing a mathematics-infused engineering and technology education curriculum had a significant effect on student mathematics performance, and students who studied mathematics via various design activities thought mathematics was more important and interesting than their control group counterparts. Other findings indicate that engineering projects have a positive impact on student attitudes toward STEM. High, Thomas, & Redmond (2010) found that after completing such projects, students demonstrated “increased confidence levels in math and science, improvement in their recognition of the advantages of making an effort in mathematics and science, increased awareness of the nature of engineering, and improved interest in engineering as a potential career.”

However, even with existing outreach efforts, many students still have “little awareness of what an engineer is or does,” but engaging students in engineering activities can have a positive and long lasting impact on their conceptions of engineering and technology (Svihla, Marshall, & Petrosino, 2009). As a result, the Memphis Virtual STEM Academy at East High School (VSA) is designed to directly address these findings by providing an enriched STEM education experience for students that includes engineering projects, integrated activities, and direct connections with STEM professionals from business and industry partners.

The VSA received funding from the National Science Foundation as an ITEST Project to investigate the implementation of a virtual STEM curriculum that provides students with self-paced modules, face-to-face STEM laboratory projects, and field experiences designed to help students understand pre-engineering concepts and principles. This strategy provides high quality STEM educational opportunities to diverse populations of students attending high schools that are unable to offer an equivalent program of study due to inadequate laboratory facilities and/or
the absence of high quality STEM teachers. This strategy is also unique from the standpoint that it draws from the experiences of a team of engineers-turned-educators and provides them with innovative opportunities to collectively implement a virtual STEM curriculum and design/implement STEM laboratory and field experiences for high school students.

Strategies Research Question:
What coherent set of experiences best support student development (e.g. knowledge, skills, dispositions) for productive participation in the STEM and ICT workforce of the future?

Project Goal:
To design, implement, and evaluate an intervention that supports student engagement in authentic, relevant experiences that reflect the skills, knowledge, and practices represented in the STEM and ICT workforce and motivates students to pursue STEM and ICT career trajectories.

References:


President’s Council of Advisors on Science and Technology. (September 2010). Report to the President: *Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America’s Future*. Executive Office of the President.

Lessons Learned Integrating Nutrition and Physics into a Course Serving Elementary Education Majors and Degree-Seeking Inmates at the Tennessee Prison for Women

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Elementary teachers traditionally have a poor scientific background and do not see the relationship between scientific disciplines (Appleton, 2008; Saad & BouJaoude, 2012). To better prepare teachers at the elementary grade level, LU began redesigned STEM courses for elementary education majors in 2009. These redesigned courses consist of two trans-disciplinary, team-taught science courses; an integrated Physics/Nutrition course (IS-2) and integrated Biology/Chemistry course (IS-1) with a service-learning component. Within these courses a community of learners was developed and science teaching modeled for elementary teachers. Modules focused on the physical and life science content of the PRAXIS. Assessment instruments have been developed and given to both the traditional and redesigned courses (Gary, et.al, 2013; Hutchinson, et. al., 2013). The results show a significant increase in the students’ science content and attitudes toward science. One reason given was the strong student content foundation in several disciplines including science. Students in the physics/nutrition course were able to use physical science in an understanding of how humans utilize matter for nutrition and energy.

In 2013, the integrated physics and nutrition course was introduced to the LIFE (Lipscomb Initiative for Education) program that provides courses leading to an associate’s degree for inmates at the Tennessee Prison for Women. This course focuses on energy and matter; the inmate students examine scientific content that usually intimidates most students, physics, with a subject that appears more welcoming: nutrition. This was the final course for the first cohort to graduate with a college degree from the program. The graduation ceremony received national press and the literature illustrates the success expected by this program. According to a 2009 National Correctional Association report, inmates who earn an associate’s degree in prison are 70% less likely to reenter prison (Esperian, 2010) and a recent U. S. Department of Justice report says that prison-based education is the single most effective tool for lowering recidivism (Davis, et.al., 2013). In spite of this evidence, few prisons offer educational opportunities to inmates and in ten years the number of post-secondary prison programs for inmates fell by 90+ percent. (The Atlantic City, 2013; Faes, 2008).

The project addressed the following research questions:

1. Is there a difference in student’s content knowledge and attitude between traditional undergraduate science courses vs. integrated science courses?
2. How did the overall grades of LIFE inmates compare with those of the Lipscomb undergraduates in the same class?
3. Can the LIFE program and the integrated science course generate interest on expanding programs for inmates and the homeless community?
4. What are some the challenges and successes found in teaching an IS-2 course at a prison location?

References:


Acknowledgments: LU’s integrated science courses were developed with funding from a NSF Science Education for New Civic Engagements and Responsibilities (SENCER) award in partnership with LU’s SALT (Service and Learning Together) program. Funding from donors and SENCER provided scholarships and textbooks to inmates in the LIFE program.
Momentum: Building Capacity for Change through Connections

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According to the National Assessment of Educational Progress (NAEP) for Tennessee, 2013, the average mathematics score for fourth-graders was higher than those in only nine other states. In addition, Tennessee has failed to significantly reduce the achievement gap for black students and for students receiving free or reduced lunch.

The goal of Momentum: Building Capacity for Change through Connections was to increase student achievement by increasing elementary teachers’ capacity to teach mathematics in a STEM-centered environment using children’s literature. This professional development program funded through Tennessee’s Race to the Top grant, took a problem-solving approach to learning mathematical content as well as pedagogy.

Thirty participants were recruited from seven schools in four Middle Tennessee school districts, and 27 completed the program. Four of these participants were non-white. The program included 17 eight-hour professional development days spread over 18 months as well as some supporting online activities. Online activities included discussion groups and workshops targeted toward specific topics such as using software, reviewing curriculum, and designing lessons. During daylong workshops, teachers solved mathematics problems emerging from children’s literature and from real life situations. They planned lessons based on these problems, connecting the lessons, where appropriate, to topics from science. Participants then taught those lessons and shared student work in subsequent workshops where they worked in grade level groups creating a bank of lessons and materials.

Guest speakers and project staff provided extensive opportunities for participants to review current literature in mathematics education and to explore ways to integrate both the content and the Standards for Mathematical Practice in the Common Core State Standards for Mathematics (National Governor’s Association Center for Best Practices, 2010). To support their classroom activities, participants received sets of children’s literature, software, and memberships in the National Council of Teachers of Mathematics and the Mid-Cumberland Reading Council.

Participants completed a pre-assessment and post-assessment based on mathematics content knowledge. Many questions had multiple entry points and could be solved with varying levels of sophistication. Most questions required a higher level of thinking rather than recall or computation. In a matched-pair t-test, participants showed significant gains in mathematical thinking and problem solving on the post-assessment. In addition, informal assessments were woven into the workshop sessions throughout the program as participants worked together to
solve problems. Artifacts such as participant work samples and responses to problem solving situations were collected. Participants exhibited a high degree of critical thinking and interest in solving problems.

The problem-solving approach to content development was very successful. The daylong workshops and the summer academy gave participants time to explore various problem-solving strategies, to work in groups to develop problem solutions, and to think about how these strategies might be implemented in their own classrooms. Program results imply that professional development of this nature is effective as a change agent for student learning.

References:


Impact of Modeling Instruction and the Inverted Curriculum in Science on Math Achievement

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What, if any, impact does inverting the curriculum (conceptual physics in 9th grade, chemistry in 10th grade and molecular biology in 11th grade) and then using the modeling instruction pedagogy (Wells, Hestenes, & Swackhamer, 1995) have on achievement in high school mathematics as measured by ACT math subscores? Glasser (2012) observed the impact that a physics-first course had on 10th grade PSAT math scores, noting that they were statistically improved, perhaps because students had to use mathematics more in the 9th grade physics course than in the traditional 9th grade biology course. This in situ study covers eight graduating classes at Pope John Paul II High School. The first four cohorts (graduates from 2006, 2007, 2008, and 2009) were taught science in the traditional order (biology, chemistry and physics) with the traditional teacher-centered pedagogy while the next two cohorts (graduates from 2010 and 2011) studied conceptual physics in 9th grade (called Physical World Concepts in Tennessee) followed by chemistry and then biology, and the last two cohorts (graduates from 2011 and 2012) used the physics-first ordering with the modeling instruction pedagogy in chemistry and biology. In this talk we look at the impact the changes in science curriculum had on mathematics achievement using the first four cohorts as baseline data and looking at changes from the math component of the PLAN test administered at the beginning of 9th grade and the math component of the ACT administered near the end of the 11th grade.

References:


A Pre-calculus Preparation Program Makes a Difference for At-risk STEM Majors

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Universities across the nation are working to increase the number of STEM graduates (BHEF, 2010; Adkins, 2012; Feder, 2012; Sheehy, 2013). Middle Tennessee State University’s Mathematics as a FirstSTEP to Success in STEM project is a five-year, $2 million NSF-funded exploration of interventions to address mathematics deficiencies in STEM majors (http://www.mtsu.edu/firststep). MTSU first-time, full-time freshman STEM majors, who are at-risk based on mathematics ACT test scores between 19 and 23, inclusively, are invited to participate in an intensive two-year program that includes a mathematics summer bridge program, academic-year support, and an introductory research experience at the end of their freshman year.

This presentation focuses on the success of the mathematics summer bridge and the academic-year support programs. The two-week pre-calculus preparation program, also called the summer bridge, uses four different instructional strategies to increase students’ readiness for pre-calculus: individualized computer assisted instruction, direct teacher-led instruction, group-based hands-on activities, and peer-led learning. Our research will help answer the following questions: Does participation in this two-week summer bridge increase pre-calculus readiness as measured by the pre/post assessment? Does participation in the two-week summer bridge increase success in college pre-calculus as defined by earning a grade of A, B, or C in the course? Does participation in the summer bridge help students feel more connected to MTSU when they start their college experience in the subsequent fall semester? Furthermore, what roles do the following academic-year interventions play in increasing student success in pre-calculus: participation in a one-hour corresponding pre-calculus seminar course, intrusive advising, and required pre-calculus tutoring.

The over 150 students who have participated in the FirstSTEP program represent a diversity of backgrounds. These students join the program in cohorts of approximately 40 students a few weeks before their first semester at MTSU. The summer mathematics bridge begins with a
pre-test of their pre-calculus readiness. Scores on the pretest average 18% correct answers. During the summer bridge, student’s focus on improving their pre-calculus readiness by attending lectures on mathematics topics needed for success in pre-calculus, completing activities designed to make learning fun on those same topics, and working with college students as their mentors in small groups to gain deeper understanding of the concepts. They also spend several hours a day using a computer program called MyMathTest (Pearson, 2010) which provides individualized learning assistance to help fill in any gaps in their mathematics backgrounds. At the end of the two weeks, the students take a post-test on the same pre-calculus readiness topics to assess their learning during the summer bridge. The average post-test score is 55%, showing a marked improvement from the pretest. However, since the students have not all mastered these mathematical concepts, they participate in a pre-calculus seminar course which helps students remediate their deficiencies and learn new pre-calculus material. Additionally, FirstSTEP students participate in required tutoring by MTSU students with strong mathematics and communication skills. The combination of the summer bridge and these additional activities while taking pre-calculus have enabled our FirstSTEP participants to exceed the success rate of the corresponding control group, MTSU first-time, full-time freshman, STEM majors with the same ACT range. The treatment group often exceeds the population in general. Results from the study of data gathered on the at-risk students will be presented.

References:


