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THEC STEM Professional Development Program: Round Two Evaluation Report

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VANDERBILT PEABODY COLLEGE

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TABLE OF CONTENTS

Contents..... i
Figures..... iii
Tables..... iv
Executive Summary..... v

SECTION ONE
Introduction..... 1
Background..... 1

SECTION TWO
Research Methods..... 3
Research Questions..... 3
Core Conceptual Framework..... 3
Data Collection and Analysis..... 4
Teacher Observation Data..... 4
Classroom Observation Instrument..... 4
Response Rate - Teacher Observation Data..... 6
Analysis of Teacher Observation Data..... 6
Teacher Survey Data..... 7
Teacher Survey Instruments..... 7
Response Rate - Teacher Survey..... 7
Analysis of Teacher Survey Data..... 8
Teacher Content Assessments..... 8
Content Assessment Instrument..... 8
Limitations..... 9

SECTION THREE
Findings Overall for THEC STEM PD Investment – Research Question 1..... 10
Classroom Observation Findings..... 10
Design of Lesson..... 10
Implementation of Lesson..... 12
Classroom Culture..... 14
Mathematics/Science Content Domain..... 16
Content Knowledge Assessment Findings..... 18

SECTION FOUR

Findings Overall for THEC STEM PD Investment – Research Question 2……....20
Teacher Survey Findings……...20
Teacher Opinions Related to STEM Teaching……..20
Teacher Perceived Importance Related to STEM Teaching…….. 20
Instructional Influences……21
Teacher Preparedness……... 21
Frequency of Use of Effective Pedagogy…….. 22
Student Activities……..22
Parental Support……... 22
Principal Support……..23
Professional Development Experiences……23

SECTION FIVE

Concluding Observations……..24
Improved Pedagogical Skills……24
Improved Content Knowledge……24
Improved Opinions……..24
Programs Considered Best Practice……...25
Summary……...25

References……...26

Appendix……27
East Tennessee State University (ETSU) – Geiken and Henson, Principal Investigators 28
East Tennessee State University (ETSU) – Keith and Price, Principal Investigators 36
East Tennessee State University (ETSU) – McDowell and Govett, Principal Investigators 43
East Tennessee State University (ETSU) – Rhoton and Zhao, Principal Investigators 46
Lipscomb University (LU) – Hutchinson and High, Principal Investigators 54
Lipscomb University (LU) – Nelson and Thornthwaite, Principal Investigators 61
Lipscomb University (LU) – Wells, Morel and Nelson, Principal Investigators 69
Middle Tennessee State University (MTSU) – Kimmins and Winters, Principal Investigators 76
Middle Tennessee State University (MTSU) – Strayer and Brown, Principal Investigators.....83
Tennessee Technological University (TTU) – Baker and Fromke, Principal Investigators 86
Tennessee Technological University (TTU) – Fidan and Baker, Principal Investigators 94
Tennessee Technological University (TTU) – Pardue and Howard, Principal Investigators 101
Tennessee Technological University (TTU) and Roane State Community College (RSCC) – Suters and Lee, Principal Investigators 110
University of Memphis (UM) – Franschetti and Conley, Principal Investigators.....118
University of Memphis (UM) – Grant and Windsor, Principal Investigators 126
University of Memphis (UM) – Powell and Larsen, Principal Investigators 134
University of Tennessee at Chattanooga (UTC) – Ingraham, Ellis, and Carver, Principal Investigators 141
University of Tennessee at Martin (UTM) – Cox, Withmer, Principal Investigators.....148

LIST OF FIGURES

Figure 1. Design of Lesson Average Score Over Time for Round Two Programs…… 11
Figure 2. Design of Lesson Average Score Over Time by Program Classification for Round Two Programs……... 12
Figure 3. Implementation of Lesson Average Score Over Time for Round Two Programs…….. 13
Figure 4. Implementation of Lesson Average Score Over Time by Type for Round Two Programs……... 14
Figure 5. Classroom Culture Average Score Over Time for Round Two Programs……...15
Figure 6. Classroom Culture Average Score Over Time by Program Classification for Round Two Programs……... 16
Figure 7. Mathematics/Science Content Domain Average Score Over Time for Round Two Programs……... 17
Figure 8. Mathematics/Science Content Domain Average Score Over Time by Program Classification for Round Two Programs……18

LIST OF TABLES

Table ES1. LSC Overall Rating vii
Table ES2. Classroom Observation Findings – Round Two Programs viii
Table ES3. Teacher Survey Findings: Teacher Opinions viii
Table ES4. Teacher Survey Findings: Teacher Perceived Importance ix
Table ES5. Teacher Survey Findings: Instructional Influences – Encourages Effective Instruction x
Table ES6. Teacher Survey Findings: Teacher Preparedness xi
Table ES7. Teacher Survey Findings: Frequency of Use of Effective Pedagogy xii
Table ES8. Teacher Survey Findings: Student Activities xiii
Table ES9. Teacher Survey Findings: Parental Support xiv
Table ES10. Teacher Survey Findings: Principal Support xv
Table ES11. Teacher Survey Findings: Professional Development Experiences xvi
Table 1. Round Two THEC STEM Professional Development Funded Programs 2
Table 2. LSC Domains 5
Table 3. LSC Overall Rating 5
Table 4. Pre- and Post-Average Percent Correct by Program Classification 19

EXECUTIVE SUMMARY

In 2010, as part of Tennessee's Race to the Top grant, The Tennessee Higher Education Commission (THEC) received funding for the implementation of STEM (science, technology, engineering, and mathematics) Professional Development (STEM PD) across the state of Tennessee. A request for proposals (RFP) was released in April 2011 for Round One Programs, then again in spring 2012 for Round Two Programs. This RFP focused on delivery of professional development designed to promote innovative practices in STEM education, and participating programs were expected to emphasize the improvement of STEM teacher pedagogical skills and content knowledge. Round One (2011-12) funding was distributed across 11 programs, and 18 programs were funded in Round Two (2012-13). This report addresses programs participating in Round Two. The research questions guiding this evaluation include:

1. What impact, if any, do THEC STEM professional development programs have on teachers' pedagogical skills and STEM content knowledge?
2. What impact, if any, do THEC STEM professional development programs have on teachers' opinions regarding the teaching of STEM?
3. Which funded STEM professional development programs demonstrate significant growth in Teacher Quality (pedagogical skills and content) and should be considered for inclusion as best practice for Tennessee?

Round Two of the THEC STEM PD program included:

- Two high school mathematics focused programs (Middle Tennessee State University, *StaRT,* and Lipscomb University, *Functions of Algebra*),
- Two high school science programs (East Tennessee State University, *PCMI,* and Lipscomb University, *Integrating STEM: The Power of Science*),
- One high school mathematics and science programs (Tennessee Technological University, and Roane State Community College, *Designing the Future*),
- Two middle/high school science programs (University of Tennessee at Martin, *Integration for Middle School Teachers,* University of Tennessee at Chattanooga, *Learning Science through Writing*),
- One middle/high school mathematics program (University of Memphis, *mMIND),*
- Six middle school focused mathematics and science programs (Middle Tennessee State University, *Project UC STEM,* University of Memphis, *Professional Development for Grades 5-8,* East Tennessee State University, *Incorporating Active Learning into Life Sciences,* Lipscomb University, *Making Mathematics Matter,* Tennessee Technological University, *From Earth to Space with STEM,* Tennessee Technological University, *STEM Around Us*),

- One middle school science program (University of Memphis, *Water, Water, Everywhere*),
- One early childhood mathematics program (Tennessee Technological University, *Shaping Early STEM Learning),*
- One early childhood science program (East Tennessee State University, *Project SEE*), and
- One early childhood mathematics and science program (East Tennessee State University, *Integrating Hands-on STEM Activities with Math and Reading Common Core Standards*).

CORE CONCEPTUAL FRAMEWORK

THEC STEM PD programs were required to organize the delivery of their programs around the Core Conceptual Framework for Effective Professional Development (Desmione, 2009). The five components of the framework include: content knowledge focus, active learning experiences, coherence with state/district goals and standards, extended duration of program, and collective participation of teams of teachers from individual schools. Round Two funded programs described within their proposals how they would address each of the five components of the framework within the context of their STEM PD.

Study Methods

This evaluation used both qualitative and quantitative data to determine the impact of the Round Two THEC STEM PD programs. Data collection included teacher classroom observations (video-recorded), two teacher surveys, and program-developed pre/post assessments of mathematics or science content knowledge.

Classroom Observations

Each teacher was required to submit three recordings of their teaching: one prior to participation in the THEC STEM PD program, one mid-way through the program, and the final video at the end of the program. Each video was scored using the Local Systemic Change Classroom Observation Protocol (LSC), which was developed by Horizon Research for use with the National Science Foundation's (NSF) State Systemic Initiatives (SSI) as a measure of reform-based instructional practices in science and mathematics. The instrument examines design of lesson, implementation of lesson, culture of instruction, and content knowledge delivered.

Teacher Surveys

Participants also completed two surveys in a pre/post manner for the THEC STEM PD programs. The first survey was the Local Systemic Change Teacher Questionnaire (LSCTQ) appropriate to their content and grade level (e.g., science or mathematics, K-6 or 7-12). The LSCTQ was also designed for use with NSF's SSI programs. The Survey of Enacted Curriculum (SEC) was the second survey used for the THEC STEM PD programs. The SEC survey was developed by the SEC Collaborative and used extensively to evaluate STEM teaching quality and alignment of instruction to academic standards.

Program-Developed Pre/Post Content Assessments

Each program was required to develop their own 25-item pre/post content knowledge assessment for participating teachers to complete. Programs provided copies of their assessments, keys, and spreadsheets of individual item responses for the evaluation.

KEY FINDINGS

Overall Findings

Classroom Observations

Overall, the THEC STEM PD Round Two programs significantly improved in all four domains (design, implementation, culture, and content) from baseline to end of program. (See Table ES2.) Design of lesson includes the planning, organization, resources, and attention to equity, level of collaboration, flow of lesson, assessments, and sense making that take place during the delivery of lesson. Implementation of lesson consists of the level of investigative mathematics/science included, quality of management of classroom, pace of lesson, modifications made, questioning strategies, and formative assessments included in the delivery of the lesson. Classroom culture refers to the amount of active participation of all students and level of collaborative learning, including having students explore their own ideas, questions, conjectures, and propositions or to challenge the ideas of others. Finally, the mathematics/science content knowledge domain focuses on the accuracy of content knowledge delivered by the teacher, as well as the alignment of content to appropriate grade and student levels of understanding.

Each item within each domain is scored on a scale of 0 to 5, with 0 being used when there is no evidence of a component within a domain, and a score of 5 awarded when a component is used "to a great extent". Each domain has multiple questions that are scored individually, and an overall rating (i.e., mean score) for each domain is generated (see Table ES1).

Table ES1. LSC Overall Rating

Score	Title
0-1.9	Ineffective Instruction
2-2.9	Elements of Effective Instruction
3-3.9	Beginning of Effective Instruction
4-4.9	Accomplished, Effective Instruction
5	Exemplary Instruction

Table ES2. Classroom Observation Findings – Round Two Programs

Domain	Baseline Rating	End Rating	End Classification
Design	2.47	3.04	Beginning of Effective Instruction
Implementation	2.70	3.44	Beginning of Effective Instruction
Classroom Culture	3.02	3.74	Beginning of Effective Instruction
Content Knowledge	3.03	3.67	Beginning of Effective Instruction

Teacher Surveys

Teacher surveys included the constructs of: teacher opinions, teacher perceived importance, instructional influences, teacher preparedness, frequency of use of effective pedagogy, student activities, parental support, principal support, and professional development experiences. An analysis of data for the Round Two Programs indicated participants overall experienced significant growth in all of these areas. Findings for each of these constructs are presented in Tables ES2-ES10 below.

Table ES3. Teacher Survey Findings: Teacher Opinions

Construct	Baseline % Agreement	End % Agreement
Students generally learn science/math best in classes with students of similar abilities.	56%	52%
I feel supported by colleagues to try out new ideas in teaching science/math.	85%	90%
Science/math teachers in this school have a shared vision of effective science/math instruction.	68%	75%
Science/math teachers in this school regularly share ideas and materials related to science/math.	73%	81%
Science/math teachers in this school are well supplied with materials for investigative science/math instruction.	43%	53%
I have time during the regular school week to work with my peers on science/ math curriculum and instruction.	41%	49%
I have adequate access to computers for teaching science/math.	47%	54%
I enjoy teaching science/math.	93%	91%
The science/math program in this school is strongly supported by local organizations, institutions, and/or business.	23%	39%

Table ES4. Teacher Survey Findings: Teacher Perceived Importance

Construct	Baseline % Agreement	End % Agreement
Provide concrete experiences before abstract concepts.	90%	90%
Develop students' conceptual understanding of science/math.	98%	98%
Take students' prior understanding into account when planning curriculum and instruction.	97%	97%
Make connections between science/math and other disciplines.	96%	95%
Have students work in cooperative learning groups.	92%	91%
Have students participate in appropriate hands-on activities.	97%	97%
Engage students in inquiry-oriented activities.	94%	96%
Have students prepare project/ laboratory/research reports.	71%	77%
Use computers.	81%	85%
Engage students in application of science/math in a variety of contexts.	96%	96%
Use performance-based assessment.	86%	85%
Use portfolios.	52%	56%
Use informal questioning to assess student.	96%	95%

Table ES5. Teacher Survey Findings: Instructional Influences – Encourages Effective Instruction

Construct	Baseline % Agreement	End % Agreement
State and/or district curriculum frameworks.	49%	50%
State and/or district testing policies and practices.	30%	29%
Quality of available instructional materials.	48%	52%
Access to computers for science/math instruction.	45%	53%
Funds for purchasing equipment and supplies for science/math.	33%	36%
System of managing instructional resources at the district/school level.	28%	38%
Time available for teachers to plan and prepare lessons.	43%	48%
Time available for teachers to work with other teachers.	40%	44%
Time available for teacher professional development.	48%	48%
Importance that the school places on science/math.	58%	59%
Consistence of science/math reform efforts with other school/district reforms.	42%	39%
Public attitudes toward reform.	25%	21%

Table ES6. Teacher Survey Findings: Teacher Preparedness

Construct	Baseline % Agreement	End % Agreement
Provide concrete experiences before abstract concepts.	75%	86%
Develop students' conceptual understanding of science/math.	79%	88%
Take prior understanding into account when planning curriculum & instruction.	80%	91%
Make connections between science/math and other disciplines.	72%	89%
Use of cooperative learning groups.	79%	90%
Have students participate in appropriate hands-on activities.	78%	92%
Have students prepare project/ laboratory/research reports.	44%	67%
Use computers.	71%	85%
Engage students in applications of science/math in a variety of contexts.	65%	87%
Use performance-based assessment.	66%	82%
Use portfolios.	32%	50%
Use informal questioning to assess student understanding.	82%	91%
Lead a class of students using investigative strategies.	64%	85%
Manage a class of students engaged in hands-on/project-based work.	77%	91%
Help students take responsibility for their own learning.	75%	90%
Recognize and respond to diversity.	79%	87%
Encourage students' interest in sci/math.	85%	92%
Use strategies that specifically encourage participation of females/minorities.	59%	78%
Engage students in inquiry-oriented activities	62%	83%

Table ES7. Teacher Survey Findings: Frequency of Use of Effective Pedagogy

Construct	Baseline % Agreement	End % Agreement
Introduce content through formal presentations.	74%	69%
Arrange seating to facilitate student discussion.	71%	79%
Use open-ended questions.	82%	87%
Require students to supply evidence to support their claims.	73%	85%
Encourage students to explain concepts to one another.	77%	84%
Encourage students to consider alternative explanations.	71%	77%
Allow students to work at their own pace.	69%	77%
Help students see connections between science/math and other disciplines.	67%	78%
Use assessment to find out what students know before or during a unit.	63%	68%
Embed assessment in regular class activities.	78%	82%
Assign science/math homework.	57%	55%
Read and comment on the reflections students have written in their notebooks or journals.	33%	38%

Table ES8. Teacher Survey Findings: Student Activities

Construct	Baseline % Agreement	End % Agreement
Participate in student-led discussions.	51%	61%
Participate in discussions with the teacher to further science/math understanding.	76%	83%
Work in cooperative learning groups.	75%	79%
Make formal presentations to the class.	18%	29%
Read from a science/math textbook in class.	34%	34%
Read other science/math-related materials in class.	34%	44%
Review homework/worksheet assignments.	64%	60%
Work on solving a real-world problem.	62%	66%
Share ideas or solve problems with each other in small groups.	65%	73%
Follow specific instructions in an activity or investigation.	60%	68%
Design or implement their own investigation.	16%	30%
Work on models or simulations.	19%	30%
Work on extended science/math investigations or projects.	12%	23%
Participate in field work.	7%	13%
Record, represent, and/or analyze data.	31%	41%
Write reflections in a notebook/journal.	34%	44%
Work on portfolios.	12%	15%
Take short-answer tests.	44%	46%
Take tests requiring open-ended responses.	37%	44%

Table ES9. Teacher Survey Findings: Parental Support

Construct	Baseline % Agreement	End % Agreement
Volunteer to assist with class activities.	4%	6%
Donate money or materials for classroom instruction.	10%	11%
Attend parent-teacher conferences.	34%	37%
Attend school activities such as PTA meetings and Family Science/Math nights.	13%	15%
Voice support for the use of an investigative approach to science/math.	7%	9%
Voice support for traditional approaches to science/math instruction.	11%	14%

Table ES10. Teacher Survey Findings: Principal Support

Construct	Baseline % Agreement	End % Agreement
Encourages selection of science/math content and instructional strategies to address individual students' learning.	82%	81%
Accepts the noise that comes with an active classroom.	86%	86%
Encourages the implementation of current national standards in science/ math education.	84%	82%
Encourages innovative instructional practices.	90%	88%
Enhances the science/math program by providing me with needed materials and equipment.	57%	61%
Provides time for teachers to meet and share ideas with one another.	64%	70%
Encourages me to observe exemplary science/math teachers.	48%	55%
Encourages me to make connections across disciplines.	79%	79%
Acts as a buffer between teachers and external pressures.	70%	70%

Table ES11. Teacher Survey Findings: Professional Development Experiences

Construct	Baseline % Agreement	End % Agreement
Participating in PD has increased my science/math content knowledge.	22%	38%
Participating in PD has increased my understanding of how children think about and learn science/math.	25%	39%
Participating in PD has increased my ability to implement high-quality science/math instructional materials.	28%	43%

Program-Developed Pre/Post Content Assessments

The analysis of data provided by Round Two programs revealed significant growth in STEM content knowledge for THEC PD programs.

Individual Program-level Findings

In addition to the overall THEC STEM PD Round Two collective program analysis, individual program analyses were conducted and narratives for each funded program have been included in the report. Eleven of the funded programs realized significant growth in teacher quality and content knowledge. The programs that have been determined to represent best practice in STEM PD for the state of Tennessee include:

1. East Tennessee State University (ETSU) – High School Chemistry & Physics (Principal Investigators Rhoton and Zhao)
2. Lipscomb University (LU) – Grades 4-7 Mathematics (Principal Investigators Wells, Morel & Nelson)
3. Lipscomb University (LU) – High School Algebra (Principal Investigators Nelson and Thornthwaite)
4. Middle Tennessee State University (MTSU) – Grades 4-8 Mathematics and Science (Principal Investigators Kimmins and Winters)
5. Middle Tennessee State University (MTSU) – High School Mathematics (Principal Investigators Strayer and Brown)
6. Tennessee Technological University (TTU) – Grades 3-6 Mathematics and Science (Principal Investigators Pardue and Howard)
7. Tennessee Technological University (TTU) – High School Mathematics and Science (Principal Investigators Fidan and Baker)
8. Tennessee Technological University (TTU) – K-2 Mathematics and Science (Principal Investigators Baker and Fromke)
9. Tennessee Technological University (TTU) and Roane State Community College (RSCC) – High School Mathematics and Science (Principal Investigators Suters and Lee)
10. University of Tennessee at Chattanooga (UTC) – Grades 4-7 Science (Principal Investigators Ingraham, Ellis, and Carver)

11. University of Tennessee at Martin (UTM) – Grades 6-12 Science (Principal Investigators Cox and Withmer)

SUMMARY

Overall, the evaluation of the THEC STEM PD Round Two programs revealed significant growth in science and mathematics teacher effectiveness and attitudes. At an individual program level, twelve programs realized significant growth in all four areas of teacher quality for participants as well. Two programs realized gains in three of the four teacher quality constructs, one program had gains in one area, and one program did not realize any gains in teacher quality. Finally, two programs did not submit sufficient data to evaluate impact on teacher quality. The full report will provide additional detail on the findings highlighted in this Executive Summary and will offer insight into the individual programs in an effort to provide a better understanding of experienced growth.

I. INTRODUCTION

BACKGROUND

In April 2011 the Tennessee Higher Education Commission (THEC) released a request for proposals (RFP) for the first round of Race to the Top funded STEM Professional Development (PD) programs. Eleven programs were funded across the state of Tennessee in Round One. In spring, 2012, the second call for proposals was released. A total of 29 programs were funded through this process and these comprise the THEC STEM Professional Development program. The purpose of the THEC STEM Professional Development program is to promote innovative practices in STEM (science, technology, engineering, and mathematics) education by further developing K-12 STEM teachers' pedagogical skills and content knowledge. In addition, the PD programs funded through this grant program and determined to be highly effective may be shared throughout Tennessee's STEM Innovation Network (TSIN). Highly effective programs are defined as those that have significant gains in teacher pedagogical skills and content knowledge.

The primary objectives of the program are:

1. To deliver high quality, research-based STEM professional development to K-12 teachers to improve pedagogical skills and content knowledge.
2. To align with the goals of Tennessee's First to the Top plan, including School readiness, College and Career readiness, Implementing the Common Core Standards, and Postsecondary Access and Success.
3. To create a STEM Professional Development best-practices warehouse for use throughout the TSIN to ensure sustainability of this PD beyond funding from Race to the Top. Through replication and sustainability, it is intended that those PD programs that are models of good practice will and can be accessed and replicated widely throughout the TSIN in order to foster deeper learning of STEM content knowledge for all students.

This annual evaluation report will focus on the complete analysis of data collected for the Round Two STEM PD programs (Table 1).

Table 1. Round Two THEC STEM Professional Development Funded Programs

Institution and Program Title	Number of Teachers*	Focus Area
ETSU, *Incorporating Active Learning into Life Sciences Teaching*	18	EC mathematics and science
ETSU, *Integrating Hands-on STEM Activities with Math and Reading CCSS*	24	MS mathematics and science
ETSU, *PCMI*	25	HS science
ETSU, *Project SEE*	25	EC science
LU, *Functions of Algebra*	20	HS mathematics
LU, *Integrating STEM: The Power of Science*	10	HS science
LU, *Making Mathematics Matter*	20	MS mathematics and science
MTSU, *StaRT*	35	HS mathematics
MTSU, *UC STEM*	25	MS mathematics and science
TTU, *Designing the Future*	25	HS mathematics and science
TTU, *Shaping Early STEM Learning*	29	EC mathematics and science
TTU, *STEM Around Us*	35	MS mathematics and science
TTU and RSCC, *From Earth to Space with STEM*	30	HS mathematics and science
UM, *mMind*	29	MS/HS mathematics and science
UM, *Professional Development for Grades 5-8*	28	MS mathematics and science
UM, *Water, Water Everywhere*	18	MS science
UTC, *Learning Science through Writing*	23	MS/HS science
UTM, *STEM Integration for Middle School Teachers Academy*	28	MS science

* Numbers presented in Table 1 reflect the number of teachers who actually completed each program. This number does not equate, however, to the number of individuals who participated in data collection activities as those numbers vary by activity.

II. RESEARCH METHODS

RESEARCH QUESTIONS

Three research questions, listed below, guided this evaluation. All are aligned with the primary objectives of the THEC STEM PD Program:

1. What impact, if any, do THEC STEM professional development programs have on teachers' pedagogical skills and STEM content knowledge?
2. What impact, if any, do THEC STEM professional development programs have on teachers' opinions regarding the teaching of STEM?
3. Which funded STEM professional development programs demonstrate significant growth in Teacher Quality (pedagogical skills and content) and should be considered for inclusion as best practice for Tennessee?

CORE CONCEPTUAL FRAMEWORK

Much has been learned through recent attempts at designing professional development programs for STEM teachers. As the knowledge base on educational reform and improving teacher quality has grown over the past decade (e.g., Johnson, Kahle, & Fargo, 2007a, 2007b; Johnson & Fargo, 2010; Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2007; Putnam & Borko, 1997) it has become more evident that traditional professional development formats do not result in sustained change in practice. Professional development linked to state and/or district reform initiatives have demonstrated the ability to transform educational practice systemically (Desimone, 2009). However, since enactment of the *No Child Left Behind Act of 2001* few attempts have been made to explore the ability of effective teacher quality programs to achieve systemic reform (Desimone, 2009; Johnson et al., 2007b).

Desimone (2009) published a seminal paper wherein she conducted a rigorous review of empirical studies of professional development to produce a core conceptual framework for research-based, effective professional development, defined as models that have had positive impact on "increasing teacher knowledge and skills and improving their practice, which hold promise for student achievement" (p. 183). The components of the core conceptual framework include content knowledge focus, active learning experiences, coherence with state/district goals and standards, extended duration of a program across academic year(s), and collective participation of teams of teachers from same school.

THEC required all submitted proposals to include these five core components in the design of their programs. All funded PD projects included the core components as the basis into which they inserted their content and context. In this report we will present details on the funded programs and the content and context of programs that were successful in achieving change in teacher practice.

In most of the published research on professional development in small settings, it has taken at least two years before significant change in teacher effectiveness has been realized. The THEC STEM PD program has provided the setting for the first large-scale implementation of the research-based core conceptual framework for effective professional development. Moreover, Tennessee has taken steps to integrate research into the significant Race to the Top investment, and the evaluation of the THEC STEM PD program will provide much-needed insight into educational reform.

DATA COLLECTION AND ANALYSIS

The evaluation of Round Two STEM PD programs used both qualitative and quantitative data to investigate the impact of THEC STEM PD. The data collected for this report included teacher classroom observations in digital recording format and two surveys completed by participating teachers. Additionally, each program developed their own content assessments (25 items as requested by the RFP) to determine participant growth in content knowledge. Each of these is described in more detail below.

Teacher Observation Data

Teacher observations were conducted for use in determining potential increased use of STEM pedagogical skills and STEM content knowledge for THEC STEM PD participants. Each participating teacher in all funded STEM PD programs was asked to submit three digital recordings of an appropriate STEM lesson. The first recording was to be conducted prior to beginning participation in the THEC STEM PD program. The second was to occur at the mid-point of participation (August 2013) and the final recording was to be completed and submitted by December 2013.

Classroom Observation Instrument

The Local Systemic Change (LSC) Classroom Observation Protocol is an observation tool used to assess the degree of instructional reform in math and science. The LSC protocol was developed by Horizon Research for use with the National Science Foundation's (NSF) State Systemic Initiatives (SSI) as a measure of reform-based instructional practices. The LSC Classroom Observation Protocol is being used as the measure of growth in teacher pedagogical skill use and is one measure of teacher content knowledge for the THEC STEM PD program. The LSC tool is valid for use in this evaluation based on the research-based foundation and wide-scale implementation of the LSC protocol in many empirical studies. Using the LSC, teacher instruction is observed and given ratings on 32 items included in four domains (see Table 2).

Table 2. LSC Domains

Domain	Number of Items
Design of Lesson	10
Implementation of Lesson	7
Classroom Culture	6
Math/Science Content	9

The *Design of Lesson* domain focuses on the structure of the observed lesson and investigates a variety lesson considerations such as the sequencing of instructional activities, roles of students and teachers, resources available, eliciting of prior knowledge, time provided for sense making, attention to diversity, and collaborative learning. The *Implementation of Lesson* domain examines the use of investigative STEM strategies employed by the teacher, as well as the pace of the lesson, attention to student understanding, questioning strategies, and both formative and summative assessments. The *Classroom Culture* domain assesses a teacher's ability to create and facilitate a classroom environment, which supports active participation, respect for ideas, effective collaboration, and inquiry into student ideas, questions, and real-world connections. The *Mathematics/Science Content* domain examines teacher understanding of content, as well as appropriateness of the level of content included in the lesson, the level of student engagement with content, and interdisciplinary and real-world connections presented by the teacher.

Each item within each domain range is scored on a scale of 0 to 5, with 0 being used when there is no evidence of a component within a domain, and a score of 5 awarded when a component is used "to a great extent". Each domain has multiple questions that are scored individually, and an overall rating (i.e., mean score) for each domain is generated (see Table 3).

Table 3. LSC Overall Rating

Score	Title
0-1.9	Ineffective Instruction
2-2.9	Elements of Effective Instruction
3-3.9	Beginning of Effective Instruction
4-4.9	Accomplished, Effective Instruction
5	Exemplary Instruction

An overall score of 0 to 1.9 is characterized with a rating of *Ineffective Instruction*. The LSC protocol describes this as a classroom where there is "little or no evidence of student thinking or engagement with important ideas of mathematics/science. Instruction is highly unlikely to enhance students' understanding of the discipline or to develop their capacity to successfully do mathematics or science". With this rating, the delivered lesson is characterized as either *passive learning* or *activity for*

activity's sake. Passive learning is when students are passive recipients of information from the teacher or textbook. Activity for activity's sake happens when a hands-on activity is employed with no clear purpose and does not lead to student conceptual development of STEM.

An overall score of 2-2.9 receives the rating of *Elements of Effective Instruction*. The LSC protocol describes this as a classroom where "instruction contains some elements of effective practice but there are serious problems in the design, implementation, content, and/or appropriateness for many students in the class". Examples of this are inappropriate content and/or level of content, lack of ability to address student difficulties, lack of opportunities for inquiry and investigation of student ideas, and problem solving.

An overall score of 3-3.9 is classified as *Beginning Stages of Effective Instruction*. The LSC protocol describes this as a classroom where, "instruction is purposeful and characterized by quite a few elements of effective practice". In this classroom, students are engaged in meaningful work at times but there are still a few weaknesses with the delivery of the lesson.

An overall score of 4-4.9 is characterized as *Accomplished, Effective Instruction*. The LSC protocol describes this as a classroom that is, "purposeful and engaging for most students". Students are engaged in meaningful work, including investigations, and the lesson is well designed and implemented. Some limitations in ability to adapt content and/or pedagogy still exist and ability to respond to student needs is also limited. Instruction is "*quite likely"* to enhance student ability to do STEM.

An overall score of 5 is *Exemplary Instruction*. The LSC protocol describes this a classroom where, "*purposeful instruction* [is occurring] *and all students are highly engaged most or all of the time with meaningful work"*. The lesson is "*artfully implemented";* the teacher is flexible and responds to student needs and interests; and instruction is highly likely to enhance student understandings of the discipline and to develop their capacity to do STEM.

Response Rate - Teacher Observation Data

For Round Two, 418 teachers were observed at least once. Of those 418 teachers, 132 teachers (31.6 percent) completed two full observations, which were then scored, and 182 teachers (43.5 percent) completed and had scored three full observations. These 182 teachers will serve as the sample for this report, as they participated in the entire PD program and provide the most accurate measure of change over time.

Analysis of Teacher Observation Data

Teacher videos were rated by a team of evaluators and analyzed quantitatively. All videos were viewed and scored by two independent raters using the LSC Classroom Observation Protocol in four domains, including design of lesson, implementation of lesson, mathematics/science content knowledge, and classroom culture, as well as an overall rating. This measure is used to determine improvement in teacher pedagogical skills and content knowledge as demonstrated through actual teacher practice.

Total scores for each domain were computed. Each domain section was comprised of a different number of total items (see Table 2). Individual item ratings ranged from 1-5 with 1 being lowest and 5 being highest (see Table 3). In addition to the domain rating, an overall rating was also assigned to each teacher for each lesson. To assess teacher growth in specific classroom practices over time and by program classification (high school chemistry, elementary science, primary math, elementary math, middle grades math) a 3-Within, 7-Between Repeated Measures ANOVAs with post-hoc investigation for differences at each observation time and between program classification groups was conducted. Finally, growth examinations between all observation time points using 3-Within Repeated Measures ANOVAs with post-hoc investigation for each specific program's STEM Teacher Quality results are conducted. Since sample sizes for individual programs are small, one-tailed tests were run to increase the sensitivity for finding statistically significant differences over time.

Teacher Survey Data

Two measures were used in this evaluation to determine teacher-reported growth in use of effective pedagogical skills, as well as potential change in opinions for participants in the funded THEC STEM PD programs. This data was in addition to classroom observation data, which also examined use of effective pedagogical content knowledge. Participants completed appropriate questionnaires for their grade band and content area. Participants also completed the surveys in a pre/post manner for the program online through Survey Monkey, prior to participation in the PD and at the end of the PD program.

Teacher Survey Instruments

Two surveys were used in this evaluation. The LSC Teacher Questionnaires (e.g., mathematics and science versions for K-8 and 9-12) were selected based upon their alignment with the LSC Classroom Observation protocol (used for the classroom observational data) and previous use in the NSF funded SSIs (http://www.horizon-research.com/LSC/news/heck_rosenberg_crawford_2006a.php). Additionally, the Survey of Enacted Curriculum (SEC), developed by the SEC Collaborative (https://secure.wceruw.org/seconline/secWebHome.htm), which has been used extensively in Georgia, Kansas, Kentucky, Michigan, Mississippi, and Ohio, is a second research-based instrument used for the evaluation. Collectively, the two instruments were used to measure preparedness to teach STEM, influences on instruction, beliefs regarding STEM teaching, parental and principal support, and quality of PD experiences.

Response Rate - Teacher Survey

A total of 284 teachers from the 18 Round Two programs completed both a pre- and post-survey. These 284 teachers serve as the sample for this report. Of this sample, 115 participants (40.5 percent) completed Science K-8 surveys, 112 (39.4 percent) completed Math 9-12 surveys, 32 participants (11.3 percent) completed Math K-8 surveys, and 25 participants (8.8 percent) completed Science 9-12 surveys.

Analysis of Teacher Survey Data

A 2-between 2-within Factorial ANOVA was employed to assess overall growth from pre/post regardless of the PD group and also look for differences in growth by PD content area (science vs. math). Next, multiple Chi-Square Tests of Independence were employed to examine pre- to post-survey response percent growth for individual items regardless of the PD program. Finally, because it is very difficult to change teacher beliefs and perceptions, one-tailed tests were implemented to increase the power for finding statistical differences. Further, we considered any pre/post improvement at the $p < .10$ to be statistically significant.

Teacher Content Assessments

Each program developed their own content assessments (25 items as requested by the RFP) to determine participant growth in content knowledge. Each program submitted copies of assessments, keys, and a spreadsheet with individual teacher responses to each item for pre/post.

Content Assessment Instrument

Each professional development program created their own assessment of teacher content knowledge aligned with content and grade levels covered in their individual program. As a result, all teacher content knowledge assessment items are different across programs. However, all assessment developers were to follow the same guidelines when creating and distributing tests: 1) pre- and post-test items given to teachers should consist of the same items on both tests; 2) all items should be objective type items (scored as correct/incorrect rather than subjectively scored with a rubric); 3) assessments should be comprised of 25 items; and 4) teachers needed the same identification number in each pre- and post-test files to allow for pre/post content knowledge comparison. Most of the eighteen round two programs followed these guidelines with the exception of one program, which did not submit content knowledge assessment data. While some programs distributed more or less than 25 items on their assessments, participants in these groups were not eliminated from analysis because percentage correct was used as the metric for comparison rather than total number of items correct.

Regardless of which Tennessee Race to the Top STEM PD program teachers were involved in, teachers' math/science content knowledge significantly improved from pre-test (M = 54.96%, SD = 20.46%) to post-test (M = 70.38%, SD = 18.12%); $t(360) = 17.04$, $p < .000$. The effect size is considered large ($_p^2$=.446) with 44.6 percent of the variance in teacher content knowledge accounted for by time of the test. The overall teacher pre- and post-test average content knowledge percent correct growth over the program was from 54.96 percent correct at baseline to 70.38 percent correct at end of program. A one-way ANOVA was used to analyze program developed content knowledge assessment data by type of program.

Limitations

All quantitative research is subject to limitations from methodological threats to internal and external validity (Onwuegbuzie, 2000). Internal validity focuses on the research design and asks if it is appropriate to support the differences found in the dependent variable as a result of the independent variable and nothing else. External validity addresses a study's ability to generalize findings from one study to and across populations, settings, and times. For this evaluation study, two major methodological limitations to validity are acknowledged: 1) teacher participation in data collection, and 2) nature of the content knowledge tests.

Teacher participation in data collection is a potential external validity limitation in this evaluation study. Out of 307 total participating teachers in the THEC STEM PD programs, response rates for completing the teacher survey at least once was 81.4 percent (n=250), having one classroom observation performed was 82.1 percent (n=252), and 72.3 percent (n=222) completed the program developed content knowledge assessment for teachers (pre/post). While these overall response rates are high, when considering that this evaluation was of a longitudinal nature, the response rates are not quite as impressive. Only 54.1 percent (n=166) of participating THEC STEM PD teachers completed both pre- and post-surveys, 40.4 percent (n=124) had three full classroom observations recorded, and 52.4 percent (n=161) produced usable pre/post achievement test scores. Further, because some THEC STEM PD participants did not participate in the data collection process, findings of this evaluation are vulnerable to non-response error. Non-response error may occur when a significant number of THEC STEM PD teachers choose to not respond and these non-respondents are significantly different from those THEC participants who responded and thus the results may become non-generalizable to the larger THEC STEM PD program sample. Any time a response rate is under 60-70 percent non-response needs to be examined further. In this evaluation, THEC participant demographics (e.g., program content, program grade level focus, gender, as ethnicity) for those responding to data collection procedures are similar to that of the overall THEC participant group. As such, we can say that there does not appear to be any systematic non-response issues making this a lesser concern than if there were specific sub-groups of individuals choosing to not participate.

The nature of the program developed content knowledge tests for teachers is an internal limitation for this evaluation study. All content knowledge tests were developed by the individual professional development programs to focus on the specific content each program was covering. While this does allow for greater content validity for these assessment outcomes, there is limited (if any) comparability across assessments. Thus, there is no way of knowing if one assessment was significantly more challenging or easier than another assessment. Consequently, comparability of growth from pre/post across programs attributing differences to type of PD delivered is certainly confounded by the differences in tests and should be done with extreme caution. It is acceptable to look at growth from pre/post for an individual program, but comparing one program's growth to another may have little to do with the PD implemented and more to do with the assessment used to collect the data.

III. FINDINGS OVERALL FOR THEC STEM PD INVESTMENT – RESEARCH QUESTION 1

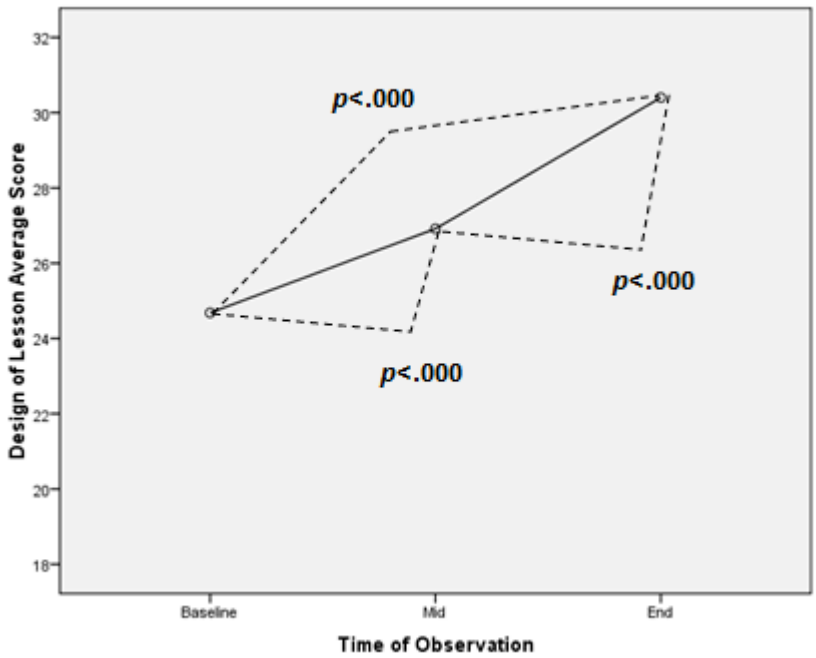
CLASSROOM OBSERVATION FINDINGS

The Local Systemic Change Classroom Observation Protocol (LSC) was used to examine teacher observations in four key areas: design of lesson, implementation of lesson, culture of instruction, and content knowledge delivered. Analysis of these videos revealed significant improvement in all four areas as indicated by findings presented below.

Design Of Lesson

An analysis of data for the 18 Round Two programs involved in the THEC STEM PD program indicated there was significant growth in the Design of Lesson construct, which encompasses the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery. At baseline, the mean score average (2.47) was rated a Level 2: Elements of Effective Instruction (M = 24.68, SD = 4.69), which increased to 2.69 (M = 26.92, SD = 4.34) at the second observation point midway through the professional development program, and increased further to (average score of 3.04) "beginning of effective instruction" range at the final observation (M = 30.40, SD = 4.51), $F(2) = 58.30$, $p < .000$. The effect size is considered large ($_p^2$=.250), with 25.0% of the variance in Design of Lesson scores accounted for by time of the observation. Figure 1 shows the statistically significant overall increase in average Design of Lesson scores over time.

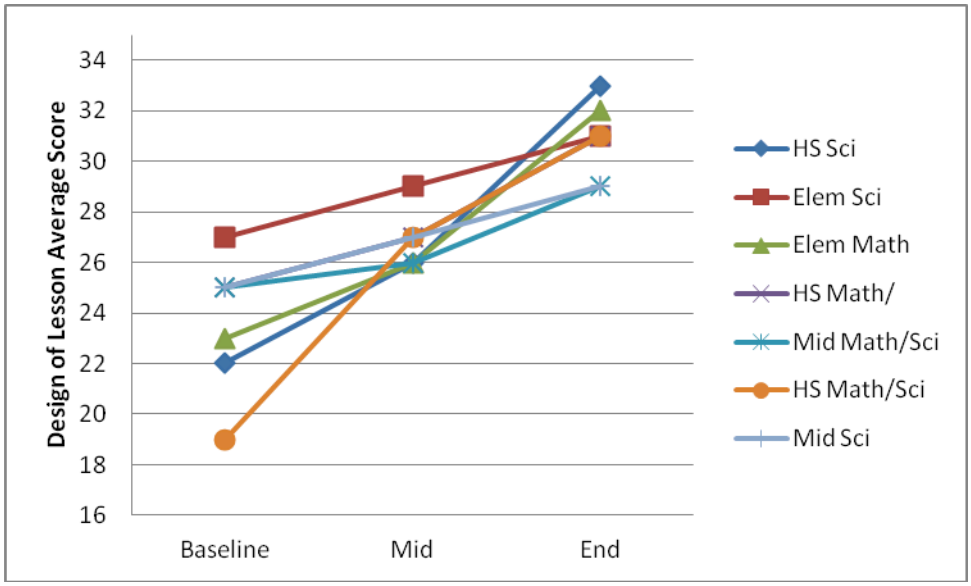
Figure 1. Design of Lesson Average Score Over Time for Round Two Programs



Average scores could have an overall range of 10-50, since there are 10 items on a 5-point scale in this sub-section. Statistically significant increases were noted between all observation points.

State level findings did vary by type of program (e.g., mathematics, science, or grade range), meaning there was a statistically significant difference in design of lesson between program classifications, $F(6) = 2.59$, $p < .05$. The effect size is considered medium ($\eta_p^2 = .082$), with 8.2 percent of the variance in design of lesson score accounted for by type of program. The only significant difference in program type was between Middle School Math/Science programs, which were significantly lower compared to Elementary Science programs ($p < .01$). The average design of lesson scores across time ranged from 1.85 (High School Math/Science) to 3.30 (High School Science), which are equivalent to a Level 1: Ineffective Instruction and Level 3: Beginning stages of Effective Instruction respectively. There was also a statistically significant interaction between program classification and time of observation for design of lesson, $F(12) = 2.88$, $p < .001$. This means as time went on, the overall group improved. The effect size is considered medium ($\eta_p^2 = .090$), with 9.0 percent of the variance in design of lesson score accounted for by the interaction between observation time and program classification. Figure 2 shows that all program classifications increased in design score from baseline to mid-program observations and again increased from mid- to end-of-program observations.

Figure 2. Design of Lesson Average Score Over Time by Program Classification for Round Two Programs

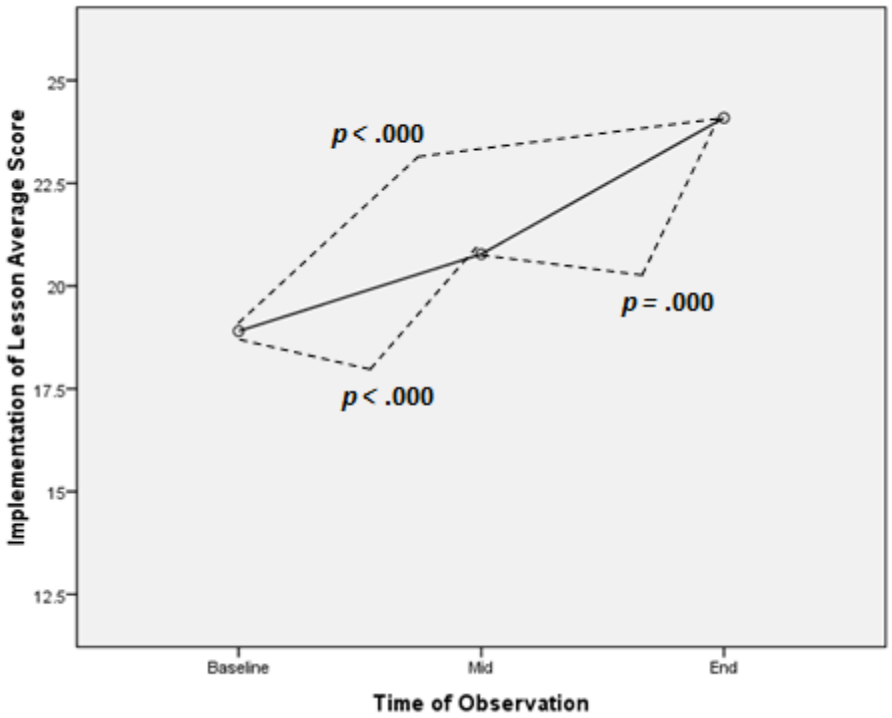


Average scores could have an overall range of 10-50, since there are 10 items on a 5-point scale in this sub-section. The only significant differences noted over time were between Middle School Math/Science programs, which were significantly lower compared to Elementary Science programs ($p < .01$).

Implementation Of Lesson

Regardless of program classification, teachers involved Round Two of Tennessee's Race to the Top STEM PD schools significantly improved their Implementation of Lesson scores from their average baseline rating of 2.70 or a Level 2: Elements of Effective Instruction ($M = 18.90$, $SD = 3.83$), to an average rating of 2.97 ($M = 20.77$, $SD = 4.11$) at the second observation recorded at the mid-point of the professional development program, to an average rating of 3.44 or a Level 3 at the end-point observation ($M = 24.09$, $SD = 3.91$), $F(2) = 48.88$, $p < .000$. The implementation of lesson construct considers the level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments. The effect size is considered large ($_p^2 = .218$) with 21.8% of the variance in Implementation of Lesson scores accounted for by time of the observation. Figure 3 shows the statistically significant increase in average Implementation of Lesson scores over time.

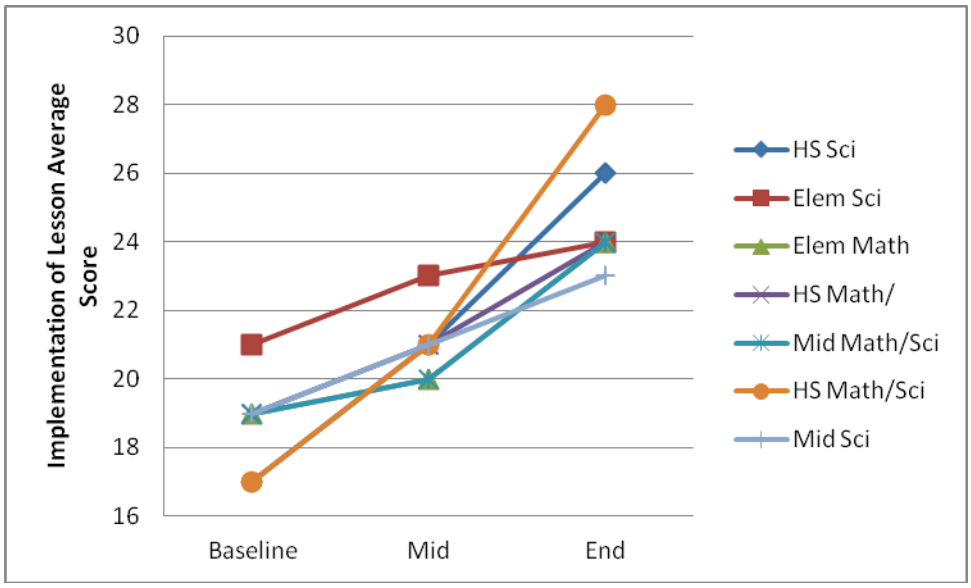
Figure 3. Implementation of Lesson Average Score Over Time for Round Two Programs



Average scores could have an overall range of 7-35, since there are seven items on a 5-point scale for this sub-section. Statistically significant increases were noted between all observation points.

As was the case with Design of Lesson, state level findings varied by type of program (e.g., mathematics, science, or grade range) in terms of Implementation of Lesson, meaning there was a statistically significant difference in implementation of lesson between program classifications, $F(6) = 2.57$, $p < .05$. The effect size is considered medium ($\eta_p^2 = .081$), with 8.1 percent of the variance in implementation of lesson score accounted for by type of program. The only significant difference in program type was between Middle School Math/Science programs, which were significantly lower compared to Elementary Science programs ($p < .01$). The average implementation of lesson score across time ranged from 2.43 (High School Math/Science) to 4.00 (High School Math/Science), which are equivalent to a Level 2: Elements of Effective Instruction and Level 4: Accomplished, Effective Instruction respectively. There was also a statistically significant interaction between program classification and time of observation for design of lesson, $F(12) = 1.78$, $p < .05$. This means as time went on, the overall group improved. The effect size is considered small ($\eta_p^2 = .058$), with 5.8 percent of the variance in implementation of lesson score accounted for by the interaction between observation time and program classification. Figure 2 shows that all program classifications increased in implementation score from baseline to mid-program observations and again increased from mid- to end-of-program observations.

Figure 4. Implementation of Lesson Average Score Over Time by Program Classification for Round Two Programs

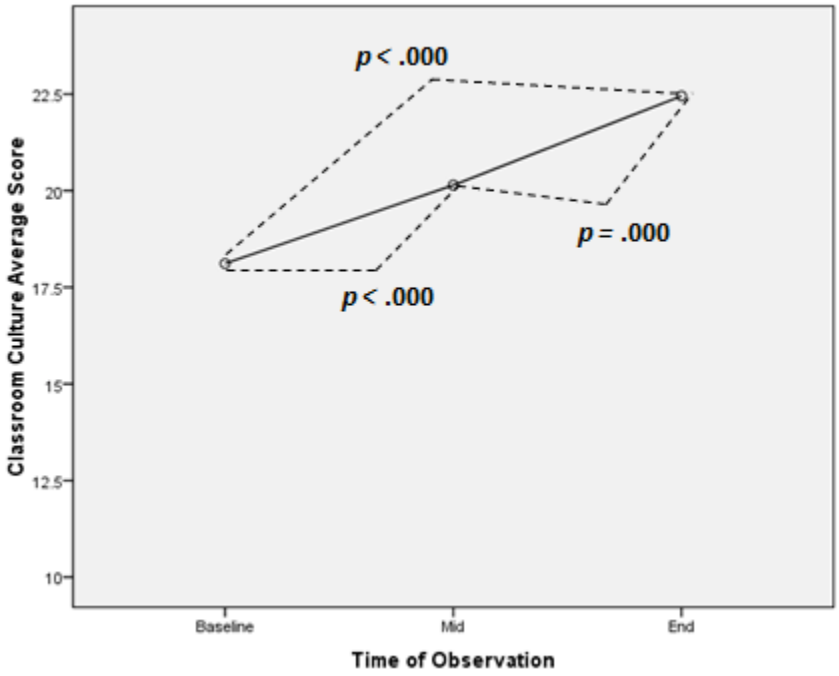


Average scores could have an overall range of 7-35, since there are seven items on a 5-point scale for this sub-section. The only significant differences noted over time were between Middle School Math/Science programs, which were significantly lower compared to Elementary Science programs ($p < .01$).

Classroom Culture

The THEC STEM PD participants also significantly improved their overall Classroom Culture scores from baseline average rating of 3.02 or a Level 3: Beginning Stages of Effective Instruction (M = 18.12, SD = 3.83), to an average rating of 3.36 (M = 20.14, SD =3.76) on the second observation recorded at the mid-point of the professional development program. This rating increased to an average rating of 3.74 (M = 22.45, SD = 2.93) at the end-point observation, $F(2)$ = 49.11, $p < .000$. The effect size is considered large ($_p^2$ = .219), with 21.9% of the variance in Classroom Culture scores accounted for by time of the observation. Figure 5 shows the statistically significant increase in average Classroom Culture scores over time. Classroom Culture refers to the amount of active participation of all students and level of collaborative learning, including allowing students to explore their own ideas, questions, conjectures, and propositions or to challenge the ideas of others.

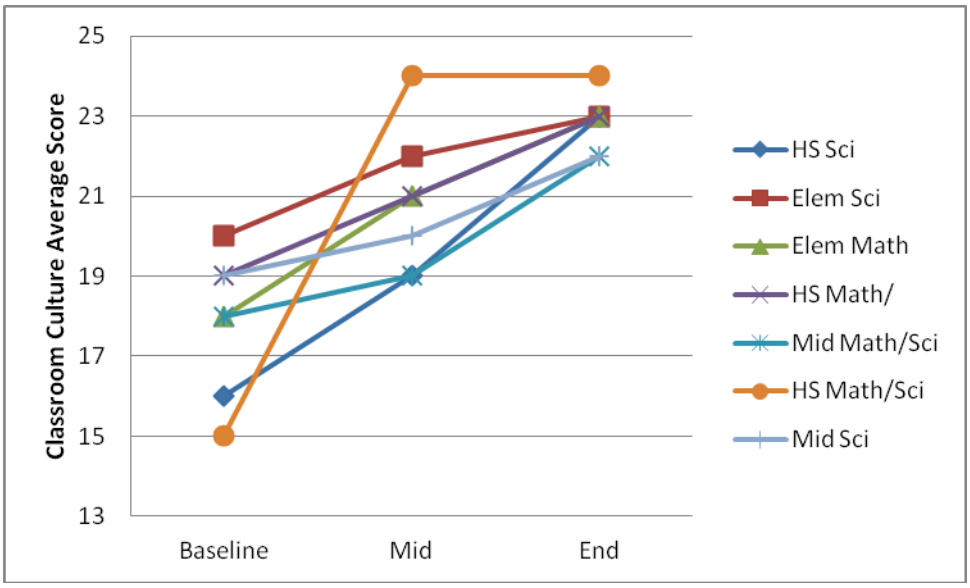
Figure 5. Classroom Culture Average Score Over Time for Round Two Programs



Average scores could have an overall range of 6-30 since there are six items on a 5-point scale for this sub-section. Statistically significant increases were noted between all observation points.

Again, as with the Design of Lesson and Implementation of Lesson constructs, there was a statistically significant difference in classroom culture between program classifications, $F(6) = 2.79$, $p < .05$. The effect size is considered medium ($\eta_p^2 = .087$), with 8.7 percent of the variance in classroom culture score accounted for by type of program. The only significant difference in program type was between Middle School Math/Science programs, which were significantly lower compared to Elementary Science programs ($p < .05$). The average classroom culture score across time ranged from 2.42 (High School Math/Science) to 4.00 (High School Math/Science), which are equivalent to a Level 2: Elements of Effective Instruction and Level 4: Accomplished, Effective Instruction respectively. A statistically significant interaction between program classification and time of observation existed for classroom culture, $F(12) = 2.22$, $p > .01$. The effect size is considered medium ($_p^2 = .087$), with 8.7 percent of the variance in Classroom Culture scores accounted for by the interaction of time of the observation and program classification. Figure 6 shows that all program classifications increased in classroom culture score from baseline to mid-observations and again increased from mid- to end-of-program observations.

Figure 6. Classroom Culture Average Score Over Time by Program Classification for Round Two Programs

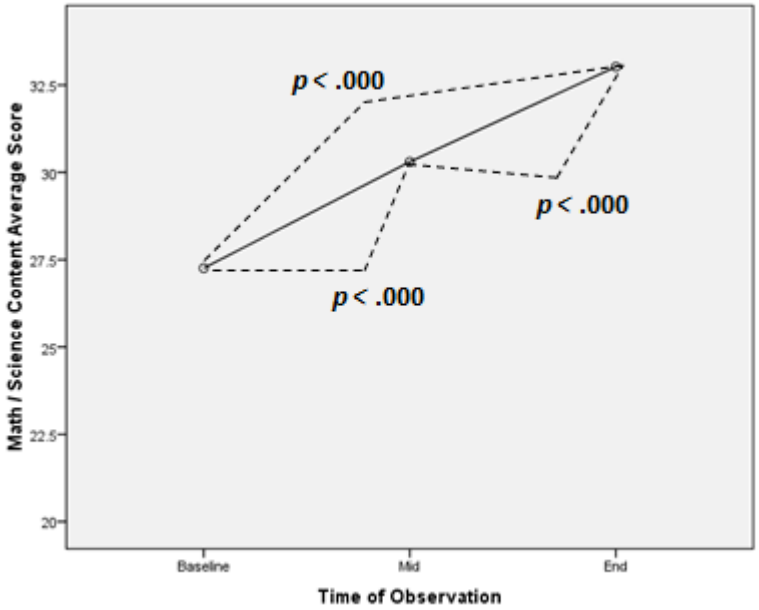


Average scores could have an overall range of 6-30 since there are six items on a 5-point scale for this sub-section. The only significant differences noted over time were between Middle School Math/Science programs, which were significantly lower compared to Elementary Science programs ($p < .05$).

Mathematics/Science Content Domain

THEC STEM PD Round Two participants significantly improved their Mathematics/Science Content scores from a baseline score of 3.03, which is rated as a Level 3: Beginning Stages of Effective Instruction ($M = 27.26$, $SD = 4.54$), to an average rating of 3.37 ($M = 30.30$, $SD = 4.64$) at the second observation point mid-way through the professional development program. By the end of the program, participants experienced further growth, with an average score of 3.67 overall ($M = 33.02$, $SD = 4.66$), $F(2) = 50.43$, $p < .000$. The effect size is considered large ($_p^2 = .224$), with 22.4% of the variance in Mathematics/Science Content scores accounted for by time of the observation. Figure 7 shows the statistically significant increase in average Mathematics/Science Content scores over time.

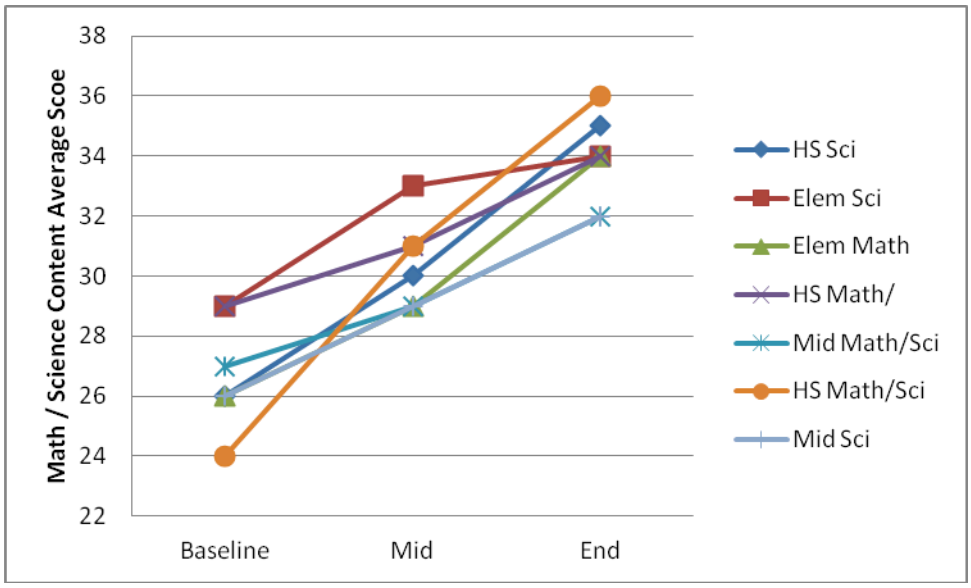
Figure 7. Mathematics/Science Content Domain Average Score Over Time for Round Two Programs



Average scores could have an overall range of 9–45 since there are 9 items on a 5-point scale for this sub-section. Statistically significant increases were noted between all time points.

Similar to Design of Lesson, Implementation of Lesson, and Classroom Culture constructs, there is a statistically significant difference in mathematics/science content between program classifications, $F(4) = 4.49$, $p < .000$. The effect size is considered medium ($\eta_p^2 = .133$), with 13.3 percent of the variance in classroom culture score accounted for by type of program. The only significant difference in program type was between Middle School Math/Science programs, which were significantly lower compared to Elementary Science programs ($p < .000$). The average classroom culture score across time ranged from 2.61 (High School Math/Science) to 4.00 (High School Math/Science), which are equivalent to a Level 2: Elements of Effective Instruction and Level 4: Accomplished, Effective Instruction respectively. There is not a statistically significant interaction between program classification and time of observation for mathematics/science content, $F(12) = 1.49$, $p < .05$. The effect size is considered small ($_p^2 = .049$), with 4.9 percent of the variance in mathematics/science content scores accounted for by the interaction of time of the observation and program classification. Figure 8 shows that all program classifications increased in classroom culture score from baseline to mid-observations and again increased from mid- to end-of-program observations.

Figure 8. Mathematics/Science Content Domain Average Score Over Time by Program Classification for Round Two Programs



Average scores could have an overall range of 9-45, since there are nine items on a 5-point scale for this sub-section. The only significant differences noted over time were between Middle School Math/Science programs, which were significantly lower compared to Elementary Science programs ($p < .000$).

CONTENT KNOWLEDGE ASSESSMENT FINDINGS

For all types of PD programs there was statistically significant growth from pre- to post-test in terms of teacher content knowledge with the exception of Elementary Math programs because they were already at a B average at pre-test. While nearly all program types showed statistically significant average increases from pre- to post-test in teacher content knowledge, Table 4 shows that teachers participating in Elementary Science, High School Math/Science, and Middle School Science programs appeared to make the greatest gains with each program type moving their teachers' content knowledge up almost two full letter grades (see Table 4). Further statistical analysis (One-Way ANOVA) revealed a statistically significant difference between groups in terms of pre-post teacher content knowledge growth; $F(6) = 14.92$, $p < .000$. Post-hoc analysis indicates that Elementary Science, High School Math/Science, and Middle School Science programs had significantly greater teacher content knowledge growth when compared to all other program types ($p < .01$).

Table 4. Pre- and Post-Average Percent Correct by Program Classification

Program Classification	Pre-test	Post-test	% Growth	Significant Growth
High School Science	75.87% (C)	82.16% (B)	+6.29% points	Yes (p<.001)
Elementary Science	48.70% (F)	71.72% (C)	+23.03% points	Yes (p<.000)
Elementary Math	87.30% (B)	89.22% (B)	+1.91% points	No (p=.283)
High School Math	52.04% (F)	62.88% (D)	+10.84% points	Yes (p<.000)
Middle School Math/Science	52.43% (F)	66.01% (D)	+13.58% points	Yes (p<.000)
High School Math/Science	47.27% (F)	79.32% (C)	+32.05% points	Yes (p<.000)
Middle School Science	36.19% (F)	66.59% (D)	+30.40% points	Yes (p<.000)

**Note*. Pre- and Post-test letter grades are also provided in the table based upon a grading scale where A=90-100%, B=80-89%, C=70-79%, D=60-69%, F=59% and below.

IV. FINDINGS OVERALL FOR THEC STEM PD INVESTMENT – RESEARCH QUESTION 2

TEACHER SURVEY FINDINGS

An examination of the surveys that participants completed pre- and post-program revealed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences.

Teacher Opinions Related to STEM Teaching

This construct examined teacher opinions regarding implementing effective STEM instructional strategies and access to associated resources necessary for doing so. A 10-item self-reported level of agreement construct, designed on a 5-point Strongly Disagree – Strongly Agree scale, evaluated teacher opinions. Overall teacher responses on this scale could range from 10-50. The THEC STEM PD participants demonstrated statistically significant improvement in opinions toward teaching mathematics/science from pre- to post-survey administration regardless of the PD program, $F(1) = 36.24$, $p < .000$. Additionally, there was a significant difference between groups with mathematics teachers having better attitudes at pre- and post-survey administration, $F(1) = 10.29$, $p < .001$. However, the difference was nominal, with mathematics teachers starting and finishing approximately 2 points higher than science teachers, who experienced similar growth.

Teacher attitudes significantly increased in agreement in areas such as feeling supported to try new teaching ideas, cohesion of school-wide teaching vision, cooperation by sharing materials, and support by local agencies. Agreement with resource issues (i.e., time and computer access) was unchanged and remained relatively low (50 percent or less agreement at pre/post). Enjoyment for teaching science/math agreement did not change, however, because it was extremely high at the pre-survey (93 percent) and remained similarly high at post-survey (91 percent).

Teacher Perceived Importance Related to STEM Teaching

This construct examined teacher-attributed importance of various use of instructional strategies, which are effective for STEM education. Thirteen items measured on a Not Important – Very Important scale assessed teacher importance. Overall teacher responses on this scale could range

from 13-52. THEC STEM PD participants did not demonstrate statistically significant improvement in reported importance of use of effective mathematics/science instructional strategies from pre- to post-survey administration regardless of the PD program, $F(1) = .096$, $p = .757$. The difference between content areas was significantly different with science teachers remaining higher than math teachers at both pre- and post-survey, $F(1) = 8.92$, $p < .01$.

With the exception of one item, all items remained statistically significantly the same at pre- and post-survey administrations. This is because on average, teachers had extremely high perceptions of the importance of the items at both survey times. The one item where statistically significant increases were found from pre- to post survey was related to having students prepare projects/labs/research projects.

Instructional Influences

This construct examined the external influences teachers experienced that impacted whether or not they chose to use effective STEM pedagogy. Teacher perceived instructional influences were evaluated with 12 items on a 3-point scale assessing degree to which a factor inhibits or encourages effective instruction. Overall scores could range from 12-36. THEC STEM PD participants did not experience statistically significant growth in this area, which means their impression of the influence of negative external pressures on their decisions to use effective pedagogy remained similar from the beginning to end of program participation, $F(1) = .706$, $p > .05$. There was not a statistically significant difference between groups based on content focus, $F(1) = 1.00$, $p > .05$.

In all instances except for two which decreased slightly from pre/post (consistence of science/math reform efforts with other school/district reforms and public attitudes toward reform), teachers perceptions of factors influencing their instruction became more positive or remained the same as they shifted to feeling the factors encouraged effective instruction at a greater rate. However, at the post-survey more than 50 percent of the respondents reported that factors such as funds, time, and public attitudes still inhibited effective instruction.

Teacher Preparedness

This construct examined teacher perceived preparedness for teaching STEM content, and use and delivery of effective STEM pedagogy. Teacher preparedness was assessed through 19 items on a 4-point scale (Not Prepared, Somewhat Prepared, Fairly Well Prepared, and Very Well Prepared) examining participants' self-reported sense of preparedness for STEM teaching in regard to content and pedagogical skills. Scores could range from 19-76. THEC STEM PD participants demonstrated statistically significant increases in preparedness to use various effective mathematics/science instructional strategies from beginning to end of program, $F(1) = 134.31$, $p < .000$. Additionally, there was no statistically significant difference between groups based on content focus (mathematics/science), $F(1) = 1.12$, $p = .289$. Overall, teachers increased from feeling Somewhat Prepared to Fairly Well Prepared and Very Well Prepared. Teachers reported feeling more prepared to do things such as provide concrete experiences before abstract concepts, develop student conceptual understanding, engage students in inquiry-oriented activities, and lead a class using investigative strategies.

Frequency of Use of Effective Pedagogy

Teacher frequency of use of effective pedagogy was determined through participant self-reported data on 14 survey items on a 5-point scale (Never, Rarely, Sometimes, Often, and Almost All Lessons). Overall scores could range from 14-70. THEC STEM PD participants reported statistically significant gains in use of effective pedagogy from pre- to post-survey, $F(1) = 11.44$, $p < .001$. Additionally, there was a statistically significant difference between groups based on content focus, $F(1) = 16.79$, $p < .000$.

All reported use of instructional practices increased from pre- to post-survey with the exception of two (introduce content through formal presentations and assign homework). Most of these practices saw a significantly positive shift, with all being near or more than 75 percent of teachers indicating Frequently Used, except for the item regarding comment on reflections. This item still saw a positive shift but less than 40 percent of teachers reported doing this frequently at post-survey.

Student Activities

This construct examined the use of effective STEM instructional activities with student as the focus. The use of cooperative groups, student generated questions for investigation, communicating findings with others, use of technology, and other student-centered practices were the context for this construct. Student Activities employed in the classroom were evaluated with 20 items on a 5-point scale assessing how often a teacher has students engage in various effective instructional activities (Never, Rarely, Sometimes, Often, and Almost All Lessons). Overall scores could range from 20-100. A statistically significant increase in use of effective student activities was found for THEC STEM PD program participants, regardless of PD program, from pre- to post-survey, $F(1) = 31.60$, $p < .000$. Additionally, there was no statistically significant difference between groups based on content focus, $F(1) = 2.62$, $p = .106$.

Teachers increased their use of effective student instructional practices from Sometimes to Between Sometimes and Often. Approximately 75% of items in this section were reported as significantly increasing from pre- to post-survey. Two of the items (discussions with teachers and work in cooperative learning groups) did not significantly increase but remained high from pre/post, while the other three items either shifted down slightly (review homework assignments) or remained below 50% agreement (read from textbook and take short-answer test).

Parental Support

This construct examined the role of parents in STEM teachers' classrooms who participated in the THEC STEM PD programs. Parental Support was evaluated by six items on a 4-point scale assessing how many parents assist with different activities in the classroom (None, A Few, About Half, and About All). Overall scores could range from 6-24. A statistically significant increase in Parental Support was found for THEC STEM PD program participants regardless of PD program from pre- to post-survey, $F(1) = 4.87$, $p < .05$. Additionally, there was not a statistically significant difference between groups based on content focus, $F(1) = 1.17$, $p = .281$. Most items showed

teachers felt unsupported by parents both before and after, with a vast majority of teachers selecting None or Few parents helping with all activities. There were no areas of significant growth.

Principal Support

This construct examined the role of administrative support in the teaching of STEM. Principal Support was evaluated by nine items on a 5-point scale assessing the degree of agreement a teacher feels with the statements (SD, Disagree, No Opinion, Agree, and SA). Overall scores could range from 9-45. A statistically significant increase in Principal Support was found regardless of PD program from pre- to post-survey, $F(1) = 4.03$, $p < .05$. Additionally, there was not a statistically significant difference between groups based on content focus, $F(1) = .569$, $p = .451$. On average, teachers increased approximately 2 points on the Principal Support scale moving from between No Opinion and Agree to averaging a response of Agree.

Three Principal Support items (providing materials/equipment for science/math, providing time for teachers to meet and share ideas, encouraging teachers to observe other science/math teachers) saw a significant shift from less to more agreement. All other Principal Support areas were notable because they had high levels of agreement at both pre/post (70 – 90%).

Professional Development Experiences

This construct examined the experiences and impressions of the THEC STEM PD participants regarding the individual programs in which they participated. The baseline measure asked participants to reflect on their past experiences with PD. The final survey participants were asked to respond if their impressions of the value of PD had changed relative to their participation in the THEC STEM PD. PD Experiences were evaluated using three items on a 5-point scale assessing the extent to which participation in the district-offered professional development had increased teachers' abilities (Not at All to A Great Extent). Overall scores could range from 3-15. A statistically significant increase in PD Experiences was found regardless of PD program from pre- to post-survey, $F(1) = 2.99$, $p < .10$. Additionally, there was a statistically significant difference between groups based on content focus, $F(1) = 5.83$, $p < .05$. On average, math teachers felt more positively about their PD Experiences at the post-survey than did teachers in the science programs. Regardless of program, the average increase in PD Experiences was approximately 15% points from pre- to post-survey. However, even with these significant increases, agreement failed to reach an average of at least 50% on any item.

V. CONCLUDING OBSERVATIONS

Round Two of the THEC STEM PD Program revealed substantial growth in STEM teacher quality across the state of Tennessee. In this section we will present some concluding observations and highlights of the evaluation report. Individual narratives for each program are included as appendices.

IMPROVED PEDAGOGICAL SKILLS

The Round Two funded STEM PD programs demonstrated significant growth in STEM pedagogical skills, as observed in participant-submitted digital recordings of their instruction. The ability of teachers to design effective STEM lesson increased from 2.47 to 3.04 on the 5-point scale. Teacher implementation of effective STEM instruction also increased significantly from 2.70 to 3.44. Additionally, participants were able to transform their learning environments and create classroom culture which supports investigative STEM education (3.02 to 3.74).

Participants' self-reported data on pre- and post-surveys indicated significant growth overall in opinions related to their own preparedness to teach STEM, frequency of use of effective STEM pedagogy (e.g., cooperative groups, technology, connections between science/math), use of student-centered activities, and connecting learning to the real-world.

IMPROVED CONTENT KNOWLEDGE

Classroom observations of teachers also revealed significant growth in content knowledge delivered during instruction (3.03 at baseline to 3.67 at end of program). This growth was also reflected in program-developed assessments of content knowledge. Analysis of overall program developed content assessment data for THEC STEM PD programs revealed statistically significant growth from pre- to post-test.

IMPROVED OPINIONS

Teachers who attended THEC STEM PD programs exhibited improved attitudes toward the teaching of STEM, as well as more positive experiences with parent and principal support. Furthermore, participants felt more supported by colleagues, and valued the use of inquiry, technology, and collaborative learning. Importantly, participants valued the PD experience. Time for collaboration with other teachers was one area in which participants did not see improvement during the PD program duration.

PROGRAMS CONSIDERED BEST PRACTICE

An examination of the evaluation data at the program level for the 18 THEC STEM PD Round Two programs revealed eleven programs that had significant impact on transforming STEM teacher quality (pedagogical skills) and content knowledge. The programs that improved both content knowledge and teacher quality, which could be considered best practice in our opinion, are as follows:

1. East Tennessee State University (ETSU) – High School Chemistry & Physics (Principal Investigators Rhoton and Zhao)
2. Lipscomb University (LU) – Grades 4-7 Mathematics (Principal Investigators Wells, Morel & Nelson)
3. Lipscomb University (LU) – High School Algebra (Principal Investigators Nelson and Thornthwaite)
4. Middle Tennessee State University (MTSU) – Grades 4-8 Mathematics and Science (Principal Investigators Kimmins and Winters)
5. Middle Tennessee State University (MTSU) – High School Mathematics (Principal Investigators Strayer and Brown)
6. Tennessee Technological University (TTU) – Grades 3-6 Mathematics and Science (Principal Investigators Pardue and Howard)
7. Tennessee Technological University (TTU) – High School Mathematics and Science (Principal Investigators Fidan and Baker)
8. Tennessee Technological University (TTU) – K-2 Mathematics and Science (Principal Investigators Baker and Fromke)
9. Tennessee Technological University (TTU) and Roane State Community College (RSCC) – High School Mathematics and Science (Principal Investigators Suters and Lee)
10. University of Tennessee at Chattanooga (UTC) – Grades 4-7 Science (Principal Investigators Ingraham, Ellis, and Carver)
11. University of Tennessee at Martin (UTM) – Grades 6-12 Science (Principal Investigators Cox and Withmer)

SUMMARY

This annual report for THEC on the STEM PD Programs has focused on the Round Two STEM PD programs. Generally, the evaluation has revealed teacher participation in the THEC STEM programs has resulted in overall growth in science and mathematics teacher effectiveness and attitudes in the state of Tennessee. At an individual program level, findings revealed many THEC funded programs also had significant impact on participants in all areas. However, a few programs had mixed, neutral, or negative impact. Individual program narratives found in the Appendix of this report provide further detail on program level findings.

REFERENCES

Desimone, L.M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*(3), 181-199.

Johnson, C.C., Kahle, J.B., & Fargo, J. (2007a) A study of sustained, whole-school, professional development on student achievement in science. *Journal of Research in Science Teaching. 44*(6), 775-786.

Johnson, C.C., Kahle, J.B., & Fargo, J. (2007b) Effective teaching results in increased science achievement for all students. *Science Education. 91*(3), 371-383.

Johnson, C.C. & Fargo, J.D. (2010). Urban school reform through transformative professional development: Impact on teacher change and student learning of science. *Urban Education, 45*(1), 4-29.

Loucks-Horsley, S., Love, N., Stiles, K. E., Mundry, S., & Hewson, P. W. (2003) *Designing professional development for teachers of mathematics and science.* Thousand Oaks, CA: Corwin Press.

Onwuegbuzie, Anthony J. (2000, November). Expanding the framework of internal and external validity in quantitative research. Paper presented at the annual meeting of the Association for the Advancement of Educational Research, Ponte Vedra, FL.

Putnam R. & Borko, H. (1997). Teacher learning: Implications of new views of cognition. In B.J. Biddle, T.L. Good, & I.F. Goodston (Eds.), *The international handbook of teachers and teaching* (pp.1223-1296). Dordrecht, The Netherlands: Kluwer.

APPENDIX – PROGRAM NARRATIVES

East Tennessee State University (ETSU) – Geiken and Henson, Principal Investigators 28
East Tennessee State University (ETSU) – Keith and Price, Principal Investigators 36
East Tennessee State University (ETSU) – McDowell and Govett, Principal Investigators 43
East Tennessee State University (ETSU) – Rhoton and Zhao, Principal Investigators 46
Lipscomb University (LU) – Hutchinson and High, Principal Investigators 54
Lipscomb University (LU) – Nelson and Thornthwaite, Principal Investigators 61
Lipscomb University (LU) – Wells, Morel and Nelson, Principal Investigators 69
Middle Tennessee State University (MTSU) – Kimmins and Winters, Principal Investigators 76
Middle Tennessee State University (MTSU) – Strayer and Brown, Principal Investigators..... 83
Tennessee Technological University (TTU) – Baker and Fromke, Principal Investigators 86
Tennessee Technological University (TTU) – Fidan and Baker, Principal Investigators 94
Tennessee Technological University (TTU) – Pardue and Howard, Principal Investigators 102
Tennessee Technological University (TTU) and Roane State Community College (RSCC) – Suters and Lee, Principal Investigators 110
University of Memphis (UM) – Franschetti and Conley, Principal Investigators..... 118
University of Memphis (UM) – Grant and Windsor, Principal Investigators 125
University of Memphis (UM) – Powell and Larsen, Principal Investigators 133
University of Tennessee at Chattanooga (UTC) – Ingraham, Ellis, and Carver, Principal Investigators 140
University of Tennessee at Martin (UTM) – Cox, Withmer, Principal Investigators..... 147

Program Narrative
East Tennessee State University (ETSU)
Geiken and Henson, Principal Investigators
Project SEE (Science in Early Elementary)

PROGRAM SETTING AND PARTICIPANTS

The East Tennessee State University (ETSU) Project SEE (Science in Early Elementary) program was a partnership between Education and Arts and Sciences at ETSU and five LEAs (Greene, Hawkins, Sullivan, Unicoi, and Washington). The program was designed to deliver a science professional development program for 25 elementary teachers (K-3). The summer institute included six days, combined with two all day seminars, eight after school workshops, and district professional learning community (PLC) meetings. Project SEE included a total of 100 hours of professional development programming.

The goals of Project SEE included the following:

1. Participating teachers will demonstrate an increase in content knowledge related to physical science: Force and Motion.
2. Participating teachers will demonstrate proficiency and increased use of the pedagogical skills of inquiry instruction and problem solving when teaching physical science.
3. Participating teachers will demonstrate an increase in dispositions related to science teaching as measured by self-efficacy beliefs and their confidence in supporting young children in learning basic physical science concepts.
4. Students will meet age applicable Tennessee state standards in science.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The ETSU Project SEE program aligned somewhat with the Core Conceptual framework in the five areas, detailed in the program proposal. **Content knowledge** focus was aligned, included developing physical science content knowledge through discussion, reflection, and group activities. Selected content was aligned with the state standards for science.

Active learning was listed as a focus for the Project SEE program. Specifically, the program targeted teacher current misconceptions regarding physics through exploration, and investigations. Further, modeling was used to help teachers build questioning strategies and build pedagogical content knowledge. After each face-to-face meeting teachers were given performance-based assignments to take back to their classrooms and complete with their students as a basis for group and individual reflection at the next meeting. Bug in the EAR technology was also used during active

classroom observations to provide real-time support for teachers implementing the program. Virtual technology was also used to enhance the program and continue to engage participants in discourse.

Coherence focused primarily on existing teacher beliefs. A second area was described as "consistency" that was described as district "buy-in" to teacher participation in the program. In regards to **duration**, the program included 100 contact hours as described previously, which extended across a 15-month period. **Collective participation** was achieved from including at least five teachers from each district and district PLC's were formed.

FINDINGS FROM OBSERVATIONS

Twenty-four of the participating 25 teachers Project SEE were observed at least once. Fifteen teachers submitted all three required videos, and this is the group that was examined for impact of the program on their instructional practice. Overall, there was significant growth for participants in this ETSU program in three of four measured areas: design, classroom culture and content knowledge.

At baseline, the Project SEE program participants were categorized as being at the "elements of effective instruction" stage on the design of lesson construct (score of 2.71), increasing significantly by the end of program (3.18) to "beginning of effective instruction". The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

Project SEE participants' implementation of lesson rating did not demonstrate significant growth for participants across the program, as the baseline score of 2.98 ("elements of effective instruction") only increased slightly to a mean score of 3.33 at the end of the program ("beginning stages of effective instruction"). The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

Content knowledge was another area of significant growth for the Project SEE program participants. At baseline, the mean score for teachers in the program was 3.20 ("beginning stages of effective instruction"). By the end of the program, the mean had raised to 3.83 ("beginning stages of effective instruction"). This means that during observations, science content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Participants also incorporated some abstraction, theory building, and connections to other disciplines in observed lessons.

Project SEE participants also significantly raised their score on the construct of classroom culture from a baseline score of 3.20 ("beginning stages of effective instruction") to a final score of 3.62 ("beginning stages of effective instruction"). Implementation of strategies including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor were evident through observations. All students were actively engaged in meaningful learning that respected ideas consistently in classroom observations conducted at the end of the program.

FINDINGS FROM SURVEYS

An examination of the surveys that ETSU Project SEE participants completed in a pre/post manner revealed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 25 participants who completed the pre-survey and 18 who completed the post-survey.

Teacher opinions regarding the importance of use of effective instructional strategies and support necessary to be successful are included in this section of the survey.

Areas of Increased Agreement in teacher opinions related to the teaching of science:

- Importance of developing students' conceptual understanding of mathematics (97 percent to 100 percent)
- Importance of considering student prior understanding when planning instruction (97 percent to 100 percent)
- Importance of having students prepare project/laboratory/research reports (69 percent to 100 percent)
- Importance of using computers (83 percent to 94 percent)
- Importance of engaging students in applications of mathematics in a variety of contexts (97 percent to 100 percent)
- Importance of using performance-based assessments (72 percent to 94 percent)
- Importance of using informal questioning to assess student understanding (93 percent to 100 percent)
- Importance of support of the school by local organizations, institutions, and/or business (18 percent to 28 percent).
- Importance of teachers regularly sharing ideas and materials for science (48 percent to 56 percent)
- Importance of support to try out new ideas in teaching science (72 percent to 89 percent)

Areas of Increased Disagreement – The one area of decline for ETSU's Project SEE participants was in regards to the use of portfolios, which was at 71 percent at baseline and dropped to 67 percent agreement at the end of the program.

Instructional Influences were a second area of focus in the survey. Participants reported slightly positive growth in all but two areas of influences that encourage effective instruction at the end of the program.

Encourages Effective Instruction – The following influences were perceived as having a stronger influence on teaching STEM by the end of the program:

- Access to computers for science instruction (41 percent to 72 percent)
- Time for planning and preparing lessons (31 percent to 67 percent)
- Time for collaboration with other teachers (33 percent to 50 percent)

- Time for professional development (33 percent to 50 percent)
- Funds for purchasing supplies (15 percent to 17 percent)
- Quality of instructional materials (18 percent to 28 percent)
- Management of instructional resources at the district level (15 percent to 21 percent)
- Importance that school places on science/math (21 percent to 33 percent)
- Consistence of science/math reform efforts with other school/district reforms 20 percent to 28 percent)
- Public attitudes toward reform (7 percent to 18 percent)

Areas of Increased Disagreement – The two areas of decline in influence on instruction for the Project SEE program participants was in regards to the state and/or district curriculum frameworks, which was at 41 percent at baseline and dropped to 28 percent agreement at the end of the program, and state and/or district testing policies which dropped from 21 percent at baseline to 0 percent at the end of the program.

Teacher Preparedness comprised the third construct of the survey. Project SEE program participants experienced growth in perceptions of preparation to deliver effective science instruction in all areas of this construct. That is, more teachers agreed that they were well prepared than when the program began:

- Providing concrete experiences before abstract concepts (48 percent to 72 percent)
- Developing student conceptual understanding (55 percent to 89 percent)
- Considering prior understanding when planning curriculum & instruction (69 percent to 89 percent)
- Making connections between science/math and other disciplines (76 percent to 94 percent)
- Using cooperative learning groups (90 percent to 94 percent)
- Use of hands-on activities (79 percent to 94 percent)
- Engaging students in inquiry-oriented activities (55 percent to 94 percent)
- Having students prepare project/laboratory/research reports (31 percent to 78 percent)
- Using computers (72 percent to 89 percent)
- Engaging students in applying science/math in a variety of contexts (59 percent to 94 percent)
- Using performance based assessments (55 percent to 78 percent)
- Using portfolios (38 percent to 56 percent)
- Using informal questioning to assess student understanding (76 percent to 89 percent)
- Leading a class using investigative strategies (38 percent to 83 percent)
- Managing students engaged in hands-on/project-based work (59 percent to 100 percent)
- Helping students take responsibility for their own learning

(69 percent to 100 percent)
- Recognizing and responding to student diversity (76 percent to 94 percent)
- Encouraging students' interest in science/math (83 percent to 100 percent)
- Using strategies that encourage participation of females and minorities in science/math (59 percent to 78 percent)

Frequency of Use of Instructional Practices consists of the ETSU Project SEE program teacher reported frequency of use of specific effective instructional practices.

Increased Use – Teachers reported more frequent use of all but two practices that from baseline to end of program:

- Arranging seating to facilitate student discussion (72 percent to 78 percent)
- Using open-ended questions (83 percent to 100 percent)
- Requiring students to use evidence to support their claims (45 percent to 78 percent)
- Encouraging students to explain concepts to one another (62 percent to 89 percent)
- Encouraging students to consider alternative explanations (48 percent to 83 percent)
- Allowing students to work at their own pace (55 percent to 61 percent)
- Helping students see connections between mathematics and other disciplines (59 percent to 94 percent)
- Using pre-assessments (34 percent to 50 percent)
- Embedding assessment in regular class activities (50 percent to 72 percent)

Decreased Use – The two areas of decline for Project SEE participants was in regards to assigning science/math homework, which was at 7 percent at baseline and dropped to 6 percent agreement at the end of the program, and reading and commenting on student journals, which dropped from 24 percent at baseline to 17 percent at the end of the program.

Student Activities are the activities that students are engaged in within the science classroom. Project SEE teachers were asked questions regarding the frequency of use of various student activities. Findings revealed that participants reported increases in all effective student activities.

Frequent Use – Participants reported more frequent use for these student activities from baseline to the end of the program:

- Participation in student-led discussions (28 percent to 44 percent)
- Participation in discussions with the teacher to further understanding (55 percent to 78 percent)
- Working in cooperative learning groups (69 percent to 89 percent)
- Reading other (non-textbook) science/math related materials in class (62 percent to 67 percent)
- Working on solving a real-world problem (28 percent to 44 percent)

- Sharing ideas or solve problems with each other in small groups (45 percent to 67 percent)
- Record, represent, and/or analyze data (34 percent to 50 percent)
- Following specific instructions in an activity or investigation (39 percent to 72 percent)
- Designing or implementing their own investigation (18 percent to 39 percent)
- Working on models or simulations (10 percent to 33 percent)
- Writing reflections in a notebook or journal (34 percent to 39 percent)
- Taking tests requiring open-ended responses (7 percent to 11 percent)
- Working on extended science/math investigations or projects (17 percent to 28 percent)

Decreased Use – The three areas of decline for Project SEE participants was in regards to having students make formal presentations to the class, which was at 14 percent at baseline and dropped to 6 percent agreement at the end of the program, and having students participate in field work, which dropped from 7 percent at baseline to 6 percent at the end of the program, and finally working on portfolios which went from 4 percent to 0 percent.

Principal Perceptions are the impressions that participants have regarding their administrator's perceptions of the teaching and learning of science/math. Project SEE participants revealed positive feelings regarding two aspects of this construct, but experienced a decline in all other areas.

Areas of Increased Agreement – Teachers agreed that their principal provided encouragement and/or support in the following areas:

- Selection of science/math content and strategies to address individual students' learning (69 percent to 72 percent)
- Accepting the noise that comes with an active classroom (76 percent to 83 percent)

Areas of Increased Disagreement – Fewer teachers agreed that their principal provides encouragement and/or support in the following areas:

- Encouraging implementation of current national standards (83 percent to 61 percent)
- Encouraging innovative instructional practices (90 percent to 83 percent)
- Provides time for teachers to meet and share ideas with one another (76 percent to 67 percent)
- Encourages me to make connections across disciplines (90 percent to 80 percent)
- Acting a buffer between teachers and external pressures (76 percent to 72 percent)
- Encouraging me to observe other exemplary science teachers (34 percent to 28 percent)
- Providing materials/equipment for science/math (41 percent to 33 percent)

Parental Support was reported to be low by participants in the Project SEE program. Participants indicated that few parents volunteer to assist with class activities (11 percent). Further, low parental support was also reported in regards to attendance at PTA or math/science nights (39 percent), voicing support for instructional approaches (22 percent) and attendance at parent-teacher conferences (65 percent). Finally, only 11percent of teachers agreed parents donate money or materials for classroom instruction.

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. Project SEE participants' did experience mixed growth in attitudes toward PD across the program. Only 22 percent of teachers felt their participation in the PD increased their content knowledge. None of the participants thought their understanding of how children think about and learn mathematics had improved (0 percent). Finally, only 22 percent of Project SEE participants felt participation had increased their ability to implement high-quality mathematics instructional materials.

FINDINGS FROM CONTENT ASSESSMENT

Twenty-five participants in the Project SEE program completed both the pre- and post-assessment developed by the program. On the pre-test, teacher average percentage was 42 percent correct. This percentage increased to 49 percent on the post-test. This was considered a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGAM

Project SEE program delivered 100-hours of content to 30 teachers of elementary school science. The focus of the program on the integration of Tennessee science standards and literacy helped to achieve a more real-world orientation for the teaching of science. ETSU was successful in having 25 of the 25 projected participants complete the program.

Findings indicate that participation in the Project SEE program had a significant impact on most measured areas of science teacher quality and participant content knowledge. The program was designed to include the five criteria in the Core Conceptual Framework (content focus, active participation, duration, coherence, and collective participation).

In respect to classroom observation data, Project SEE teachers experienced significant gains in three of the four domains (design, content, and classroom culture) across the program. The one area that did not have significant growth was implementation of the lesson. Project SEE teachers started out rated comparatively high in this category (2.98) and improved to 3.33, which was improvement, just not a statistically significant improvement.

Teachers in this program reported implementation of investigative science instructional strategies, (e.g., using open-ended questions, connections between the disciplines, alternative assessments). Teachers also overwhelmingly felt more prepared to deliver effective science instruction, with increases in all areas of the construct. Frequency of use of investigative science strategies also increased. One area of decline that was of concern is the lack of participant perceived value and use of portfolios. Principal support was reported to be good overall despite some areas of decline.

Parental support was reported overall to be low, including participation at parent-teacher meetings, PTA, science/math night events. The Project SEE program impact was clearly articulated by participants in a transformation of their beliefs regarding the use of effective practice, as well as their impressions of influence of the program on their teaching. Overall, this program demonstrated significant gains in including most areas of teacher quality, teacher opinions, preparedness, and observed content knowledge.

Program Narrative
East Tennessee State University (ETSU)
Keith and Price, Principal Investigators
Hands-On STEM

PROGRAM SETTING AND PARTICIPANTS

The East Tennessee State University (ETSU) Integrating Hands-On STEM Activities with Math and Reading Common Core Standards (Hands-On STEM) program was a partnership between ETSU Education and Arts & Sciences faculty, and five school districts (Bristol City, Greene County, Hawkins County, Kingsport City, and Sullivan County) in Northeast Tennessee. The program delivered an 18-month intensive professional development program for 24 teachers of grades 6-8 science and mathematics A 60-hour summer workshop was completed, along with four additional daylong workshops, and three school visits, for a total of 93-hours of professional development programming.

The goals of the Hands-On STEM program were:

1. Participant teachers will demonstrate enhanced mathematical and science content and advanced pedagogical knowledge and skills, and improved pedagogical content (PCK) and technological pedagogical content knowledge (TPCK).
2. Students of participating teachers will engage in STEM, reading and LA learning through Hands-On, Inquiry-focused, Integrated, Problem solving (HIIP) based investigations and increased awareness of how reading and writing serve inquiry.
3. Students of participating teachers will demonstrate improved achievement in all subject areas – math, science, reading and writing according to benchmark assessments.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The Hands-On STEM program aligned with some components of the Core Conceptual framework. **Content knowledge** was not an area of alignment for the Hands-On STEM program. The proposal did not specifically articulate content knowledge areas that would be emphasized, other than very generally stating that integrated curriculum would be a focus and that would include the integration of mathematics, science, reading, and language arts. Therefore, it is difficult to determine the content focus was (e.g. physical science, numeracy).

Active learning was discussed in the proposal as a focus; however, it was very hard to determine what percentage of the actual content of the program was devoted to this. Further, the active

learning strategies that were described were peer collaboration, planning, addressing student needs, and presenting and discussing. One clear omission from this list is the use of modeling of instruction by the presenters. A second is the immersion of participants in experiencing inquiry in the role of the learner. A third area of concern is the statement that participants would be engaged in developing curriculum – though there is no discussion of what kind of training or preparation the program was to provide to enable teachers to develop high-quality instructional materials.

Coherence was discussed in terms of activities that address teacher beliefs. There was no discussion of alignment with district polices and/or state standards/assessments. The **duration** of the program included 93 hours of contact with participants, which is consistent with the framework. This time was also extended across an 18-month period for sustained support for classroom implementation. **Collective participation** was achieved by inclusion of three teachers from each participating school in the program.

FINDINGS FROM OBSERVATIONS

All 24 teachers involved in ETSU's Hands-On STEM program were observed at least once. Thirteen teachers submitted all three required videos. This group of 13 was examined for impact of the program on instructional practice. Overall, there was significant growth for program participants in all four measured areas: design, implementation, classroom culture, and content knowledge.

Hands-On STEM program participants were characterized as delivering "elements of effective instruction" (score of 2.40) on the design of lesson at baseline. Observations at the end of the program revealed significant growth to 3.22 ("beginning effective instruction"). The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

The implementation of lesson rating also grew significantly for participants overall across the program. At baseline Hands-On STEM teachers received a 2.77 ("elements of effective instruction") but improved to a score of 3.56 by end of program ("beginning effective instruction"). The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

Hands-On STEM teachers at baseline received a score for science content knowledge of 2.87 ("elements of effective instruction"). By the end of the program, participants had experienced significant growth (3.81 "beginning stages of effective instruction"). This means that during observations, science content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Participants also incorporated some abstraction, theory building, and connections to other disciplines in observed lessons.

Classroom culture was another area of significant growth for the Hands-On STEM teachers. The overall group began at 2.94 ("elements of effective instruction"). However, by the end of the program, participants had improved considerably and gained a score of 3.94 ("beginning stages of effective instruction"). Implementation of strategies, including collaborative learning, centering

instruction on student generated questions, and ideas and intellectual rigor, were not evident through observations. All students were actively engaged in meaningful learning that respected ideas consistently in classroom observations conducted at the end of the program.

FINDINGS FROM SURVEYS

An examination of the surveys that participants completed in a pre/post manner revealed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 24 participants who completed the pre-survey and 24 who completed the post-survey.

Teacher opinions regarding the importance of use of effective instructional strategies and support necessary to be successful are included in this section of the survey.

Areas of Increased Agreement in teacher opinions related to the teaching of science:

- Importance of having students work in cooperative learning groups (94 percent to 98 percent)
- Importance of having students prepare project/laboratory/research reports (59 percent to 87 percent)
- Importance of using computers (90 percent to 96 percent)
- Importance of engaging students in applications of mathematics in a variety of contexts (98 percent to 100 percent)
- Importance of using performance-based assessments (80 percent to 91 percent)
- Importance of using informal questioning to assess student understanding (98 percent to 100 percent)
- Importance of support of the school by local organizations, institutions, and/or business (35 percent to 60 percent).
- Importance of teachers regularly sharing ideas and materials for science (63 percent to 81percent)
- Importance of support to try out new ideas in teaching science (82 percent to 96 percent)

Areas of Increased Disagreement – The one area of decline for Hands-On STEM participants was in regards to the importance of considering student prior understanding when planning instruction (61 percent to 52 percent).

Instructional Influences were a second area of focus in the survey. Participants reported positive growth in all areas of influence that encourage effective instruction at the end of the program.

Encourages Effective Instruction – The following influences were perceived as having a more positive influence on teaching mathematics by the end of the program:

- State and/or district curriculum frameworks (73 percent to 81 percent)
- State and/or district testing policies (46 percent to 57 percent)

- Access to computers for instruction (54 percent to 72 percent)
- Time for planning and preparing lessons (31 percent to 67 percent)
- Time for collaboration with other teachers (33 percent to 50 percent)
- Time for professional development (33 percent to 50 percent)
- Funds for purchasing supplies (45 percent to 55 percent)
- Quality of instructional materials (52 percent to 70 percent)
- Management of instructional resources at the district level (44 percent to 62 percent)
- Importance that school places on science/math (61 percent to 72 percent)
- Consistence of science/math reform efforts with other school/district reforms 48 percent to 60 percent)

Teacher Preparedness comprised the third construct of the survey. Hands-On STEM program participants experienced growth in perceptions of preparation to deliver effective science instruction in all but two areas of this construct.

Growth in Perceived Preparation – Teachers who participated in the program reported being better prepared in the following areas at the end of the program:

- Providing concrete experiences before abstract concepts (84 percent to 96 percent)
- Developing student conceptual understanding (80 percent to 94 percent)
- Considering prior understanding when planning curriculum and instruction (88 percent to 96 percent)
- Making connections between science/math and other disciplines (73 percent to 94 percent)
- Using cooperative learning groups (78 percent to 96 percent)
- Engaging students in inquiry-oriented activities (69 percent to 96 percent)
- Having students prepare project/laboratory/research reports
- (35 percent to 83 percent)
- Using computers (75 percent to 98 percent)
- Engaging students in applying science/math in a variety of contexts (63 percent to 98 percent)
- Using performance based assessments (61 percent to 87 percent)
- Using informal questioning to assess student understanding (84 percent to 98 percent)
- Leading a class using investigative strategies (65 percent to 91 percent)
- Managing students engaged in hands-on/project-based work
- (79 percent to 94 percent)
- Recognizing and responding to student diversity (88 percent to 94 percent)
- Encouraging students' interest in science/math (86 percent to 94 percent)
- Using strategies that encourage participation of females and minorities in science/math (67 percent to 87 percent)

- Helping students take responsibility for their own learning (88 percent to 94 percent)

Frequency of Use of Instructional Practices consists of Hands-On STEM teachers reported frequency of use of specific instructional practices. Participants reported increase in most areas.

Increased Use – There were several practices for which more participants reported frequent use from pre- to post-survey administration. These practices included:

- Requiring students to use evidence to support their claims (77 percent to 83 percent)
- Encouraging students to explain concepts to one another (80 percent to 85 percent)
- Encouraging students to consider alternative explanations (73 percent to 81 percent)
- Allowing students to work at their own pace (76 percent to 83 percent)
- Helping students see connections between science/math and other disciplines (73 percent to 85 percent)
- Embedding assessment in regular class activities (77 percent to 89 percent)
- Using pre-assessments (55 percent to 77 percent)

Decreased Use – More participants reported infrequent use of arranging seating to facilitate student discussion (88 percent to 83 percent) at the end of the program.

Student Activities are the activities that students are engaged in within the classroom. Hands-On STEM participants were asked questions regarding the frequency of use of various student activities. There was positive growth in all aspects of this construct across the program.

Frequent Use – Participants reported more frequent use of some student activities by the end of the program. These included having students:

- Participating in student-led discussions (59 percent to 72 percent)
- Participating in discussions with the teacher to further understanding (80 percent to 85 percent)
- Sharing ideas or solve problems with each other in small groups (71 percent to 79 percent)
- Working on models or simulations (29 percent to 45 percent)
- Recording, representing, and/or analyzing data (33 percent to 51 percent)
- Writing reflections in a notebook or journal (37 percent to 70 percent)
- Taking short-answer tests (37 percent to 45 percent)
- Taking tests requiring open-ended responses (41 percent to 57 percent)
- Making formal presentations to the class (23 percent to 35 percent)

- Following specific instructions in an activity or investigation (67 percent to 83 percent)
- Designing or implementing his or her own investigation (10 percent to 46 percent)
- Working on portfolios (10 percent to 17 percent)
- Participate in field work (6 percent to 15 percent)

Principal Perceptions are the impressions that participants have about their administrator's perceptions of the teaching and learning of science/math. Hands-On STEM participants revealed positive feelings regarding this construct.

Areas of Increased Agreement – Teachers agreed that their principal provides encouragement and/or support in the following areas:

- Encouraging selection of science/math content and strategies to address individual students' learning (82 percent to 87 percent)
- Accepting the noise that comes with an active classroom (84 to 98 percent)
- Providing materials/equipment for science/math (59 percent to 79 percent)
- Encouraging teachers to make connections across disciplines (75 percent to 87 percent)
- Acting as a buffer between teachers and external pressures (61 percent to 77 percent)
- Encourages me to observe exemplary science/math teachers (51 percent to 67 percent)
- Provides time for teachers to meet and share ideas with one another (69 percent to 74 percent)

Parental Support was reported to be very low by participants in the Hands-On STEM program. Eighty-nine percent of participants indicated that few parents volunteer to assist with class activities. Additionally, teachers reported that parents do not donate money for materials (83 percent), attend PTA or math/science nights (66 percent), or voice support for various instructional approaches (87 percent). However, 57 percent of participants agreed that parents do participate in parent-teacher conferences.

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the THEC STEM PD program to increase their skills. Hands-On STEM participants were somewhat positive regarding the impact the program had on their ability to implement high-quality instruction (43 percent agreement), their content knowledge (48 percent agreement), on their understanding of how children think about science (52 percent agreement).

FINDINGS FROM CONTENT ASSESSMENT

Twenty-three participants in the Hands-On STEM program completed both the pre- and post-assessment that was developed by the program. On the pre-test, teacher average percentage was 87 percent correct. This percentage increased to 89 percent on the post-test. This was not a statistically

significant increase, but demonstrates that teachers retained their high level of existing content knowledge across the program.

CONCLUDING OBSERVATIONS FOR PROGRAM

The Hands-On STEM program was focused on 93 contact hours of professional development for 24 teachers of grades 6-8 science. The program emphasized developing mathematics and science pedagogical content knowledge (PCK), as well as technology pedagogical content knowledge (TPCK) through an emphasis of the HIIP approach where reading and writing are integrated with math and science to serve inquiry. Despite close alignment in the proposal with the Core Conceptual Framework in three areas (content focus, active participation, coherence) as described previously, findings indicate participation had a significant impact on teacher quality. Participants in the Hands-On STEM program performed surprisingly well on the pre-assessment, with 87 percent of teachers passing the test. This increased only slightly to 89 percent passing at the end of the program, which was not a significant gain. Hands-On STEM was successful in having 24 of the 27 projected participants complete the program.

In respect to classroom observation data, Hands-On STEM teachers experienced significant gains in all four domains (design, implementation, content, and classroom culture) across the program. Additionally, teachers in this program reported implementation of investigative science instructional strategies, including those that require a high level of ability to facilitate student scientific discourse (e.g., using evidence, explaining concepts to others, considering alternative explanations, working with models and simulations, and recording, representing, and analyzing data).

Hands-On STEM teachers reported more support from principals. Reported PD experiences included only 43 percent of teachers feeling their content knowledge was impacted. However, it may be that the content might was a review for some teachers, as evidenced by the performance on the pre/post test as well. Participants (52 percent) did feel prepared to implement the new strategies at the end of the program. Parental support was mixed, as Hands-On STEM teachers reported 57 percent agreement with the statement that parents attend parent-teacher conferences, though less agreement was discovered in other areas of parent support. Overall, this program demonstrated significant gains in teacher quality and on some aspects of the teacher survey.

Program Narrative
East Tennessee State University (ETSU)
McDowell and Govett, Principal Investigators
Incorporating Active Learning into Life Science Teaching

PROGRAM SETTING AND PARTICIPANTS

The East Tennessee State University (ETSU) Incorporating Active Learning into Life Science Teaching program was a partnership between ETSU Education and Arts & Sciences faculty and six school districts (Bristol County, Greene County, Hawkins County, Kingsport City, Unicoi County and Washington County) in Northeast Tennessee. The program delivered an 18-month intensive professional development program for 18 middle school teachers of science and mathematics. A ten-day summer institute was completed in 2013, along with expert science visits, and feedback meetings, for a total of 90 hours of professional development programming.

The goals of this project included the following:

1. Improve teachers' content knowledge and pedagogical techniques in the areas of Life Sciences and Mathematics.
2. Train teachers in the use of classroom friendly, curriculum-focused Learning Modules which engage students in Embedded Inquiry to address biological questions.
3. Build Professional Learning Communities of teachers, administrators and university experts to develop, implement, assess and disseminate methods to improve science and math learning.
4. Provide project participants and participating schools appropriate science tools to implement goals on a sustainable basis.

The objectives of this project included the following:

1. Achieve a normalized gain of at least 30% from pre-workshop to post-workshop test scores for life science and math content among participating teachers.
2. Document broad improvement in scores for teachers' attitudes toward the nature of science and teaching science, and in teachers' efficacy, as measured by pre and post workshop teacher attitude surveys.
3. Obtain a 10% value-added increment in school average normal curve equivalent (NCE) scores for science in grades 6-8.
4. Accomplish a demonstrable enhancement in participating schools' classroom equipment and supplies, and in teachers' and students' regular use of these materials.

5. Disseminate practical and effective biology and math Learning Modules through the program website, professional meetings, and other channels.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The Incorporating Active Learning into Life Science Teaching program aligned with the Core Conceptual framework in all five areas, detailed in the program proposal. First, the focused on Life Science (Biology) and mathematics **content knowledge**, aligned with Common Core standards (mathematics) and science state standards for grades 6-8. A detailed alignment table for content was provided. Some specific topics included microscope use, chloroplast densities, photosynthesis, respiration, and classification.

Active learning was described as a focus in the proposal, including the use of inquiry, investigations, making sense of data, and forming conclusions supported by evidence. These are all activities that participants would encounter throughout the PD. This was also observed during the site visit to this program in Summer 2013.

Coherence was described in the proposal as including connections with goals, alignment with state and district standards, and communication with others. The **duration** of the program included 90 hours of contact with participants, which is consistent with the framework. This was achieved through a combination of a ten-day summer institute and four additional workshops across the academic year. **Collective participation** was achieved by including two teachers from each middle school, one mathematics and one science teacher.

FINDINGS FROM OBSERVATIONS

Only one participant from the Incorporating Active Learning into Life Science Teaching program provided two videos for this program (baseline and mid-year). As a result, program-level teacher observation analyses are unable to be conducted.

FINDINGS FROM SURVEYS

The Incorporating Active Learning into Life Science Teaching program had only seven participants who completed the pre survey and none completed the post-survey. Therefore survey data is not included for this program in the evaluation.

FINDINGS FROM CONTENT ASSESSMENT

Sixteen participants in the Incorporating Active Learning into Life Science Teaching program completed both the pre- and post-assessment that was developed by ETSU program staff. On the pre-test, teacher average percentage was 34 percent correct. This percentage increased to 86 percent on the post-test. This was considered a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGRAM

Due to the lack of data collection required for the evaluation by the Incorporating Active Learning into Life Science Teaching program, the ability to draw concluding observations is limited. There was a significant difference in content test findings from pre to post as administered and reported by the program PIs. Only 18 of the projected 25 participants completed the program.

Program Narrative
East Tennessee State University (ETSU)
Rhoton and Zhao, Principal Investigators
Professional Community of Modeling Instruction (PCMI)

PROGRAM SETTING AND PARTICIPANTS

ETSU's Professional Community of Modeling Instruction (PCMI) program was a partnership between the College of Arts & Sciences and the College of Education to deliver an 18-month intensive professional development program for 25 high school teachers of chemistry and/or physics. ETSU partnered with nine LEAs (Bristol City, Carter County, Greene County, Greeneville City, Hawkins County, Johnson County, Sullivan County, Unicoi County, and Washington County) for this program. Twelve summer workshop days were conducted, along with six monthly sessions and an online component, for a total of 108 contact hours of instruction.

The goals of this project included:

1. Participating teachers will improve pedagogical knowledge and skills, and teach their chemistry and physics courses using Modeling Instruction, supported by the establishment of professional learning community at participating schools.
2. Students of participating teachers will demonstrate improved knowledge of chemistry and physics through Modeling Instruction, enrolling in more rigorous science courses.

The objectives of the PCMI included:

1. Participating teachers will increase their pedagogical content knowledge of MI, and conceptual learning of chemistry and physics by 30% by the end of project.
2. Participating teachers will establish professional learning communities of MI, which will receive school support and commit to continuous improvement of science teaching.
3. Students (11th grade) who complete chemistry and physics using Modeling Instruction will increase their College Readiness Benchmark score in science (using ACT) by 10%.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The PCMI program aligned with the Core Conceptual framework with a focus on chemistry and physics **content knowledge** delivered through a lens of content and pedagogy delivered by the chemistry and education faculty. Modeling of effective integration of content with increasing pedagogical skill (modeling) was also included. **Active learning** was a focus including the use of multiple modeling cycle lessons where teachers participated in the student role. At least 80 percent of activities were to be focused on active learning experiences. **Coherence** was focused primarily on addressing teacher beliefs. Additionally, districts had buy-in to the project and provided support for teachers in the program. The **duration** of the program included 108-hours of contact with participants, which is consistent with the framework. This was achieved through a 80-hour, 2-week intensive summer workshop, combined with 48 hours of follow-up days in the fall, as well as 10 hours of web-based work. **Collective participation** was achieved by including two teachers from each school, according to the proposal.

FINDINGS FROM OBSERVATIONS

The PCMI program had 19 of the participating 25 teachers who were observed at least once. Twelve teachers submitted all three required videos, and this is the group that was examined for impact of the program on their instructional practice. Overall, there was significant growth for participants in the PCMI program participants in all four measured areas: design, implementation, classroom culture, and content knowledge.

At baseline, the PCMI program participants received a mean score of 2.05 (characterized as delivering "elements of effective instruction"), which increased to a final mean score of 3.18 ("beginning stages of effective instruction") by the end of the program. The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that took place in the lesson delivery.

PCMI program participants also experienced growth in the area of implementation of lesson. The baseline mean rating for teachers was 2.37 ("elements of effective instruction") and improved to a mean of 3.54 at end of program ("beginning stages of effective instruction"). Teacher ability to implement effective science instruction improved considerably. The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

PCMI teachers at baseline received a score for science content knowledge of 2.75 ("elements of effective instruction"). By the end of the program, ETSU participants had experienced significant growth to 3.81 ("beginning stages of effective instruction"). This means that during observations, science content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Participants also incorporated some abstraction, theory building, and connections to other disciplines in observed lessons.

Classroom culture was another area of significant growth for the PCMI science teachers. The overall group began at a score of 2.36 ("elements of effective instruction"). However, by the end of the program, participants had improved considerably with a score of 3.75 ("beginning stages of effective instruction"). Implementation of strategies including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor were not evident through observations. All students were actively engaged in meaningful learning that respected ideas consistently in classroom observations conducted at the end of the program.

FINDINGS FROM SURVEYS

An examination of the pre/post surveys that participants completed revealed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 15 participants who completed the pre-survey and 17 who completed the post-survey.

Teacher opinions were mixed at the end of the PCMI program as compared to the baseline, prior to participation in the program.

Areas of Increased Agreement – More teachers agreed with the following items after the program:

- Teachers collaborated to share ideas more (82 percent to 90 percent)
- Teachers have time to collaborate with peers (20 percent to 53 percent)
- The school mathematics program is supported by local organizations, institutions (20 percent to 59 percent)
- Importance of using portfolios (80 percent to 94 percent)
- Importance of considering students prior understanding when planning curriculum and instruction (94 percent to 100 percent)
- Importance of having students participate in inquiry-oriented activities (96 percent to 100 percent)

Areas of Increased Disagreement – Fewer teachers agreed with the following items after the program:

- Importance of developing students' conceptual understanding of science/math (100 percent to 94 percent)
- Importance of making connections between science/math and other disciplines (100 percent to 82 percent)
- Importance of having students work in cooperative learning groups (100 percent to 88 percent)
- Importance of having students work in appropriate hands-on activities (100 percent to 94 percent)
- Importance of having students prepare project/laboratory/research reports (87 percent to 76 percent)

- Importance of using informal questioning to assess student learning (100 percent to 93 percent)
- Importance of having students use computers (87 percent to 82 percent)
- Importance of using performance-based assessment (93 percent to 65 percent)
- Importance of using informal questioning to assess student learning (93 percent to 88 percent)

Instructional Influences were a second area of focus in the survey. The PCMI participants reported mixed experiences with variables in this area at the end of the program.

More Influence on Effective Instruction – The following influences were perceived as having a more of an influence by the end of the program:

- State and/or district testing polices and practices (7 percent to 24 percent)
- Quality of available materials (53 percent to 76 percent)
- Funds for equipment and supplies (33 percent to 47 percent)
- System of managing instructional resources at district or school level (25 percent to 44 percent)
- Time for professional development (20 percent to 53 percent)
- Time to work with other teachers (33 percent to 41 percent)
- Consistency of science/math reform efforts with other school/district reforms (36 percent to 41 percent)
- Importance of mathematics/science within the school (47 percent to 56 percent)

Less Influence on Effective Instruction – The following influences were perceived as having less of an influence on the program by the end of the program:

- State and/or district curriculum frameworks (33 percent to 29 percent)
- Time to plan and prepare lessons (67 percent to 53 percent)
- Access to computers for instruction (60 percent to 53 percent)
- Public attitudes toward reform (31 percent to 29 percent)

Teacher Preparedness comprised the third construct of the survey. Participants in the PCMI program experienced gains in all areas of perceived preparedness across the program, as indicated by a greater percentage of teachers indicating that they were fairly well or well prepared in the following construct areas:

- Providing concrete experiences before abstract concepts (60 percent to 100 percent)
- Developing students' conceptual understanding of science/math (79 percent to 100 percent)
- Considering student prior understanding when planning curriculum and instruction (57 percent to 88 percent)

- Making connections between science/math and other disciplines (73 percent to 100 percent)
- Using hands-on activities (80 percent to 100 percent)
- Using cooperative learning groups (60 percent to 94 percent)
- Engaging students in inquiry-oriented activities (60 percent to 100 percent)
- Having students prepare project/laboratory/research reports (67 percent to 82 percent)
- Using computers (87 percent to 94 percent)
- Engaging students in applying science/math in a variety of contexts (60 percent to 88 percent)
- Using performance based assessments (60 percent to 76 percent)
- Using portfolios (27 percent to 59 percent)
- Leading a class using investigative strategies (73 percent to 100 percent)
- Helping students take responsibility for their own learning (67 percent to 94 percent)
- Recognizing and responding to student diversity (47 percent to 76 percent)
- Using strategies that encourage participation of females and minorities in science/math (33 percent to 65 percent)
- Encouraging student interest in science/math (67 percent to 94 percent)

Frequency of Use of Instructional Practices consists of teacher-reported frequency of use of specific instructional practices. PCMI program participants reported more frequent use of all but one strategy (introducing content by formal presentation) by the end of the program:

- Arranging seating to facilitate student discussion (60 percent to 94 percent)
- Using open-ended questions (67 percent to 94 percent)
- Requiring students to supply evidence to support their claims (73 percent to 100 percent)
- Encouraging students to explain concepts to one another (73 percent to 100 percent)
- Encouraging students to consider alternative explanations (73 percent to 94 percent)
- Allowing students to work at their own pace (73 percent to 78 percent)
- Helping students see connections between science/math and other disciplines (80 percent to 88 percent)
- Using pre-assessments (60 percent to 71 percent)
- Embedding assessments in regular class activities (73 percent to 88 percent)
- Assigning science/math homework (73 percent to 88 percent)
- Reading and commenting on student reflections in notebooks/journals (27 percent to 53 percent)

Student Activities are the activities that students are engaged in within the classroom. PCMI participants were asked questions regarding the frequency of use of various student activities.

Findings in regards to the frequency of use of effective student activities from baseline to end of program revealed an increase of use of strategies in all areas of this construct.

- Participating in student led discussions (60 percent to 100 percent)
- Participating in discussions with the teacher to further science/math understanding (73 percent to 100 percent)
- Making formal presentations to the class (40 percent to 65 percent)
- Reading other (non-textbook) science/math related materials in class (20 percent to 29 percent)
- Working on solving real-world problems (53 percent to 76 percent)
- Sharing student ideas or solve problems with each other in small groups (73 percent to 88 percent)
- Following specific instructions in an activity or investigation (60 percent to 88 percent)
- Designing or implementing his or her own investigation (20 percent to 41 percent)
- Working on models or simulations (21 percent to 71 percent)
- Working on extended science/math investigations or projects (13 percent to 29 percent)
- Recording, representing, and/or analyzing data (60 percent to 94 percent)
- Writing reflections in a notebook or journal (40 percent to 53 percent)
- Working on portfolios (0 percent to 25 percent)
- Participating in field work (0 percent to 18 percent)
- Taking tests requiring open-ended responses (27 percent to 71 percent)
- Taking short-answer tests (40 percent to 53 percent)

Principal Perceptions are the impressions that participants have about their administrator's support for the teaching and learning of science/mathematics. Participants in the PCMI program had mostly positive views of their leadership despite decline in some areas across the program.

Areas of Increased Agreement – Teachers agreed their principal provided encouragement and/or support in the following areas:

- Providing materials/equipment for science/math (43 percent to 60 percent)
- Encourages innovative instructional practices (93 percent to 100 percent)
- Enhances the math/science program by providing needed materials and equipment (47 percent to 59 percent)
- Encouraging teachers to observe other exemplary teachers (27 percent to 53 percent)
- Encouraging the implementation of current national standards in science/math education (73 percent to 94 percent)
- Providing time for teachers to meet and share ideas (20 percent to 59 percent)

- Encourages teachers to make connections across the disciplines (73 percent to 82 percent).
- Acts as a buffer between teachers and external pressures (67 percent to 76 percent)

Parental Support was reported to be very low by participants in the PCMI program. At the end of the program, zero percent of participants indicated parents volunteer to assist with class activities, and only six percent indicated parents donate money for materials. Further, zero percent of participants reported parents attend parent-teacher conferences. Finally, only six percent of participants agreed parents voice support for STEM instruction.

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. PCMI participants (67 percent) reported positive impressions of the impact of the PD at the end of the program in regards to impact on content knowledge (an increase from 0 percent at baseline). The impact on understanding how students learn was also an area of growth for ETSU (20 percent to 100 percent). Finally, the ability to implement high-quality science/math instructional materials was also an area of growth for participants (38 percent to 100 percent).

FINDINGS FROM CONTENT ASSESSMENT

Twenty-five participants in the PCMI program completed both the pre- and post-assessment that was developed by ETSU program staff. On the pre-test, teacher average percentage was 73 percent correct. This percentage increased to 81 percent on the post-test. This was considered a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGRAM

ETSU's PCMI program specifically addressed the five components of the Core Conceptual Framework (content focus, active participation, duration, coherence, and collective participation) in the grant proposal as part of their planned focus. The PCMI program included 108 hours of programming for 25 teachers of high school chemistry and physics. Program outcomes indicate that PCMI had a significant impact on teacher quality. Specifically, classroom observation data revealed significant changes in the areas of design of the lesson, implementation of the lesson, classroom culture, and science content. ETSU was successful in having all 25 of the 25 projected participants complete the program.

Teacher survey findings were positive. In their self-reports, participants indicated increased use of effective strategies for teaching chemistry and physics (e.g., use of real-world contexts, open-ended questions, evidence to support claims, pre-assessments, homework, and journaling). PCMI teachers reported they felt much more prepared to implement effective science teaching. For example, the use of cooperative groups, inquiry, computers, management, diversity, generating student interest, and developing conceptual understandings of science were all areas participants agreed they were prepared for.

Teacher perceptions of administrative support were positive. Agreement grew across the program regarding principal support of innovative instructional practices, provisions for materials and equipment, and time for collaboration. Parental support was reported as very low. Teachers reported they felt the PD program had great impact on their ability to implement effective science instruction (100 percent agreement) and content knowledge (100 percent agreement) at the end of the program. Overall, this program demonstrated strong gains in teacher quality, teacher attitudes, content knowledge, and perceived preparedness.

Program Narrative
Lipscomb University (LU)
Hutchinson and High, Principal Investigators
Integrating STEM: The Power of Science

PROGRAM SETTING AND PARTICIPANTS

The Lipscomb University Integrating STEM: The Power of Science program (Integrating STEM) was a partnership between chemistry and education faculty to deliver the program to high school chemistry teachers. The 15-month professional development program included 80 contact hours for 10 teacher participants. LU partnered with three LEA's (Metro Nashville Public Schools, Williamson County, and Scott County) for the Integrated STEM program.

The goals of the Integrating STEM project were for teachers to:

1. Recognize, understand, and apply the state science standards in a well as embedded math and engineering as they connect to STEM education.
2. Incorporate activities into their classrooms and laboratories to meet the state science standards and reach all levels of students.
3. Convert cookbook labs and design new labs into inquiry-based labs with appropriate formative assessment instruments.
4. Perform inquiry-based demonstrations that require active student participation.
5. Integrate research based teaching strategies and pedagogy into their teaching.
6. Adapt civic engagement approaches with science content and laboratories.
7. Adapt current social/scientific topics into learning modules to illustrate state standards.
8. Create integrated science labs connecting STEM areas.
9. Apply Web 2.0 and lab simulations effectively in teaching and student learning.
10. Utilize the Sapling Learning programs across biology, physics and chemistry disciplines.

The objectives of the Integrating STEM included the following:

1. The increase the number of teachers equipped to teach STEM courses in high schools.
2. To establish sustainable learning communities (PLCs) through which teachers will gain ongoing professional guidance and support.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The Integrating STEM program aligned with two of the five components of the Core Conceptual framework, with a focus on relevant science **content knowledge** including patterns, cause & effect, scale, systems, energy, matter, structure & function, and stability & change (Next Generation Science Standards topics). It was not clear how these topics aligned with Tennessee standards in the proposal narrative under content focus. In regards to **active learning** the proposal did little to describe the authentic learning environments that teacher participants would experience. In fact, most of the description in the active learning section included the examples instructors would show to participants, so it is difficult to determine how active engagement was achieved. A planned site visit to the program was cancelled by the program as the summer workshop was moved to fall dates.

Coherence did not include a purposeful focus on addressing existing teacher beliefs. According to the proposal, the Integrating STEM team would use the Tennessee standards as the means for generating coherence between the districts and the program, as well as between the program and teachers. This is a superficial strategy that does not engage partners and participants fully in the buy-in of the program.

The **duration** of the program included a planned 96-hours of contact with participants, which is consistent with the framework. It is unclear if these contact hours were achieved with the alternate schedule (removal of summer session). **Collective participation** was not described outside of establishing professional learning communities. It is not clear if this program included the suggested team from each school/district to ensure sustainability of the effort.

FINDINGS FROM OBSERVATIONS

Only four of the 10 total participants submitted videos and could be identified (matching names with evaluation assigned identification numbers) from this program, and of that group, only two provided videos for the evaluation (baseline and mid-year). Overall thirteen participants submitted at least one video. However, none of those participants submitted a baseline and end of year video. As a result, teacher observation analyses are unable to be conducted for this program.

FINDINGS FROM SURVEYS

An examination of the surveys that Integrating STEM participants completed pre/post program revealed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 18 participants who completed the pre-survey and seven who completed the post-survey.

Teacher opinions for the Integrating STEM program were mixed at the end of the program, as some areas of agreement improved and others declined.

Areas of Increased Agreement – in teacher opinions related to the teaching of mathematics:

- Importance of support from colleagues to try out new ideas in teaching mathematics (67 percent to 100 percent)
- Importance of school support by local organizations, institutions (28 percent to 43 percent)
- Importance of developing student's conceptual understanding of mathematics (79 percent to 89 percent)
- Importance of having students work in cooperative learning groups (89 percent to 100 percent)
- Importance of developing students' conceptual understanding of science/math (94 percent to 100 percent)

Areas of Increased Disagreement – Participants experienced a decline in the following areas of this construct:

- Importance of using performance-based assessment (94 percent to 71 percent)
- Importance of project/laboratory/research reports (94 percent to 71 percent)
- Importance of using computers (100 percent to 86 percent)
- Importance of connecting math/science to other disciplines (100 percent to 86 percent)
- Importance of engaging students in applications of science/math in a variety of contexts (94 percent to 86 percent)
- Importance of the use of portfolios (78 percent to 71 percent)

Instructional Influences were a second area of focus in the survey. The Integrating STEM participants reported growth in positive influence of all but two variables in this area at the end of the program.

Encourages Effective Instruction – The following influences were perceived as having more influence on teaching mathematics effectively by the end of the program:

- Access to computers (69 percent to 71 percent)
- Funds for equipment and supplies (38 percent to 57 percent)
- Time to work with other teachers (33 percent to 43 percent)
- Public attitudes toward reform (29 percent to 57 percent)
- Quality of available materials (69 percent to 71 percent)
- System of managing instructional resources at district or school level (21 percent to 43 percent)
- The importance the school places on mathematics/science (47 percent to 57 percent)
- Consistency of science/math reform efforts with other school/district reforms (36 percent to 57 percent)
- Time to plan and prepare lessons (27 percent to 43 percent)

Less Influence on Instruction – The following influences were perceived as having less of an influence on teaching by the end of the program:

- State and/or district testing polices and practices (44 percent to 29 percent)
- Time for professional development (56 percent to 43 percent)

Teacher Preparedness comprised the third construct of the survey. Participants in the Integrating STEM program experienced gains in all areas of preparedness across the program, as indicated by more teachers indicating that they were fairly well or well prepared.

- Providing concrete experiences before abstract concepts (72 percent to 100 percent)
- Developing student conceptual understanding (78 percent to 100 percent)
- Considering students' prior understanding when planning curriculum and instruction (71 percent to 86 percent)
- Making connections between science/mathematics and other disciplines (78 percent to 100 percent)
- Using cooperative learning groups (78 percent to 86 percent)
- Using hands-on activities (89 percent to 100 percent)
- Engaging students in inquiry-oriented activities (67 percent to 100 percent)
- Having students prepare project/laboratory/research reports (78 percent to 100 percent)
- Using computers (88 percent to 100 percent)
- Engaging students in applying science/math in a variety of contexts (67 percent to 100 percent)
- Leading a class using investigative strategies (78 percent to 86 percent)
- Managing a class of students engaged in hands-on/project-based work (83 percent to 86 percent)
- Helping students take responsibility for their own learning (72 percent to 100 percent)
- Using strategies that encourage participation of females and minorities in science/math (65 percent to 71 percent)
- Encouraging students' interest in science/mathematics (89 percent to 100 percent)
- Use informal questioning to assess student learning (89 percent to 100 percent)
- Use portfolios (72 percent to 86 percent)
- Use performance based assessments (67 percent to 100 percent)
- Recognizing and responding to student diversity (67 percent to 86 percent)

Frequency of Use of Instructional Practices consists of teacher-reported frequency of use of specific instructional practices. Integrating STEM program participants reported more frequent use of most strategies at the end of the program:

- Using open-ended questions (83 percent to 86 percent)

- Requiring students to provide evidence to support their claims (56 percent to 100 percent)
- Encouraging students to consider alternative explanations (67 percent to 71 percent)
- Encouraging students to explain concepts to one another (72 percent to 100 percent)
- Helping students see connections between math/science and other disciplines (67 percent to 86 percent)
- Assign science/math homework (72 percent to 86 percent)

Decline in Frequency of Use – Integrating STEM participants did experience some decline in use of the following practices across the program: introducing content through formal presentations (83 percent to 57 percent), arranging seating to facilitate student discussions (67 percent to 43 percent), allowing students to work at their own pace (78 percent to 71 percent), using formative assessments (61 percent to 57 percent), embedding assessment in regular class activities (94 percent to 71 percent), and reading and commenting on student journal reflections (50 percent to 43 percent).

Student Activities are the activities that students are engaged in within the classroom. Integrating STEM participants were asked questions regarding the frequency of use of various student activities. Findings in regards to the frequency of use of effective student activities from baseline to end of program revealed mixed growth in this construct for teachers.

Frequent Use – Participants reported more frequent use for these student activities by end of program:

- Making formal presentations to the class (11 percent to 29 percent)
- Working on models or simulations (33 percent to 86 percent)
- Working on extended mathematics investigations of projects (33 percent to 43 percent)
- Recording, representing, and/or analyzing data (44 percent to 57 percent)
- Writing reflections in a notebook or journal (39 percent to 57 percent)
- Working on portfolios (22 percent to 29 percent)

Decreased Use – More teachers in the Integrating STEM program also reported infrequent use of some student activities that are considered effective practice:

- Working in cooperative learning groups (67 percent to 57 percent)
- Participating in discussions with the teacher to further mathematics understanding (72 percent to 57 percent)
- Sharing student ideas or solve problems with each other in small groups (67 percent to 57 percent)
- Participating in student-led discussions (44 percent to 29 percent)
- Designing or implementing his or her own investigation (53 percent to 43 percent)
- Participating in field work (17 percent to 14 percent)

- Share ideas or solve problems with each other in small groups (67 percent to 57 percent)

Principal Perceptions are the impressions that participants have about their administrator's perceptions of the teaching and learning of science/math. Participants in the Integrating STEM program had positive views on support from their leadership from baseline to end of program.

Areas of Increased Agreement – Participants in this program agreed they received encouragement and/or support in the following areas:

- Encouraging innovative instructional practices (83 percent to 86 percent)
- Providing time for teachers to meet and share ideas (56 percent to 71 percent)
- Encouraging teachers to make connections across disciplines (67 percent to 86 percent)
- Acting as a buffer between teachers and external pressures (67 percent to 71 percent)

Areas of Decreased Agreement – Participants in this program decreased in agreement regarding the encouragement and/or support received from their principal in the following areas:

- Encouraging selection of science/mathematics content and instructional strategies to address individual students' learning (67 percent to 57 percent)
- Encouraging the implementation of current national standards in science/math education (78 percent to 71 percent)
- Providing materials/equipment for science/math (61 percent to 57 percent)
- Encouraging me to observe exemplary science/mathematics teachers (67 percent to 57 percent)
- Accepting the noise that comes with an active classroom (89 percent to 86 percent)

Parental Support was reported by participants in the Integrating STEM program to have increased across the program in all but one area. Areas of growth included parents donating money or materials (43 percent), parents voicing support for various instructional strategies (43 percent), and attending parent-teacher conferences (43 percent), and/or PTA or math/science nights (17 percent). One are of zero agreement was the item focused on most parents volunteering to assist with class activities.

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. Integrating STEM participants reported positive impressions of the impact of the PD at the end of the program in regards to impact on content knowledge (50 percent), as well as the impact on understanding how students learn (40 percent), and ability to implement high-quality science/math instructional materials (67 percent).

FINDINGS FROM CONTENT ASSESSMENT

The Integrating STEM program did not submit complete content knowledge assessments for analysis and therefore could not be included in this part of the evaluation of the THEC STEM PD program. We received only data from two participants at one point in the program (uploaded as PDF's) and it is unclear whether these are pre or post as well.

CONCLUDING OBSERVATIONS FOR PROGRAM

The concluding observations from the Integrating STEM program are limited due to the fact that the program did not provide sufficient teacher observation and content assessment data for the evaluation. The teacher survey data revealed mixed findings with improved attitudes and preparedness in some areas, but declines in most constructs as well. Only 10 of the projected 25 participants completed the LU program.

Program Narrative
Lipscomb University (LU)
Nelson and Thornthwaite, Principal Investigators
The Function of Algebra (FOA)

PROGRAM SETTING AND PARTICIPANTS

The Functions of Algebra (FOA) program at Lipscomb University was a partnership between the College of Arts & Sciences and the College of Education to deliver a 16-month intensive professional development program for 20 teachers of high school mathematics. LU partnered with 4 LEA's (Metro Nashville Public Schools, Robertson County, Sumner County, Scott County) for this program. A summer academy conducted, along with two Saturday sessions, and virtual follow-up for a total of 82 contact hours of instruction.

The goals of this project included enabling participants to:

1. Teach the state Common Core State Standards in algebra.
2. Raise student performance on Gateway/End of Course and ACT tests.
3. Generate student enthusiasm for mathematics.

The objectives of the Functions of Algebra program were:

1. Participants will have an understanding of algebraic functions and their applications.
2. Participants will have knowledge of current pedagogical techniques.
3. Participants will have hands-on activities for use in the classroom.
4. Participants will have appropriate technological skills for teaching algebra.
5. Participants will have hands-on experiences of the applications of algebraic functions.
6. Participants will have knowledge of problem solving techniques used in algebra.
7. Participants will have ideas for overcoming math anxiety.
8. Participants will have access to an online community of educators for collaboration.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The FOA program aligned four of the five components of the Core Conceptual framework, with a focus on mathematics **content knowledge** delivered an integrated approach that provided real-world connections to biology, physics, and engineering as participants were engaged in the work of STEM professionals and their research. The specific mathematics content was algebraic functions.

Active learning was a focus for the FOA project and copies of activities were included in the application. Participants experienced hands-on activities used to deepen understanding, develop problem-solving techniques, and model applications. At least 80 percent of activities were to be focused on active learning experiences. **Coherence** was achieved through program activities that were structured to include a purposeful focus on addressing existing teacher beliefs. However, the proposal did not discuss how FOA sought buy-in and alignment with partnering districts. The **duration** of the program included 80-hours of contact with participants, which is consistent with the framework. This was achieved across a sustained, 16-month period that included a summer academy and Saturday meetings. **Collective participation** was ensured through recruiting at least two high school mathematics teachers from each district.

FINDINGS FROM OBSERVATIONS

The submission rate for teacher-provided videos of their teaching for the FOA program included 23 participants who submitted at least one video. However, only 10 of the completing group of 20 teachers submitted all three required videos, and this is the group that was examined for impact of the program on their instructional practice. Overall, results indicate significant growth in all of the four constructs (e.g., design of lesson, implementation of lesson, classroom culture, and mathematics content) related to desired change in teacher practice and content knowledge across the program.

At baseline, the FOA program participants were characterized as "elements of effective instruction" on the design of lesson construct (score of 2.37) increasing significantly by the end of program (2.95). The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

The FOA program participants began the program with an implementation of lesson at a score of 2.72 ("elements of effective instruction") and improved this mean score to 3.27 ("beginning stages of effective instruction") by the end of program. The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

Teachers in the FOA program began with content knowledge rated at a score of 2.95 ("elements of effective instruction"). Again, teachers made significant improvements across the program realizing an improved mean score of 3.79 ("beginning stages of effective instruction") by the end of the program. This means that most of the time during observations, mathematics content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Participants did not incorporate abstraction, theory building, and connections to other disciplines in observed lessons.

Classroom culture is the final area of significant growth for FOA participants. At baseline, the mean score for teachers in the program was 2.88 ("elements of effective instruction"), which grew to an improved mean of 3.57 ("beginning stages of effective instruction") at the end of the program. Implementation of strategies, including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor, were not evident through observations. Active

participation of all students was not observed as being encouraged and respected in a consistent manner.

FINDINGS FROM SURVEYS

An examination of the surveys that participants completed pre/post program revealed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 20 participants who completed the pre-survey and 20 who completed the post-survey.

Teacher opinions were mixed at the end of the FOA program as compared to the baseline, prior to participation in the program.

Areas of Increased Agreement in teacher opinions included the following:

- Teachers in the school share a common vision of effective science/math instruction (58 percent to 65 percent)
- Teachers were well supplied with materials for mathematics (38 percent to 45 percent)
- Importance of having students participate in hands-on activities (83 percent to 95 percent)
- Importance of having students engaged in inquiry-oriented activities (75 percent to 85 percent)
- Importance of using computers (58 percent to 70 percent)
- Importance of informal questioning to assess student understanding (96 percent to 100 percent).
- Importance of using portfolios (38 percent to 40 percent)
- Importance of engaging students in applications of science/math in a variety of contexts (88 percent to 95 percent)

Areas of Increased Disagreement in teacher opinions were the following:

- Importance of time to collaborate with peers (67 percent to 69 percent) Importance of connecting math/science to other disciplines (92 percent to 84 percent)
- Importance of using performance-based assessment (92 percent to 70 percent)
- Importance of having students prepare project/laboratory/research reports (54 percent to 50 percent)

Instructional Influences were a second area of focus in the survey. The FOA participants reported mixed experiences with variables in this area at the end of the program.

Encourages Effective Instruction – The following influences were perceived as having a more influence on teaching mathematics by the end of the program:

- State and/or district testing polices and practices (14 percent to 25 percent)
- Access to computers (38 percent to 58 percent)
- Funds for equipment and supplies (22 percent to 37 percent)
- System of managing instructional resources at the district/school level (15 percent to 20 percent)
- Time to plan and prepare lessons (35 percent to 45 percent)
- Time available for teachers to work with other teachers (41 percent to 45 percent)
- The importance the school places on mathematics/science (57 percent to 60 percent)

Less Influence on Instruction – The following influences were perceived as having less of an influence on teaching by the end of the program:

- Consistency of science/math reform efforts with other school/district reforms (38 percent to 10 percent)
- Quality of available materials (58 percent to 50 percent)
- Time for professional development (35 percent to 30 percent)
- Public attitudes toward reform (21 percent to 10 percent)

Teacher Preparedness comprised the third construct of the survey. Participants in the FOA program experienced gains in all areas of preparedness across the program, as indicated by more teachers agreeing that they were fairly well or well prepared.

- Providing concrete experiences before abstract concepts (46 percent to 53 percent)
- Developing student conceptual understanding (75 percent to 85 percent)
- Making connections between science/math and other disciplines (54 percent to 70 percent)
- Using cooperative learning groups (71 percent to 75 percent)
- Using hands-on activities (46 percent to 80 percent)
- Engaging students in inquiry-oriented activities (33 percent to 65 percent)
- Having students prepare project/laboratory/research reports (33 percent to 50 percent)
- Using computers (63 percent to 70 percent)
- Engaging students in applying science/math in a variety of contexts (58 percent to 75 percent)
- Using performance based assessments (63 percent to 70 percent)
- Leading a class using investigative strategies (50 percent to 70 percent)
- Managing students engaged in hands-on/project-based work (63 percent to 75 percent)

- Helping students take responsibility for their own learning (70 percent to 75 percent)
- Recognizing and responding to student diversity (70 percent to 75 percent)
- Encouraging students' interest in science/math (67 percent to 75 percent)
- Using strategies that encourage participation of females and minorities in science/math (46 percent to 65 percent)

Frequency of Use of Instructional Practices consists of teacher-reported frequency of use of specific instructional practices. FOA program participants reported more frequent use of all strategies at the end of the program:

- Arranging seating to facilitate student discussion (58 percent to 74 percent)
- Using open-ended questions (92 percent to 95 percent)
- Requiring students to use evidence to support their claims (24 percent to 36 percent)
- Encouraging students to explain concepts to one another (88 percent to 95 percent)
- Assigning science/math homework (79 percent to 95 percent)
- Demonstration of a science/math principle or phenomenon (40 percent to 58 percent)
- Arranging seating to facilitate student discussion (77 percent to 92 percent)
- Encouraging students to explain concepts to one another (80 percent to 92 percent)
- Encouraging students to consider alternative explanations (83 percent to 95 percent)
- Allowing students to work at their own pace (63 percent to 70 percent)
- Embedding assessments in regular class activities (75 percent to 95 percent)
- Helping students see connections between math/science and other disciplines (54 percent to 70 percent)

Areas of Increased Disagreement in teacher opinions were the following:

- Introducing content through formal presentations (87 percent to 74 percent)
- Using assessment to find out what student know before or during a unit (63 percent to 60 percent)
- Reading and commenting on student reflections in journals (39 percent to 30 percent)

Student Activities are the activities that students are engaged in within the classroom. Participants were asked questions regarding the frequency of use of various student activities. Findings in regards to the frequency of use of effective student activities from baseline to end of program revealed mixed findings for this construct.

Frequent Use – Participants reported more frequent use for some student activities from beginning to end of program:

- Participating in student-led discussions (50 percent to 60 percent)
- Participating in discussions with the teacher to further understanding (63 percent to 75 percent)
- Working in cooperative learning groups (67 percent to 75 percent)
- Making formal presentations to the class (17 percent to 20 percent)
- Reading other (non-textbook) science/math related materials in class (17 percent to 20 percent)
- Sharing ideas or solve problems with each other in small groups (54 percent to 75 percent)
- Following specific instructions in an activity or investigation (54 percent to 65 percent)
- Writing reflections in a notebook or journal (21 percent to 30 percent)
- Participating in field work (13 percent to 15 percent)
- Recording, representing, and/or analyzing data (17 percent to 25 percent)
- Working on portfolios (3 percent to 15 percent)
- Taking tests requiring open-ended responses (30 percent to 46 percent)

Decreased Use – More teachers in the FOA program also reported infrequent use of some student activities that are considered effective practice:

- Working on models or simulations (22 percent to 20 percent)
- Working on extended science/math investigations or projects that are a week or more in duration (22 percent to 15 percent)
- Working on solving real-world problems (79 percent to 75 percent)

Principal Perceptions are the impressions that participants have about their administrator's perceptions of the teaching and learning of science/math. Participants in the FOA program had very positive views on support from their leadership.

Areas of Increased Agreement – Teachers agreed their principal provided encouragement and/or support in the following areas:

- Encouraging selection of science/math content and instructional strategies to address individual students' learning (83 percent to 85 percent)
- Providing materials/equipment for science/math (58 percent to 65 percent)
- Providing time for teachers to meet and share ideas (79 percent to 80 percent)
- Encouraging teachers to make connections across disciplines (71 percent to 75 percent)

Areas of Increased Disagreement – More teachers expressed disagreement that their principals provided encouragement and/or support in the following areas across the program:

- Accepting the noise that comes with an active classroom (96 percent to 90 percent)
- Encouraging the implementation of current national standards in science/math education (92 percent to 80 percent)
- Encouraging innovative instructional practices (100 percent to 85 percent)
- Acting as a buffer between teachers and external pressures (67 percent to 60 percent)

Parental Support was reported to be very low by participants in the FOA program. One hundred percent of participants indicated that few parents volunteer to assist with class activities, only five percent indicated parents donate money for materials, and only 16 percent agreed parents attend PTA or math/science nights.

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. FOA participants reported positive impressions of the impact of the PD at the end of the program than at baseline. Impact on content knowledge increased from 20 percent to 33 percent, impact on understanding how students learn rose from 37 percent to 46 percent, and ability to implement high-quality science/math instructional materials increased from 17 percent to 60 percent.

FINDINGS FROM CONTENT ASSESSMENT

Twenty participants in the FOA program completed both the pre- and post-assessment that was developed by Lipscomb staff. On the pre-test, teacher average percentage was 62 percent correct. This percentage increased to 69 percent on the post-test. This was considered a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGRAM

The FOA professional development program specifically addressed four of the five components of the Core Conceptual Framework (content focus, active learning, duration, and collective participation) in the grant proposal as part of their planned focus. Program outcomes indicate that the FOA intervention had positive impact on some aspects of teacher quality (e.g., ability to implement the lessons, classroom culture, and math content knowledge). FOA was successful in having 20 of the 25 projected participants complete the program.

Teacher survey findings were mostly positive for FOA. In their self-reports, participants indicated increased use of most effective strategies for teaching mathematics. However, the use of writing tools and applying knowledge (portfolios, open-ended assessments, real-world contexts) decreased across the program. FOA participants felt much more prepared to implement effective mathematics teaching in their self-reports. For example, the use of cooperative groups, inquiry, computers, management, diversity, generating student interest, and developing conceptual understandings were all areas more participants reported feeling prepared to use.

Instructional influences that teachers felt were more important across the program relating to effective teaching of mathematics included items focused on collaboration (e.g. time for planning with others.

Teacher perceptions of administrative support were very positive, except for a couple of areas including support for innovative practices. Parental support was reported as very little. In regards to participant impressions of the PD program as 60 percent reported their ability to implement effective science instruction had increased across the program. Overall, this program demonstrated significant gains in teacher quality, content knowledge, and in some areas of attitudes and perceived preparedness.

Program Narrative
Lipscomb University (LU)
Wells, Morel, and Nelson, Principal Investigators
Making Mathematics Matter (MMM)

PROGRAM SETTING AND PARTICIPANTS

The Lipscomb University Making Mathematics Matter (MMM) program was a partnership between LU Arts and Sciences and Education Faculty and three LEAs (Metro Nashville Public Schools, Robertson County, and Sumner County). The program was designed to deliver a 12-month intensive professional development program for 20 teachers of grades 4-7 mathematics. An eight-day summer institute was completed, along with Saturday sessions and online support, for a total of 90-hours of professional development programming.

The goals of the MMM program included:

1. Participants will experience problem-based learning as both student and teacher and will implement this inquiry method in their own classroom.
2. Participants will demonstrate improved understanding and knowledge of the state math standards and embedded inquiry and technology/engineering standards in grades 4-7.
3. Participants will improve their understanding and use of mathematical models to solve real world problems.
4. Participants will connect their teaching of math and science to the need for career preparation of students in the health care and disease prevention fields.
5. Participants will experience effective professional collaboration through professional learning communities, peer coaching, and social media and will sustain this professional collaboration after the training is concluded. Training in effective collaborative protocols will be provided.
6. Participants will create units of study that will be shared with other teachers across the state.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The MMM program aligned with the Core Conceptual framework in all five areas, detailed in the program proposal. First, MMM focused on mathematics **content knowledge**, aligned with the Common Core States Standards for Mathematics. Specific focus included statistics, geometry, and infectious diseases, in the context of using mathematical modeling and problem-based learning.

Active learning was a focus of at least 80 percent of activities, including engaging participants in facilitated model lessons where the teachers play the role of the learner first, then plan and deliver their own lessons. **Coherence** focused on addressing teacher beliefs and alignment with appropriate content standards for the state to ensure coherence with district curriculum. The **duration** of the program included 90-hours of contact extended across a 12-month period with participants, which is consistent with the framework. **Collective participation** was achieved by including two teachers from each participating school.

The MMM program had 24 teachers who were observed at least once. However, only 10 of the 20 teachers who completed the program submitted all three required videos, and this is the group that was examined for impact of the program on their instructional practice. Overall, results indicated significant growth on the four constructs (implementation of lesson, classroom culture, and mathematics content) related to desired change in teacher practice and content knowledge across the program.

The MMM program participants were characterized as delivering "elements of effective instruction" (score of 2.22) on the design of lesson at baseline. Observations at the end of the program revealed significant growth to 2.76 ("elements of effective instruction"). The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery. Though this was slight improvement, it was not deemed to be statistically significant.

The implementation of lesson rating grew significantly for participants overall across the program. At baseline MMM teachers received a 2.62 ("elements of effective instruction") but improved to a score of 3.15 ("beginning stages of effective instruction") by end of program. The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

MMM teachers at baseline received a score for content knowledge of 2.89 ("elements of effective instruction"). By the end of the program, MMM participants had experienced significant growth (3.41, "beginning stages of effective instruction"). This means that during observations, mathematics content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Participants also incorporated some abstraction, theory building, and connections to other disciplines in observed lessons.

Classroom culture was another area of significant growth for the MMM teachers. The overall group began at 2.81 ("elements of effective instruction"). However, by the end of the program, MMM participants had improved considerably and gained a score of 3.54 ("beginning stages of effective instruction"). Implementation of strategies, including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor, were evident through most observations. All students were actively engaged in meaningful learning that respected ideas consistently in classroom observations conducted at the end of the program.

FINDINGS FROM SURVEYS

An examination of the surveys that participants completed in a pre/post manner revealed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 20 participants who completed the pre-survey and 20 who completed the post-survey.

Teacher opinions regarding the importance of use of effective instructional strategies and support necessary to be successful are included in this section of the survey. The MMM participants had mixed levels of agreement in this construct area.

Areas of Increased Agreement in teacher opinions related to the teaching of mathematics:

- Teachers feel supported by colleagues to try out new ideas (81 percent to 95 percent)
- Importance of having prepare project/laboratory/research reports (52 percent to 70 percent)
- Importance of use of portfolios (37 percent to 45 percent)
- Importance of making connections between science/math and other disciplines (89 percent to 95 percent)

Areas of Decreased Agreement – in teacher opinions related to the teaching of mathematics: participants reported increased disagreement with the following items related to the teaching of mathematics.

- Importance of developing students' conceptual understanding of mathematics (100 percent to 95 percent)
- Importance of considering students' prior understandings when planning curriculum and instruction (100 percent to 90 percent)
- Importance of use of cooperative learning groups (96 percent to 85 percent)
- Importance of use of hands-on activities (93 percent to 90 percent)
- Importance of engaging students in applications of mathematics in variety of contexts (100 percent to 95 percent)
- Importance of use of performance based assessment (93 percent to 80 percent)
- Importance of use of informal questioning (96 percent to 90 percent)

Instructional Influences were a second area of focus in the survey. The MMM participants reported mixed findings in regards to influences that encourage effective instruction. The following influences were perceived as having more influence on the teaching mathematics effectively by the end of the program:

- State and/or district curriculum frameworks (46 percent to 55 percent)
- Management of instructional resources at the district/school level (23 percent to 47 percent)

- Time available for teacher professional development (38 percent to 63 percent)
- Public attitudes toward reform (24 percent to 31 percent)

Less Influence on Instruction – The following influences were perceived as having less of an influence on teaching by the end of the program:

- State and/or district testing policies (38 percent to 30 percent)
- Access to computers for mathematics instruction (63 percent to 50 percent)
- Funds for purchasing equipment and supplies for science/math (73 percent to 33 percent)
- Time available for teachers to plan and prepare lessons (58 percent to 50 percent)
- Importance that school places on science/math (81 percent to 72 percent)

Teacher Preparedness comprised the third construct of the survey. MMM program participants experienced growth in perceptions of preparation to deliver effective mathematics instruction in all areas but one of this construct. Teachers who participated in the program reported being better prepared in the following areas:

- Providing concrete experiences before abstract concepts (74 percent to 90 percent)
- Developing student conceptual understanding (85 percent to 90 percent)
- Considering prior understanding when planning curriculum & instruction (78 percent to 95 percent)
- Making connections between science/math and other disciplines (63 percent to 85 percent)
- Using hands-on activities (74 percent to 95 percent)
- Engaging students in inquiry-oriented activities (59 percent to 80 percent)
- Having students prepare project/laboratory/research reports (33 percent to 60 percent)
- Using computers (81 percent to 85 percent)
- Engaging students in applying science/math in a variety of contexts (59 percent to 90 percent)
- Using performance based assessments (69 percent to 85 percent)
- Using portfolios (22 percent to 50 percent)
- Using informal questioning to assess student understanding (78 percent to 95 percent)
- Leading a class using investigative strategies (63 percent to 75 percent)
- Managing students engaged in hands-on/project-based work (67 percent to 75 percent)
- Encouraging students' interest in science/math (78 percent to 85 percent)
- Using strategies that encourage participation of females and minorities in science/math (52 percent to 80 percent)
- Helping students take responsibility for their own learning (67 percent to 95 percent)

Areas of Decreased Agreement – in teacher opinions related to the their perceived preparedness for teaching mathematics included just one area, recognizing and responding to diversity (81 percent to 75 percent).

Frequency of Use of Instructional Practices consists of MMM teacher reported mixed frequency of use of specific instructional practices.

Increased Use – There were several practices for which more participants reported more frequent use from baseline to end of the program. These practices included:

- Arranging seating to facilitate student discussion (85 percent to 90 percent)
- Requiring students to use evidence to support their claims (85 percent to 95 percent)
- Helping students see connections between mathematics and other disciplines (48 percent to 80 percent)
- Reading and commenting on student reflections in journals
- (22 percent to 35 percent)
- Embedding assessment in regular class activities (70 percent to 90 percent)

Decreased Use – More participants reported more infrequent use of two practices from baseline to end of the program:

- Using open-ended questions (89 percent to 85 percent)
- Encouraging students to consider alternative explanations (89 percent to 85 percent)
- Allowing students to work at their own pace (85 percent to 80 percent)
- Using pre-assessments (81 percent to 75 percent)

Student Activities are the activities that students are engaged in within the classroom. MMM participants were asked questions regarding the frequency of use of various student activities and reported growth of use of most activities across the duration of the program. More participants reported frequent use for these student activities from baseline to end of program:

- Participating in discussions with the teacher to further understanding (74 percent to 95 percent)
- Making formal presentations to the class (22 percent to 30 percent)
- Reading other (non-textbook) mathematics related materials in class
- (22 percent to 35 percent)
- Sharing ideas or solving problems with each other in small groups (81 percent to 85 percent)
- Designing or implement their own investigation (19 percent to 25 percent)
- Following specific instructions in an activity or investigation (41 percent to 65 percent)

- Working on models or simulations (22 percent to 30 percent)
- Working on extended mathematics investigations or projects (15 percent to 25 percent)
- Participating in field work (11 percent to 25 percent)
- Recording, representing, and/or analyzing data (15 percent to 30 percent)
- Working on portfolios (12 percent to 20 percent)
- Taking tests requiring open-ended responses (41 percent to 65 percent)
- Taking short-answer tests (44 percent to 55 percent)

Infrequent Use – Teachers in the program also reported decreased use of some student activities that are considered effective practice. Teachers reported infrequent use of the following student activities from baseline to end of program:

- Writing reflections in a notebook or journal (42 percent to 30 percent)
- Working on solving real-world problem (89 percent to 70 percent)

Principal Perceptions are the impressions that participants have about their administrator's perceptions of the teaching and learning of science/math. MMM participants revealed growth in positive feelings regarding this construct in two areas by the end of the program:

- Providing time for teachers to meet and share ideas (63 percent to 80 percent)
- Encourages teachers to observe exemplary math/science faculty (37 percent to 65 percent)

The areas of decline in agreement with regards to principal support for the MMM program across the duration of the project were:

- Accepting the noise that comes with an active classroom (93 percent to 75 percent)
- Encourages selection of science/math content and instructional strategies to address individual students' learning (93 percent to 80 percent)
- Encourages innovative instructional practice (85 percent to 80 percent)
- Providing materials/equipment for science/math (74 percent to 65 percent)
- Encouraging teachers to make connections across disciplines (89 percent to 75 percent)

Parental Support was reported to be very low by participants in the MMM program. All of the participants indicated (100 percent) that few parents volunteer to assist with class activities, donate money for materials (20 percent), and few attend parent-teacher conferences (45 percent) or PTA or math/science nights (15 percent).

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. MMM participants were positive regarding the impact the program had on their content knowledge (57 percent) and 60 percent thought the PD had increased ability to implement high-quality mathematics instructional

materials. However, only 50 percent thought their understanding of how children think about mathematics had been increased as a result of participation in the MMM program.

FINDINGS FROM CONTENT ASSESSMENT

Twenty participants in the MMM program completed both the pre- and post-assessment that was developed by Lipscomb program staff. On the pre-test, teacher average percentage was 46 percent correct. This percentage increased to 60 percent on the post-test. This was considered a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGRAM

The MMM program implemented a mathematics professional development program for teachers in middle school that included a focus on the integration of mathematics skills and content with science concepts, mainly infectious disease, and the use of problem-based learning as a pedagogical focus. Participants worked collaboratively with project staff to develop new lessons for use in their own classrooms. The MMM professional development program was designed to include the five criteria in the Core Conceptual Framework (content focus, active participation, duration, coherence, and collective participation). MMM was successful in having 20 of the 25 projected participants complete the program.

In respect to classroom observation data, MMM teachers experienced significant gains all four domains (design, implementation, content, and classroom culture) across the program. Teachers in this program reported implementation of investigative mathematics instructional strategies, including those that require a high level of ability to facilitate student scientific discourse (e.g., integration collaboration). Some teachers reported decreased use of investigative strategies that should be aligned with those previously mentioned (e.g., open-ended assessments, alternative explanations, pre-assessments). Student activities increased overall, with decline of use of journaling and real-world contexts for learning.

MMM teachers reported more support from principals in providing time for collaboration and encouragement to observe other effective teachers. There was a decrease across the program in the perceived support from principals for innovative instruction, however. Reported PD experiences affirmed that 57 percent of teachers felt their content knowledge was positively impacted. Further, program developed assessments and classroom observational data also demonstrated growth in content knowledge as well. Parental support reported was very low. Overall, this program demonstrated significant gains in teacher quality, teacher content knowledge, and on most key areas of teacher attitudes (including importance, use, and preparation) aligned with the program.

Program Narrative
Middle Tennessee State University (MTSU)
Kimmins and Winters, Principal Investigators
UC STEM

PROGRAM SETTING AND PARTICIPANTS

The Project UC STEM: Understanding and Connecting STEM program was a partnership between Mathematical Sciences and Elementary & Special Education at MTSU to deliver a grade 4-8 mathematics and science focused program. The professional development program included 91 contact hours for 25 teacher participants from grades 4-8. MTSU partnered with five LEA's (Bedford County, Cannon County, Coffee County, DeKalb County, and Grundy County) for this program. UC STEM included a sustained duration of 18 months that was comprised of 13 days of face-to-face instruction (10 days in summer total and one PD day each semester – 3).

The goals of the UC STEM project included to:

1. Improve teachers' mathematical and scientific content knowledge.
2. Enhance teachers' instructional effectiveness in their focus area (science or mathematics).
3. Increase teachers' disposition toward and ability to integrate all four STEM disciplines into their instruction.

The objectives of the UC STEM program included the following:

1. The average participant's performance on a content knowledge exam will improve significantly from pre-project to post-project.
2. All teachers will implement and document their use of at least three different instructional strategies modeled during the UC STEM PD (e.g. Conceptual Change Model of Instruction, CRA Model of Instruction, Inquiry Challenge, Socratic Seminar, Learning Circus, Fact-Finding Mission).
3. Each teacher will participate in eleven AIMS Lego DACT activities during the UC STEM PD and will implement at least three in their classroom.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The proposed UC STEM program aligned with the five components of the Core Conceptual framework, with a focus on mathematics and science **content knowledge** delivered through integration of the disciplines using AIMS, Lego DACTA, and other activities. The content focus included measurement, estimation, proportional reasoning, geometry, simple machines, motion, and energy. **Active learning** was a focus, including the use of whole group, small group, and other

formats where teachers actively reconstructed their knowledge through engagement in grade-level appropriate activities where the teacher is immersed in STEM pedagogy.

Coherence was addressed through a intentional focus on teacher beliefs and alignment with appropriate state content standards. The **duration** of the program included 91-hours of contact with participants, which is consistent with the framework. This was achieved through two, five-day summer institutes, combined with three full follow-up days. **Collective participation** was achieved through the recruitment of teams of two teachers (one math and one science) from each participating school.

FINDINGS FROM OBSERVATIONS

The submission rate for teacher-provided videos for the UC STEM program was good and included 15 of the 25 participants who completed the program that submitted all three videos. There were 27 participants who submitted at least one video. Overall, results showed significant growth in all four constructs (e.g., design of lesson, implementation of lesson, classroom culture, and mathematics content) related to desired change in teacher practice and content knowledge across the program.

At baseline, the UC STEM program participants were characterized as being at the "elements of effective instruction" stage on the design of lesson construct (score of 2.68), increasing significantly, by the end of program (2.84). The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

The UC STEM program participants began the program with an implementation of lesson score of 2.90 ("elements of effective instruction") and improved this slightly to 3.32 ("beginning stages of effective instruction") by the end of program. The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

Teachers in the UC STEM program began the program with a content knowledge overall mean score of 3.08 ("beginning stages of effective instruction"). Again, teachers made significant improvement across the program, realizing an improved mean score of 3.67 ("beginning stages of effective instruction"). This means that during observations, mathematics content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Participants incorporated abstraction, theory building, and connections to other disciplines in observed lessons.

Classroom culture was the final area without significant improvement for UC STEM participants. At baseline, the mean score for teachers in the program was 3.17, which grew significantly to a mean of 3.88 ("beginning stages of effective instruction") by the end of the program. Implementation of strategies, including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor, were not evident through observations. Active participation of all students was observed as being encouraged and respected in a consistent manner.

FINDINGS FROM SURVEYS

An examination of pre/post survey data for UC STEM participants revealed mixed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 25 participants who completed the pre-survey and 24 who completed the post-survey.

Teacher opinions for UC STEM participants demonstrated both growth and decline in various areas of the construct.

Areas of Increased Agreement – More teachers agreed with the following items after the program:

- Teachers have necessary supplies and/materials for mathematics (46 percent to 71 percent)
- Importance of having students prepare project/laboratory/research reports (68 percent to 79 percent)
- Importance of having students use computers (79 percent to 91 percent) Teachers in the school share a common vision of effective science/math instruction (25 percent to 33 percent)
- Importance of having students participate in appropriate hands-on activities (96 percent to 100 percent)
- Importance of having students participate in inquiry-oriented activities (93 percent to 96 percent)
- Importance of using portfolios (46 percent to 54 percent)

Areas of Increased Disagreement – Fewer teachers agreed with the following items after the program:

- Importance of connecting math/science to other disciplines (93 percent to 88 percent)
- Importance of using performance-based assessment (89 percent to 75 percent)
- The school mathematics program is supported by local organizations, institutions (41 percent to 39 percent)

Instructional Influences were a second area of focus in the survey. The UC STEM participants reported less influence of external variables on instruction area at the end of the program.

More Influence on Effective Instruction – The following influences were perceived as having a more influence on teaching effectively by the end of the program:

- State and/or district curriculum frameworks (38 percent to 41 percent)
- System of managing instructional resources at district or school level (23 percent to 36 percent)
- Public attitudes toward reform (10 percent to 16 percent)
- Quality of available materials (46 percent to 48 percent)

- Importance of mathematics/science within the school (61 percent to 58 percent)
- Consistency of science/math reform efforts with other school/district reforms (50 percent to 57 percent)

Less Influence on Effective Instruction – The following influences were perceived as having a more negative relationship on teaching mathematics effectively by the end of the program:

- State and/or district testing polices and practices (24 percent to 19 percent)
- Access to computers (46 percent to 33 percent)
- Funds for equipment and supplies (30 percent to 22 percent)
- Time to work with other teachers (36 percent to 29 percent)
- Time for professional development (54 percent to 33 percent)

Teacher Preparedness comprised the third construct of the survey. Participants in the UC STEM program experienced gains in all areas of perceived preparedness across the program, as indicated by a greater percentage of teachers indicating that they were fairly well or well prepared in the following construct areas:

- Providing concrete experiences before abstract concepts (79 percent to 96 percent)
- Developing student conceptual understanding (86 percent to 96 percent)
- Taking student prior understanding into consideration when planning curriculum and instruction (82 percent to 88 percent)
- Making connections between science/math and other disciplines (61 percent to 96 percent)
- Using cooperative learning groups (75 percent to 92 percent)
- Having students participate in appropriate hands-on activities (68 percent to 92 percent)
- Engaging students in inquiry-oriented activities (46 percent to 79 percent)
- Having students prepare project/laboratory/research reports (22 percent to 58 percent)
- Using computers (68 percent to 75 percent)
- Engaging students in applying science/math in a variety of contexts (57 percent to 88 percent)
- Using performance based assessments (57 percent to 83 percent)
- Using portfolios (7 percent to 35 percent)
- Using informal questioning to assess student learning (79 percent to 92 percent)
- Leading a class using investigative strategies (46 percent to 92 percent)
- Managing a class of students engaged in hands-on/project-based work (75 percent to 100 percent)
- Helping students take responsibility for their own learning (71 percent to 92 percent)
- Recognizing and responding to student diversity (75 percent to 92 percent)
- Encouraging students' interest in science/math (86 percent to 96 percent)

- Using strategies that encourage participation of females and minorities in science/math (39 percent to 58 percent)

Frequency of Use of Instructional Practices consists of teacher-reported frequency of use of specific instructional practices. UC STEM program participants reported more frequent use of most strategies by the end of the program:

- Arranging seating to facilitate student discussion (68 percent to 75 percent)
- Using open-ended questions (75 percent to 91 percent)
- Requiring students to supply evidence to support their claims (79 percent to 92 percent)
- Encouraging students to explain concepts to one another (79 percent to 83 percent)
- Helping students see connections between math/science and other disciplines (79 percent to 83 percent)
- Embedding assessment in regular class activities (71 percent to 79 percent)
- Reading and commenting on student reflections in notebooks/journals (14 percent to 39 percent)

The two areas of decline for the UC STEM program in use of instructional practices were in using pre-assessments (57 percent to 46 percent) and assigning science/math homework (71 percent to 67 percent).

Student Activities are the activities that students are engaged in within the classroom. UC STEM participants were asked questions regarding the frequency of use of various student activities. Findings in regards to the frequency of use of effective student activities from baseline to end of program revealed an increase of use of strategies in most of the areas of this construct.

Frequent Use – Participants reported more frequent use for these student activities by end of the program:

- Participating in student-led discussions (52 percent to 67 percent)
- Participating in discussions with the teacher to further understanding (79 percent to 92 percent)
- Making formal presentations to the class (14 percent to 38 percent)
- Reading other (non-textbook) science/math related materials in class (14 percent to 54 percent)
- Working on solving a real-world problem (57 percent to 63 percent)
- Engaging in hands-on science/math activities (55 percent to 72 percent)
- Following specific instructions in an activity or investigation (54 percent to 67 percent)
- Designing or implementing his or her own investigation (14 percent to 17 percent)
- Working on models or simulations (14 percent to 29 percent)

- Working on extended science/math investigations or projects (4 percent to 21 percent)
- Writing reflections in a notebook or journal (19 percent to 42 percent)
- Working on portfolios (0 percent to 8 percent)
- Taking tests requiring open-ended responses (36 percent to 86 percent)
- Working in cooperative learning groups (79 percent to 83 percent)
- Sharing student ideas or solve problems with each other in small groups (57 percent to 63 percent)

Decreased Use – More teachers reported less frequent use of some effective student activities by the end of the program:

- Recording, representing, and/or analyzing data (26 percent to 22 percent)
- Taking short-answer tests (54 percent to 40 percent)
- Taking tests requiring open-ended items (43 percent to 38 percent)

Principal Perceptions are the impressions that participants have about their administrator's support for the teaching and learning of science/mathematics. Participants in the UC STEM program had very positive views of their leadership, which increased across the program in all areas.

- Encouraging selection of science/math content and instructional strategies to address individual students' learning (75 percent to 83 percent)
- Accepts the noise that comes with an active classroom (92 percent to 93 percent)
- Encouraging the implementation of current national standards in science/math education (75 percent to 79 percent)
- Encourages innovative instructional practices (86 percent to 96 percent)
- Providing materials/equipment for science/math (64 percent to 67 percent)
- Providing time for teachers to meet and share ideas (61 percent to 88 percent)
- Encouraging teachers to observe other exemplary teachers (46 percent to 70 percent)
- Encourages teachers to make connections across disciplines (71 percent to 83 percent)
- Acting as a buffer between teachers and external pressures (68 percent to 71 percent)

Parental Support was reported to be very low by participants in the UC STEM program. In fact, only four percent of participants indicated that parents volunteer to assist with class activities, and/or donate money for materials. Additionally, only 25 percent agreed parents voice support for various instructional strategies and only 50 percent agreed parents attend parent-teacher conferences. Finally, only 22 percent agreed parents attend PTA or math/science nights.

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. UC STEM participants (43 percent) reported positive impressions of the impact of the PD at the end of the program in regards

to impact on content knowledge (an increase from 11 percent at baseline). The impact on understanding how students learn increased across the program (25 percent to 50 percent), and ability to implement high-quality science/math instructional materials increased from baseline (29 percent) to the end of the program (57 percent).

FINDINGS FROM CONTENT ASSESSMENT

The UC STEM program administered a pre/post assessment to 24 program participants. On the pre-test, teacher average percentage was 44 percent correct. This percentage increased to 60 percent on the post-test. This was considered a statistically significant increase for MTSU participants.

CONCLUDING OBSERVATIONS FOR PROGRAM

The UC STEM professional development program aligned with all aspects of the components of the Core Conceptual Framework (e.g., content focus, active participation, duration, and coherence) in the grant proposal as part of their planned focus. Program outcomes indicate the UC STEM intervention had a statistically significant impact on teacher quality (e.g., ability to design and implement instruction, classroom culture, and content knowledge). The UC STEM program participants realized an increase in percentage of items correct on the pre/post assessment from baseline to end of program (44 percent to 60 percent respectively). UC STEM was successful in having 25 of the 30 projected participants complete the program.

Teacher reported opinions and perceptions of preparation, as well as frequency of use of strategies revealed growth for participants in the UC STEM program. In their self-reports, participants indicated increased use of most effective strategies for teaching mathematics (e.g., use of real-world contexts, alternative explanations, connections between mathematics/science and other disciplines, formative assessments). Additionally, participant's felt more prepared to implement effective mathematics teaching in their self-reports. UC STEM participants increased their use of student activities in all areas besides open-ended and short-answer assessment, but it may have been the case that assessment development was not a focus of the program.

UC STEM participants were supported to decrease the impact of instructional influences on discouraging effective instruction. Teacher perceptions of administrative support were very positive. Agreement grew across the program regarding principal support of innovative instructional practices. However, parental support was reported as being very limited. In regards to participant impressions of the PD program, more than half of teacher participants (57 percent) reported that they felt the program had impacted their ability to implement effective mathematics instruction. Further, participants also felt their ability to understand how children think about/learn science (50 percent), and mathematics content knowledge (43 percent) had improved as well. Overall, the UC STEM program had a significant impact on teacher quality, content knowledge, and in some areas of teacher beliefs and preparedness.

Program Narrative
Middle Tennessee State University (MTSU)
Strayer and Brown, Principal Investigators
StaRT: Statistical Reasoning and Thinking

PROGRAM SETTING AND PARTICIPANTS

The StaRT: Statistical Reasoning and Thinking program at Middle Tennessee State University was a partnership between the Department of Mathematical Sciences and the College of Education to deliver a grade 7-12 mathematics focused program. The professional development program included 35 teacher participants from three LEA's (Rutherford County, Williamson County, and Bedford County) for this program. There were 98 contact hours which included 10 summer workshop days conducted, along with four PD days conducted in fall/spring.

The goals of the StaRT project included the following:

1. Strengthen teachers' content knowledge in data collection, data analysis, and statistical methods.
2. Develop teachers' pedagogical expertise in cultivating a standards-based learning environment as they teach statistics content using high-cognitive demand.
3. Enhance teachers' capacity to use technology effectively in math and science instruction.

The objectives of the StaRT program were focused on developing teachers who:

1. Understand at multiple levels the key statistical concepts that undergrid data analysis.
2. Plan instruction that requires students to collect and analyze real data in math and science lessons.
3. Are skilled in using classroom discourse to successfully implement HCD tasks.
4. Have increased capacity to teach with technology.
5. Demonstrate an increasingly self-reflective practice.
6. Demonstrate a deepening understanding of and engagement with standards documents.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The proposed StaRT program aligned with four of the five components of the Core Conceptual framework, with a focus on mathematics **content knowledge** in the areas of data collection, data analysis, and statistical methods. Program content was aligned closely with state content standards. **Active learning** was a focus, including the use of engaging participants in completing HCD statistical tasks and small action research projects.

Coherence was addressed through a purposeful focus on addressing existing teacher beliefs. There were also connections to state standards and content was planned in consultation with district

curriculum specialists. The **duration** of the program included 98-hours of contact with participants, which is consistent with the framework. This was achieved through a 10-day summer institute, combined with 4 additional days of PD. **Collective participation** was not clear, as the proposal stated the a professional learning community (PLC) would be established, but school level recruitment was not discussed.

FINDINGS FROM OBSERVATIONS

The StaRT program had thirteen of the total 35 participants who submitted all three required videos. Additionally, there were 30 participants who submitted at least one video. Overall, results significant growth in all of the four constructs (e.g., design of lesson, implementation of lesson, classroom culture, and mathematics content) related to desired change in teacher practice and content knowledge across the program.

At baseline, the StaRT program participants were characterized as "elements of effective instruction" on the design of lesson construct (score of 2.47) which significantly increased by the end of program (3.22, "beginning stages of effective instruction"). The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

The StaRT program participants began the program with an implementation of lesson at a score of 2.76 ("elements of effective instruction"), which significantly increased to 3.64 ("beginning stages of effective instruction") by the end of program. The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

Teachers in the StaRT program began with content knowledge rated at a score of 3.39 ("beginning states of effective instruction"). This area also experienced a significant increase across the program to a score of 3.81 by the end of the program. This means that most of the time during observations, mathematics content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and connections to real-world contexts were used. Participants incorporated some abstraction, theory building, and connections to other disciplines in observed lessons.

Classroom culture for the StaRT participants was the final area of significant improvement. At baseline, the mean score for teachers in the program was 3.36, which increased to a mean of 3.86 ("beginning stages of effective instruction") at the end of the program. Implementation of strategies, including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor, were revealed through observations. Active participation of all students was also observed as being encouraged and respected in a consistent manner.

FINDINGS FROM SURVEYS

The MTSU program did not have participants complete the post-survey, therefore there was incomplete survey data available and an analysis was not possible.

FINDINGS FROM CONTENT ASSESSMENT

The 27 participants in the StaRT program completed both the pre- and post-assessment. On the pre-test, teacher average percentage was 45 percent correct. This percentage increased to 58 percent on the post-test. This was considered a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGRAM

The StaRT professional development program addressed most aspects of the components of the Core Conceptual Framework (e.g., content focus, active participation, and duration) in the grant proposal as part of their planned focus. Program outcomes indicate the MTSU intervention did have a statistically significant impact on teacher quality (e.g., ability to implement the lessons, classroom culture, and math content knowledge). MTSU was successful in having 35 participants, which was more than the projected 30 teachers, complete the program.

StaRT teachers also demonstrated significant gains on the mathematics content assessment, with baseline percentage of 45 percent correct responses growing to 58 percent at the end of the program.

There were no survey findings for this program, as the post-questionnaires were not completed by the program.

Program Narrative
Tennessee Technological University (TTU)
Baker and Fromke, Principal Investigators
Shaping Early STEM Learning

PROGRAM SETTING AND PARTICIPANTS

The Shaping Early STEM Learning program at the Tennessee Tech University was a partnership between the College of Arts & Sciences and the College of Education to deliver a grade K-2 mathematics, science, and engineering focused program. The professional development program included 90 contact hours for 29 teacher participants. TTU partnered with 13 LEA's (Cannon County, Clay County, Cumberland County, DeKalb County, Jackson County, Overton County, Lebanon County, Putnam County, Sequatchie County, Sumner County, Van Buren County, Warren County, and White County) for this program. There were 60 hours of summer institute, 20 hours of Saturday sessions, and 10 hours of online PLC.

The goals of the Shape Early STEM Learning project was to transform the teaching of K-2 STEM through increased teacher content and pedagogical content knowledge in geometry and measurement, participation in the engineering design cycle, and creation of new educational objects and materials for the classroom.

The objectives of the Shaping Early STEM Learning program included:

1. Increase participants' content knowledge in mathematics (targeting geometry and measurement), science, and engineering as measured by a pre/post test.
2. Increase participants' pedagogical content knowledge as evidenced by pre/during/post videos of their teaching practices.
3. Increase participants' pedagogical content knowledge as evidenced by the team development of learning objects (thematic units, lesson plans, activities, assessments) aligned with the K-2 Common Core math (targeting geometry and measurement) and Tennessee science and engineering standards.
4. Change participants' beliefs about STEM teaching as they experience math, science, technology, and engineering activities as students.
5. Increase the awareness of participant teachers of STEM careers and the engineering design cycle by participating in the design and creation of educational materials for use in their own classrooms.
6. Position participant teachers as surrogate STEM career representatives to their students given they themselves will be the creative sources for newly engineered products.
7. Create Professional Learning Communities (PLC) at schools of participating teachers.
8. Further participant teachers' professionalism by their presentation and/or participation in STEM education conferences.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The proposed Shaping Early STEM Learning program aligned with the five components of the Core Conceptual framework, with a focus on science and mathematics **content knowledge** delivered through alignment with the Common Core State Standards for Mathematics and the Tennessee science and engineering standards. **Active learning** was a focus, including the use of engaging teachers in the role of the student in inquiry and problem solving activities, including the engineering design cycle.

Coherence was addressed through a purposeful focus on addressing existing teacher beliefs. Additionally, letters of support were included from partnering districts, but no discussion of any collaborative planning and alignment with school needs was included.

The **duration** of the program included 90-hours of contact with participants, which is consistent with the framework. This was achieved through a combination of summer institute and four Saturday sessions, as well as an online follow-up components. **Collective participation** was achieved through recruiting teams of at least two teachers from each participating elementary school.

FINDINGS FROM OBSERVATIONS

The submission rate for teacher-provided videos of their teaching for the Shaping Early STEM Learning program included 37 participants who submitted at least one video and 15 submitted the required three videos for the evaluation (out of 29 who completed the PD program). Overall, results demonstrate significant growth in all of the four constructs (e.g., design of lesson, implementation of lesson, classroom culture, and mathematics content) related to desired change in teacher practice and content knowledge across the program.

At baseline, the Shaping Early STEM Learning program participants were characterized as "elements of effective instruction" on the design of lesson construct (score of 2.70) which increased by the end of program (score of 3.10, "beginning stages of effective instruction"). The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

The Shaping Early STEM Learning program participants began the program with an implementation of lesson at a score of 2.95 ("elements of effective instruction") and improved this mean score to 3.63 ("beginning stages of effective instruction") by the end of program, which was statistically significant. The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

Teachers in the Shaping Early STEM Learning program began with content knowledge rated at a score of 3.28 ("beginning stages of effective instruction"). Again, teachers made improvements across the program realizing an improved mean score of 3.81 ("beginning stages of effective

instruction") by the end of the program. This means that during observations, mathematics content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Participants occasionally incorporated abstraction, theory building, and connections to other disciplines in observed lessons.

Classroom culture for Shaping Early STEM Learning participants was the final area that also demonstrated significant improvement. At baseline, the mean score for teachers in the program was 3.32, which grew to a mean of 3.94 ("beginning stages of effective instruction") at the end of the program. Implementation of strategies, including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor, were revealed through observations. Active participation of all students was observed as being encouraged and respected in a consistent manner.

FINDINGS FROM SURVEYS

An examination of pre/post survey data for Shaping Early STEM Learning participants revealed mixed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 29 participants who completed the pre-survey and 29 who completed the post-survey.

Teacher opinions for Shaping Early STEM Learning participants' demonstrated growth and some decline in various areas of the construct.

Areas of Increased Agreement – More teachers agreed with the following items after the program:

- Teachers have necessary supplies and/materials for mathematics (33 percent to 62 percent)
- Teachers have time to collaborate with peers (33 percent to 51 percent)
- The school mathematics program is supported by local organizations, institutions (25 percent to 34 percent)
- Importance of having students participate in inquiry-oriented activities (93 percent to 97 percent)
- Importance of using performance-based assessment (90 percent to 92 percent)
- Importance of using portfolios (65 percent to 68 percent)

Areas of Increased Disagreement – Fewer teachers agreed with the following items after the program:

- Importance of having students work in cooperative learning groups (100 percent to 95 percent)
- Importance of having students prepare project/laboratory/research reports (63 percent to 57 percent)
- Importance of using informal questioning to assess students (97 percent to 92 percent)

Instructional Influences were a second area of focus in the survey. Shaping Early STEM Learning participants reported their experiences with influence of variables on instruction in this area at the end of the program.

More Influence on Effective Instruction – The following influences were perceived as having a more of an influence on teaching by the end of the program:

- State and/or district curriculum frameworks (48 percent to 56 percent)
- State and/or district testing polices and practices (33 percent to 36 percent)
  - Quality of available materials (32 percent to 54 percent)
- Access to computers (23 percent to 43 percent)
- Funds for equipment and supplies (23 percent to 32 percent)
- Time to plan and prepare lessons (25 percent to 53 percent)
- Time to work with other teachers (28 percent to 50 percent)
- Time for professional development (43 percent to 50 percent)
- Importance of mathematics/science within the school (60 percent to 64 percent)
- Consistency of science/math reform efforts with other school/district reforms (40 percent to 49 percent)

Less Influence on Effective Instruction – The following influences were perceived as having a less of an influence on teaching by the end of the program:

- System of managing instructional resources at district or school level (32 percent to 28 percent)
- Public attitudes toward reform (24 percent to 20 percent)

Teacher Preparedness comprised the third construct of the survey. Participants in the Shaping Early STEM Learning program experienced gains in all areas of perceived preparedness across the program, as indicated by a greater percentage of teachers indicating that they were fairly well or well prepared in the following construct areas:

- Providing concrete experiences before abstract concepts (75 percent to 97 percent)
- Developing student conceptual understanding (74 percent to 95 percent)
- Taking student prior understanding into consideration when planning curriculum and instruction (83 percent to 97 percent)
- Making connections between science/math and other disciplines (65 percent to 92 percent)
- Using cooperative learning groups (75 percent to 92 percent)
- Having students participate in appropriate hands-on activities (83 percent to 100 percent)
- Engaging students in inquiry-oriented activities (53 percent to 89 percent)
- Having students prepare project/laboratory/research reports

(23 percent to 46 percent)
- Using computers (49 percent to 92 percent)
- Engaging students in applying science/math in a variety of contexts (68 percent to 97 percent)
- Using performance based assessments (75 percent to 95 percent)
- Using portfolios (40 percent to 59 percent)
- Using informal questioning to assess student learning (78 percent to 92 percent)
- Leading a class using investigative strategies (38 percent to 84 percent)
- Helping students take responsibility for their own learning (64 percent to 95 percent)
- Recognizing and responding to student diversity (74 percent to 95 percent)
- Using strategies that encourage participation of females and minorities in science/math (45 percent to 92 percent)
- Encourage students' interest in science/math (82 percent to 100 percent)
- Managing a class of students engaged in hands-on/project-based work (65 percent to 100 percent)

Frequency of Use of Instructional Practices consists of teacher-reported frequency of use of specific instructional practices. Shaping Early STEM Learning program participants reported more frequent use of all strategies by the end of the program:

- Introducing content through formal presentations (75 percent to 84 percent)
- Arranging seating to facilitate student discussion (85 percent to 95 percent)
- Using open-ended questions (80 percent to 89 percent)
- Requiring students to supply evidence to support claims (68 percent to 81 percent)
- Encouraging students to explain concepts to one another (70 percent to 89 percent)
- Encouraging students to consider alternative explanations (63 percent to 76 percent)
- Allowing students to work at their own pace (79 percent to 81 percent)
- Helping students see connections between math/science and other disciplines (73 percent to 86 percent)
- Using formative assessment (55 percent to 81 percent)
- Embedding assessment in regular class activities (85 percent to 86 percent)
- Assigning science/math homework (49 percent to 57 percent)
- Reading and commenting on student reflections in notebooks/journals (25 percent to 42 percent)

Student Activities are the activities that students are engaged in within the classroom. Shaping Early STEM Learning participants were asked questions regarding the frequency of use of various student activities. Findings in regards to the frequency of use of effective student activities from baseline to end of program revealed an increase of use of strategies in most of the areas of this construct.

Frequent Use – Participants reported more frequent use for these student activities by end of the program:

- Participating in discussions with the teacher to further understanding (78 percent to 86 percent)
  Participating in student-led discussions (55 percent to 67 percent)
- Making formal presentations to the class (25 percent to 32 percent)
- Reading other (non-textbook) science/math related materials in class (58 percent to 76 percent)
- Working on solving a real-world problem (60 percent to 78 percent)
- Engaging in hands-on science/math activities (55 percent to 72 percent)
- Following specific instructions in an activity or investigation (70 percent to 83 percent)
- Designing or implementing his or her own investigation (18 percent to 41 percent)
- Working on extended science/math investigations or projects (13 percent to 24 percent)
- Working on models or simulations (21 percent to 47 percent)
- Recording, representing, and/or analyzing data (38 percent to 53 percent)
- Writing reflections in a notebook or journal (38 percent to 46 percent)
- Working on portfolios (22 percent to 23 percent)
- Taking tests requiring open-ended responses (28 percent to 41 percent)
- Participating in field work (5 percent to 14 percent)
- Working in cooperative learning groups (80 percent to 86 percent)
- Sharing student ideas or solve problems with each other in small groups (68 percent to 81 percent)
- Taking short-answer tests (35 percent to 43 percent)

Principal Perceptions are the impressions that participants have about their administrator's support for the teaching and learning of science/mathematics. Participants in the Shaping Early STEM Learning program had very positive views of their leadership.

Areas of Increased Agreement – Teachers agreed their principal provided encouragement and/or support in the following areas:

- Encouraging selection of science/math content and instructional strategies to address individual students' learning (73 percent to 81 percent)
- Accepts the noise that comes with an active classroom (75 percent to 78 percent)
- Encouraging the implementation of current national standards in science/math education (92 percent to 95 percent)
- Providing materials/equipment for science/math (53 percent to 57 percent)
- Providing time for teachers to meet and share ideas (58 percent to 76 percent)
- Encouraging teachers to observe other exemplary teachers (33 percent to 49 percent)

Encourages teachers to make connections across the disciplines (68 percent to 78 percent)

- Acting as a buffer between teachers and external pressures (53 percent to 68 percent)

Parental Support was reported to be low by participants in the Shaping Early STEM Learning program. In fact, only 14 percent of participants indicated that parents volunteer to assist with class activities, only 22 percent donate money for materials, and only 16 percent voice support for various instructional strategies. However, 57% of participants indicated parents attend parent-teacher conferences, though only five percent reported parents attend PTA or math/science nights.

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. Shaping Early STEM Learning participants (71 percent) reported positive impressions of the impact of the PD at the end of the program in regards to impact on content knowledge (an increase from only nine percent at baseline). The impact on understanding how students learn, and ability to implement high-quality science/math instructional materials were also areas of growth, with increases in the area of student learning from nine percent to 56 percent, and gains in ability to implement high-quality science/math instruction from 23 percent to 60 percent at end of program.

FINDINGS FROM CONTENT ASSESSMENT

Twenty-nine participants in the Shaping Early STEM Learning program completed both the pre- and post-assessment that was developed by the TTU program. On the pre-test, teacher average percentage was 59 percent correct. This percentage increased to 80 percent on the post-test. This was considered a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGRAM

The Shaping Early STEM Learning professional development program addressed most aspects of the components of the Core Conceptual Framework (e.g., content focus, active participation, duration, and coherence) in the grant proposal as part of their planned focus. Participants experienced significant gains in teacher quality and content knowledge across the program. Shaping Early STEM Learning teacher content knowledge scores improved from 59 percent passing at baseline to 80 percent at the end of the program. The Shaping Early STEM Learning was successful in having 29 of the 30 projected participants complete the program.

Teacher reported opinions and perceptions of preparation, as well as frequency of use of strategies revealed significant growth for participants in the Shaping Early STEM Learning program. In their self-reports, participants indicated increased use of effective strategies for teaching (e.g., use of real-world contexts, alternative explanations, connections between mathematics/science and other disciplines, formative assessments). Additionally, participant's felt more prepared to implement effective teaching in their self-reports. For example, the use of development of student conceptual understanding, use of hands-on, inquiry, computers, diversity, and helping students take responsibility for their own learning were all areas more participants reported feeling prepared to use. Shaping Early STEM Learning participants perceived influence of time for collaboration,

planning, and PD on quality of instruction grew – indicating an increased appreciation for collaboration and making connections.

Teacher perceptions of administrative support were very positive. However, parental support was reported as very little in all areas besides attendance at parent-teacher conferences – which 57 percent of participants reported parent involvement in. In regards to participant impressions of the PD program, more than half of teacher participants (56 percent) reported that they felt the program had impacted their ability to understand how children think about/learn science and/or mathematics. Shaping Early STEM Learning participants also reported (71 percent agreement) that the program had had an impact on their content knowledge, as well as their ability to implement effective mathematics instruction (60 percent agreement). Overall, this Shaping Early STEM Learning program had a significant impact on teacher quality, content knowledge, teacher opinions and preparedness to teach STEM.

Program Narrative
Tennessee Technological University (TTU)
Fidan and Baker, Principal Investigators
Designing the Future: Curriculum Development through Project-based Inquiry Using Design and Modeling Tasks

PROGRAM SETTING AND PARTICIPANTS

The TTU Designing the Future: Curriculum Development through Project-based Inquiry Using Design and Modeling Tasks program was a partnership between the College of Engineering and the College of Education to deliver a PD program for high school teachers of math, science, and CTE. The professional development program included 96 contact hours for 25 teacher participants. TTU partnered with 15 LEA's (Cannon County, Clay County, Cumberland County, DeKalb County, Fentress County, Macon County, Overton County, Pickett County, Putnam County, Sequatchie County, Sumner County, VanBuren County, Warren County, Wilson County, and York Institute) for this program. There were 12 workshop days conducted, including a seven-day summer academy and follow-up support days.

The goals of Designing the Future included:

1. This project will increase secondary math, science, and CTE teachers' understanding of cutting-edge design, simulation, and modeling tools. Engagement with these tools and integration of state standards and the STEM Academy standards will help teachers increase their content knowledge of STEM concepts.
2. Through this project, participating math, science, and CTE teachers will learn pedagogical best practices in incorporating and disseminating a number of 21st century concepts and their linkage to the secondary math and science curriculum. Teachers will increase the incorporation of standards-based STEM concepts in their math, science, and CTE classrooms.

The objectives of the Designing the Future program included:

1. Teacher participants will design and construct prototypes using the remotely accessible rapid prototyping lab facilities and resources.
2. Teacher participants will create and analyze data on the structure-testing instrument based on hands-on applications of force and load.
3. Teacher participants will access and manipulate engineering resources such as MyRobotNation, TTU's MoLE-SI, AutoCAD, SPORE, Alice, Google SketchUp, and 3Dtin.

4. Teacher participants will collaborate with guest speakers who delivery pieces of STEM-related instruction and then the teacher participants will integrate these best practices into their own classroom practices.
5. Teacher participants will complete a pre and post survey that will drive continuous improvement in the delivery of content and pedagogy throughout the PD.
6. Teacher participants will attend at least half of the virtual office hours provided by the project PIs as part of the support system of content and pedagogy.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The proposed Designing the Future program aligned with all aspects of the five components of the Core Conceptual framework, with a focus on mathematics, science, and CTE **content knowledge** including engineering, 3D modeling, design, programming, simulation, and other Tennessee math (CCSS) and science standards. **Active learning** was a focus, including the use of hands-on software and production practices, as well as problem-based learning, project-based learning, and curriculum development. Participants experienced new concepts through the role of the student, and then were provided support to refine delivery of practice.

Coherence was addressed through a purposeful focus on addressing existing teacher beliefs. It is not clear if districts were involved in the planning of the PD or how well it aligned with their focus, but letters of support were provided. The **duration** of the program included 96-hours of contact with participants, which is consistent with the framework. **Collective participation** was achieved with having at least two teachers from each school participate.

FINDINGS FROM OBSERVATIONS

The submission rate for teacher-provided videos for the TTU program was less than desirable, as only two of the 25 PD program participants submitted all three videos. There were 13 participants who submitted at least one video. Overall, results showed significant growth in all four of the four constructs (e.g., design of lesson, implementation of lesson, classroom culture, and mathematics content) related to desired change in teacher practice and content knowledge across the program for the two participants.

At baseline, TTU program participants were characterized as being at the "ineffective instruction" stage on the design of lesson construct (score of 1.93), increasing significantly to "beginning of effective instruction" by the end of program (3.10). The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

TTU program participants began the program with an implementation of lesson score of 2.52 ("elements of effective instruction") and improved this to 4.00 ("accomplished, effective instruction") by the end of program, which was determined to be statistically significant. The implementation of lesson construct examines level of investigative mathematics/science in the

lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

Teachers in the TTU program began the program with a content knowledge overall mean score of 2.85 ("elements of effective instruction"). Teachers made statistically significant improvements across the program in this area, realizing an improved mean score of 4.00 ("accomplished, effective instruction") by the end of the program. This means that some of the time during observations, content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Participants occasionally incorporated abstraction, theory building, and connections to other disciplines in observed lessons.

Classroom culture rose with statistically significant improvement for TTU participants. At baseline, the mean score for teachers in the program was 2.61 ("elements of effective instruction"), which grew significantly to a mean of 3.78 by the end of the program. Implementation of strategies, including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor, were evident through observations. Active participation of all students was observed as being encouraged and respected in a consistent manner.

FINDINGS FROM SURVEYS

An examination of pre/post survey data for Designing the Future participants revealed mixed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 25 participants who completed the pre-survey and nine who completed the post-survey.

Teacher opinions for Designing the Future participants demonstrated both some growth in various areas of the construct. Additionally, several areas were at 100 percent agreement at baseline that remained the same at the end of the program: considering student prior knowledge when planning curriculum and instruction, making connections between math/science and other disciplines, having students participate in hands-on activities, engaging students in inquiry-oriented activities, and engaging students in applications of science/math in variety of contexts.

Areas of Increased Agreement – More teachers agreed with the following items after the program:

- Teachers collaborated to share ideas more (84 percent to 100 percent)
- Teachers have time to collaborate with peers (24 percent to 56 percent)
- The school program is supported by local organizations, institutions (20 percent to 78 percent)
- Importance of considering students' prior understanding into account when planning curriculum and instruction (86 percent to 89 percent)
- Having students work in cooperative learning groups (93 percent to 100 percent)
- Using informal questioning to assess student learning (93 percent to 100 percent)

Areas of Increased Disagreement – Fewer teachers agreed with the following items after the program:

- Importance of using performance based assessment (93 percent to 78 percent)
- Importance of having students prepare project/laboratory/research reports (100 percent to 89 percent)
- Importance of using computers (93 percent to 89 percent)
- Importance of use of portfolios (64 percent to 56 percent)

Instructional Influences were a second area of focus in the survey. The Designing the Future participants reported changes in perceived influences of external variables on instruction from baseline to the end of the program.

More Influence on Effective Instruction – The following influences were perceived as having a more positive relationship on teaching mathematics effectively by the end of the program:

- Quality of available materials (64 percent to 67 percent)
- Access to computers (50 percent to 56 percent)
- Funds for equipment and supplies (43 percent to 56 percent)
- Time to work with other teachers (36 percent to 67 percent)
- Time for professional development (64 percent to 67 percent)
- Time for teachers to plan and prepare lessons (57 percent to 67 percent)
- Importance of mathematics/science within the school (64 percent to 88 percent)
- Consistency of science/math reform efforts with other school/district reforms (29 percent to 50 percent)

Less Influence on Effective Instruction – The following influences were perceived as having a more negative relationship on teaching mathematics effectively by the end of the program:

- State and/or district curriculum frameworks (21 percent to 11 percent)
- State and/or district testing polices and practices (13 percent to 0 percent)
- Public attitudes toward reform (29 percent to 22 percent)
- System of managing instructional resources at district or school level (31 percent to 22 percent)

Teacher Preparedness comprised the third construct of the survey. Participants in the program experienced gains in most areas of perceived preparedness across the program, as indicated by a greater percentage of teachers indicating that they were fairly well or well prepared in the following construct areas:

- Providing concrete experiences before abstract concepts (78 percent to 79 percent)
- Developing student conceptual understanding (86 percent to 89 percent)

- Taking student prior understanding into consideration when planning curriculum and instruction (64 percent to 89 percent)
- Using cooperative learning groups (71 percent to 89 percent)
- Having students participate in appropriate hands-on activities (86 percent to 89 percent)
- Engaging students in inquiry-oriented activities (64 percent to 78 percent)
- Having students prepare project/laboratory/research reports (86 percent to 89 percent)
- Using computers (67 percent to 69 percent)
- Engaging students in applying science/math in a variety of contexts (71 percent to 78 percent)
- Using performance based assessments (78 percent to 79 percent)
- Using portfolios (43 percent to 56 percent)
- Using informal questioning to assess student learning (77 percent to 89 percent)
- Leading a class using investigative strategies (71 percent to 89 percent)
- Helping students take responsibility for their own learning (78 percent to 79 percent)
- Recognizing and responding to student diversity (79 percent to 89 percent)
- Using strategies that encourage participation of females and minorities in science/math (64 percent to 100 percent)

Decline in Preparation – In one areas Designing the Future participants' felt less prepared following participation in the program which was focused on the managing of a class of students engaged in hands-on/project-based work (75 percent to 100 percent).

Frequency of Use of Instructional Practices consists of teacher-reported frequency of use of specific instructional practices. Designing the Future program participants reported more frequent use of most strategies by the end of the program:

- Introducing content through formal presentations (64 percent to 67 percent)
- Arranging seating to facilitate student discussion (79 percent to 100 percent)
- Using open-ended questions (93 percent to 100 percent)
- Requiring students to supply evidence to support their claims (79 percent to 89 percent)
- Encouraging students to explain concepts to one another (79 percent to 89 percent)
- Encouraging students to consider alternative explanations (64 percent to 89 percent)
- Using formative assessment (57 percent to 78 percent)
- Assigning science/math homework (50 percent to 67 percent)

Decline in Frequency of Use – A greater percentage of Designing the Future participants reported less frequent use of the following effective instructional practices across the program: helping students to see connections between math/science and other disciplines (86 percent to 78 percent),

embedding assessment in regular class activities (79 percent to 67 percent), allowing students to work at their own pace (93 percent to 78 percent), and reading and commenting on student reflections in notebooks/journals (36 percent to 22 percent).

Student Activities are the activities that students are engaged in within the classroom. Designing the Future participants were asked questions regarding the frequency of use of various student activities. Findings in regards to the frequency of use of effective student activities from baseline to end of program revealed an increase of use of strategies in most of the areas of this construct.

Frequent Use – Participants reported more frequent use for these student activities by end of the program:

- Participating in discussions with the teacher to further understanding 84 percent to 88 percent)
- Sharing student ideas or solve problems with each other in small groups (48 percent to 78 percent)
- Designing or implementing his or her own investigation (21 percent to 33 percent)
- Taking tests requiring open-ended responses (20 percent to 44 percent)

Decreased Use – More teachers reported less frequent use of some effective student activities by the end of the program:

- Participating in student led discussions (72 percent to 56 percent)
- Making formal presentations to the class (40 percent to 11 percent)
- Reading other (non-textbook) science/math related materials in class (60 percent to 0 percent)
- Working on solving a real-world problem (68 percent to 44 percent)
- Working on extended science/math investigations or projects (16 percent to 0 percent)
- Following specific instructions in an activity or investigation (80 percent to 67 percent)
- Working on models or simulations (28 percent to 22 percent)
- Recording, representing, and/or analyzing data (80 percent to 33 percent)
- Writing reflections in a notebook or journal (56 percent to 13 percent)
- Working on portfolios (32 percent to 22 percent)
- Participating in field work (44 percent to 11 percent)

Principal Perceptions are the impressions that participants have about their administrator's support for the teaching and learning of science/mathematics. Participants in the Designing the Future program had very positive views of their leadership. Only one area (encourages the use of innovative instructional practices) experienced a decline across the program (93 percent to 88 percent), though the majority of participants were still in agreement.

Areas of Increased Agreement – Teachers agreed their principal provided encouragement and/or support in the following areas:

- Encouraging selection of science/math content and instructional strategies to address individual students' learning (86 percent to 89 percent)
- Encouraging the implementation of current national standards in science/math education (79 percent to 89 percent)
- Accepts the noise that comes with an active classroom (86 percent to 89 percent)
- Providing materials/equipment for science/math (50 percent to 67 percent)
- Providing time for teachers to meet and share ideas (43 percent to 78 percent)
- Encouraging teachers to observe other exemplary teachers (43 percent to 67 percent)

Parental Support was reported to be very low by participants in the Designing the Future program. In fact, none of the participants indicated (0 percent) that parents volunteer to assist with class activities, donate money for materials, or attend parent-teacher conferences. Further, only 11 percent of participants (up from 8 percent at baseline) agreed parents voice support for various instructional strategies, or attend PTA or math/science nights.

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. Designing the Future participants (25 percent) reported increased positive impressions of the impact of the PD at the end of the program in regards to impact on content knowledge (an increase from 0 percent at baseline). The same growth was also reported for the impact on understanding how students learn (0 percent to 25 percent) as well. Unfortunately, Designing the Future fewer participants felt the program had increased their ability to implement high-quality science/math instructional materials (33 percent at baseline to 17 percent at end of program).

FINDINGS FROM CONTENT ASSESSMENT

Eight participants in the Designing the Future program completed both the pre- and post-assessment developed by the TTU program. On the pre-test, teacher average percentage was 47 percent correct. This percentage increased to 79 percent on the post-test. This was considered a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGRAM

The Designing the Future professional development program addressed all aspects of the components of the Core Conceptual Framework (e.g., content focus, active participation, duration, and coherence) in the grant proposal as part of their planned focus. The Designing the Future program was successful in having all 25 of the 25 projected participants complete the program. However, due to the very low participation in the submission of classroom videos, an analysis of the impact on teacher effectiveness is not possible for this program.

Teacher reported opinions and perceptions of preparation, as well as frequency of use of strategies revealed growth for participants in the Designing the Future program. In their self-reports,

participants indicated increased use of some effective strategies for teaching, but there was a decline in frequency of making connections between mathematics/science and other disciplines. Participants felt more prepared in all areas besides management of the classroom. Teachers reported a shift in influences on effective instruction, as time to collaborate; time for professional development, and other types of support had a stronger influence on their teaching than state and district standards and assessments.

Teacher perceptions of administrative support were very positive. Agreement grew across the program regarding principal support for provisions for materials and equipment, making connections across disciplines, time for collaboration, the noise level of active classrooms, and the level of administrative buffering between teachers and external forces. However, parental support was reported as very little on all constructs by end of program. In regards to participant impressions of the PD program, one quarter of teacher participants (25 percent) reported that they felt the program had more impact than previous PD experiences on their ability to understand how children think about/learn science and/or mathematics content knowledge. However, participants' view of the ability of PD to grow their ability to implement effective instruction declined across the program (33 percent to 17 percent). Overall, there were positive gains in teacher quality and content knowledge, as well as some aspects of teacher opinions and preparedness in the program, though only 17 percent of participants felt the PD had improved their ability to deliver effective instruction.

Program Narrative
Tennessee Technological University (TTU)
Pardue and Howard, Principal Investigators
STEM Around Us

PROGRAM SETTING AND PARTICIPANTS

The STEM Around Us program at TTU was a partnership between the Millard Oakley STEM Center and Curriculum and Instruction to deliver a grade 3-6 mathematics and science focused program. The professional development program included 90 contact hours for 35 teacher participants. TTU partnered with 15 LEA's (Cannon County, Clay County, Cumberland County, DeKalb County, Fentress County, Jackson County, Lebanon County, Macon County, Overton County, Pickett County, Putnam County, Van Buren County, Warren County, White County and Wilson County) for this program. There were 15 professional development days and additional virtual time spent in the professional learning community web-portal over an 18-month period.

There were three goals of the STEM Around Us project:

1. Strengthen teachers' content knowledge and pedagogical content knowledge for teaching science and math in grades 3-6.
2. Improve the classroom STEM "tool-kit" for each teacher.
3. Build a regional grade 3-6 STEM professional learning community using a collaborative web portal to provide continuity.

The objectives of the STEM Around Us program included:

1. Through dialogue with subject matter experts and community STEM stakeholder, teachers will deepen their understanding of science and math content in areas where gaps were identified.
2. Teachers will learn strategies associated with innovative teaching approaches such as the Legacy Cycle and Talking Science.
3. Teachers will create, test, improve and transfer their own instructional modules, which integrate key math and science concepts, and support learner dialogue and differentiated instruction.
4. Teachers have increased their content knowledge for key science and math concepts and core disciplinary ideas are measured by pre and post instruments.
5. Teachers have increased their knowledge about pedagogical approaches for teaching math and science as measured by pre and post surveys and examination of classroom videos.
6. As a group, teachers have created, evaluated, tested and revised 16 Legacy Cycle based instructional modules.
7. Teachers will take stock of their existing STEM toolkit.
8. Teachers will create a plan for how to fill in the gaps.
9. Teachers will write a mini-grant to improve their kits.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The proposed STEM Around Us program aligned with most aspects of the five components of the Core Conceptual framework, with a focus on mathematics and science **content knowledge** to include concepts such as: the universe, the Earth, atmosphere, matter, energy and motion, forces in nature, interdependence, biodiversity and change, number and operations, geometry and measurement, algebra, data analysis and statistics. **Active learning** was focused on learning through the Legacy Cycle, a challenge-based instructional pedagogy including having participants focus on self-evaluation, reflection, and exploration.

Coherence was discussed through the lens of changing practice and this was detailed. What were not explicitly connected to this were the needs of the districts in regards to instruction. **Duration** of the program included 90 hours and use of professional learning communities to achieve necessary sustained contact over the 18-month period. **Collective participation** was achieved through the selection of teacher teams of two colleagues from partnering school LEAs.

FINDINGS FROM OBSERVATIONS

The submission rate for teacher-provided videos for the STEM Around Us program included 17 participants out of the 35 who completed the PD program) who submitted all three videos. There were 33 participants who submitted at least one video. Overall, results significant growth in all of the four constructs (e.g., design of lesson, implementation of lesson, classroom culture, and mathematics content) related to desired change in teacher practice and content knowledge across the program.

Teachers in the STEM Around Us program significantly improved their ability to design and implement effective instruction across the program. At baseline, program participants were characterized as being at the "elements of effective instruction" stage on the design of lesson construct (score of 2.52), increasing significantly by the end of program (2.97). The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

At baseline the STEM Around Us program participants received a 2.63 rating ("elements of effective instruction") on implementation of lesson. This area was also improved through participation in the program, as participants scored significantly higher (score of 3.35) at the end point of the program (characterized as "beginning stages of effective instruction"). The implementation of lesson construct considers the level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments. Moreover, STEM Around Us participants were able to deliver more effective instruction at the end of their program.

Participants experienced growth in content knowledge demonstrated in observed lessons across the program. The baseline rating for STEM Around Us program teachers was 2.97, which falls under the "beginning stages of effective instruction" level. However, significant growth was realized across the program, with the final rating of "beginning stages of effective instruction" and a score of 3.56.

During observations, content delivered was significant and worthwhile and appropriate for the developmental needs of students. Additionally, teacher-provided content was accurate, and some connections to real-world contexts were used. Teachers also incorporated abstraction, theory building, and connections to other disciplines on a regular basis.

Classroom Culture was the final area the STEM Around Us teachers experienced significant change across the program. At baseline, the mean score for teachers in the program was 3.20 ("beginning of effective instruction"), which grew significantly to a mean of 3.72 by the end of the program. Implementation of strategies, including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor, were not evident through observations. Active participation of all students was not observed as being encouraged and respected in a consistent manner.

FINDINGS FROM SURVEYS

An examination of pre/post survey data for STEM Around Us participants revealed mixed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 35 participants who completed the pre-survey and 26 who completed the post-survey.

Teacher opinions for STEM Around Us participants demonstrated both growth and decline in various areas of the construct.

Areas of Increased Agreement – More teachers agreed with the following items after the program:

- Importance of considering students' prior knowledge when planning curriculum and instruction (87 percent to 92 percent)
- Importance of having students prepare project/laboratory/research reports (66 percent to 92 percent)
- Importance of having students use computers (76 percent to 88 percent)
- Teachers have time to collaborate with peers (29 percent to 35 percent)
- The school mathematics program is supported by local organizations, institutions (5 percent to 23 percent)

Areas of Increased Disagreement – Fewer teachers agreed with the following items after the program:

- Importance of developing students' conceptual understanding of science/math (100 percent to 92 percent)
- Importance of connecting math/science to other disciplines (100 percent to 92 percent)
- Importance of having students work in cooperative learning groups (97 percent to 92 percent)

- Importance of having students participate in appropriate hands-on activities (100 percent to 92 percent)

Instructional Influences were a second area of focus in the survey. The STEM Around Us participants reported mixed experiences with variables in this area at the end of the program. There was only one area of influence that grew to be more of an influence across the program, state and/or district testing policies and practices (26 percent to 29 percent).

Less Influence on Effective Instruction – The following influences were perceived as having less influence on participants by the end of the program:

- Quality of available materials (31 percent to 24 percent)
- Access to computers (57 percent to 40 percent)
- Time to work with other teachers (39 percent to 29 percent)
- Time for professional development (50 percent to 33 percent)
- Public attitudes toward reform (25 percent to 43 percent)
- System of managing instructional resources at district or school level (27 percent to 16 percent)
- Importance of mathematics/science within the school (58 percent to 40 percent)
- Consistency of science/math reform efforts with other school/district reforms (50 percent to 29 percent)
- Public attitudes toward reform (30 percent to 13 percent)

Teacher Preparedness comprised the third construct of the survey. Participants in the STEM Around Us program experienced gains in all areas of perceived preparedness across the program, as indicated by a greater percentage of teachers indicating that they were fairly well or well prepared in the following construct areas:

- Providing concrete experiences before abstract concepts (50 percent to 69 percent)
- Developing student conceptual understanding (37 percent to 65 percent)
- Taking students' prior understanding into consideration when planning curriculum and instruction (54 percent to 81 percent)
- Making connections between science/math and other disciplines (53 percent to 81 percent)
- Using cooperative learning groups (71 percent to 96 percent)
- Using hands-on activities (53 percent to 85 percent)
- Engaging students in inquiry-oriented activities (32 percent to 85 percent)
- Having students prepare project/laboratory/research reports (18 percent to 58 percent)
- Engaging students in applying science/math in a variety of contexts (37 percent to 73 percent)
- Using performance based assessments (39 percent to 81 percent)

- Using portfolios (21 percent to 38 percent)
- Using informal questioning to assess student learning (68 percent to 85 percent)
- Leading a class using investigative strategies (45 percent to 77 percent)
- Managing a class of students engaged in hands-on/project-based work (71 percent to 92 percent)
- Helping students take responsibility for their own learning (71 percent to 85 percent)
- Recognizing and responding to student diversity (79 percent to 96 percent)
- Using strategies that encourage participation of females and minorities in science/math (55 percent to 81 percent)
- Encouraging students' interest in science/math (76 percent to 85 percent)

Frequency of Use of Instructional Practices consists of teacher-reported frequency of use of specific instructional practices. STEM Around Us program participants reported less frequent use of most strategies by the end of the program:

- Arranging seating to facilitate student discussion (74 percent to 65 percent)
- Using open-ended questions (71 percent to 58 percent)
- Requiring students to supply evidence to support their claims (68 percent to 62 percent)
- Encouraging students to explain concepts to one another (71 percent to 58 percent)
- Encouraging students to consider alternative explanations (71 percent to 54 percent)
- Allowing students to work at their own pace (68 percent to 50 percent)
- Helping students see connections between math/science and other disciplines (63 percent to 54 percent)
- Using formative assessment (61 percent to 31 percent)
- Embedding assessment in regular class activities (76 percent to 58 percent)
- Assigning science/math homework (34 percent to 19 percent)
- Reading and commenting on student reflections in notebooks/journals (34 percent to 23 percent.

Student Activities are the activities that students are engaged in within the classroom. STEM Around Us participants were asked questions regarding the frequency of use of various student activities. Findings in regards to the frequency of use of effective student activities from baseline to end of program revealed mixed findings.

Frequent Use – Participants reported more frequent use for these student activities by end of the program:

- Designing or implementing his or her own investigation (3 percent to 19 percent)
- Working on models or simulations (13 percent to 16 percent)

- Working on extended science/math investigations or projects (5 percent to 15 percent)

Decreased Use – Teachers reported less frequent use of some effective student activities by the end of the program:

- Participating in student led discussions (50 percent to 42 percent)
- Participating in discussions with the teacher to further understanding 78 percent to 65 percent)
- Reading other (non-textbook) science/math related materials in class (41 percent to 35 percent)
- Working on solving a real-world problem (63 percent to 50 percent)
- Following specific instructions in an activity or investigation (56 percent to 44 percent)
- Writing reflections in a notebook or journal (32 percent to 31 percent)

Principal Perceptions are the impressions that participants have about their administrator's support for the teaching and learning of science/mathematics. Participants in the STEM Around Us program had mostly positive views of their leadership.

Areas of Increased Agreement – Teachers agreed their principal provided encouragement and/or support in the following areas:

- Encouraging selection of science/math content and instructional strategies to address individual students' learning (68 percent to 73 percent)
- Providing materials/equipment for science/math (37 percent to 42 percent)
- Encourages innovative instructional practices (68 percent to 77 percent)

Areas of Decreased Agreement – Teachers agreed their principal provided encouragement and/or support in the following areas:

- Encouraging teachers to observe other exemplary teachers (32 percent to 27 percent)
- Encouraging the implementation of current national standards in science/math education (84 percent to 77 percent)
- Encourages teachers to make connections across disciplines (79 percent to 68 percent)

Parental Support was reported to be very low by participants in the STEM Around Us program. In fact, zero percent of participants indicated that parents volunteer to assist with class activities, only four percent agree parents donate money for materials, and only 19 percent agree parents voice support for various instructional strategies. Attendance at meetings is also an area of less than desired parent participation, as STEM Around Us participants reported only 46 percent agree parents attend parent-teacher conferences and only 12 percent agree parents attend PTA or math/science nights.

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. STEM Around Us participants (23 percent) reported positive growth in impressions of the impact of PD at the end of the program in regards to impact on content knowledge (an increase from 9 percent at baseline). There was also growth in participant perceptions of impact on understanding how students learn (5 percent to 23 percent), and ability to implement high-quality science/math instructional materials (5 percent to 17 percent). However, the increases still did not reflect over 50 percent agreement regarding the impact of STEM Around Us on participants.

FINDINGS FROM CONTENT ASSESSMENT

The STEM Around Us program had 26 participants that completed the pre/post assessment. On the pre-test, teacher average percentage was 36 percent correct. This percentage increased to 67 percent on the post-test. This was considered a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGRAM

The STEM Around Us professional development program addressed most aspects of the components of the Core Conceptual Framework (e.g., content focus, active participation, duration, and coherence) in the grant proposal as part of their planned focus. Program outcomes indicate the STEM Around Us program had a statistically significant impact on teacher quality (e.g., ability to implement the lessons, classroom culture, and math content knowledge) and content knowledge (36 percent at baseline improving to 67 percent passing at end of program). STEM Around Us was successful in having 35 of the 40 projected participants complete the program.

Teacher reported opinions and perceptions of preparation, as well as frequency of use of strategies revealed growth in most areas for participants in the STEM Around Us program. In their self-reports, participants indicated increased use of some effective strategies for teaching STEM (e.g., explanations, connections between mathematics/science and other disciplines, formative assessments). Additionally, participant's felt more prepared to implement effective STEM teaching in their self-reports.

Teacher perceptions of administrative support were positive in most areas except for encouragement to make connections across disciplines, which may suggest administrators have a more traditional, siloed approach to instruction. Agreement grew across the program regarding principal support of innovative instructional practices, provisions for materials and equipment, making connections across disciplines, time for collaboration, the noise level of active classrooms, and the level of administrative buffering between teachers and external forces.

Parental support was reported as very little with zero percent of participants agreeing parents provide support in the classroom, and only 12 percent agreed parents participate in PTA and/or math/science nights. However, 46 percent agreed parents attend parent-teacher conferences. In regards to participant impressions of the PD program, only 23 percent reported that they felt the program had more impact than previous PD experiences on their ability to understand how children think about/learn science and/or mathematics, 23 percent felt the PD improved their content

knowledge, and only 17 percent felt their ability to implement effective STEM instruction had improved in the STEM Around Us program. Overall, data in this evaluation indicated the STEM Around Us program did have a significant impact on teacher quality, content knowledge, and some teacher opinions, frequency of use of strategies, and perceived preparedness to enact STEM.

Program Narrative
Tennessee Technological University (TTU) and Roane State Community College (RSCC)
Suters and Lee, Principal Investigators
From Earth to Space with STEM

PROGRAM SETTING AND PARTICIPANTS

The From Earth to Space with STEM program was a partnership between the College of Education at TTU and Roane State Community College mathematics and science department to deliver a grade 9-10 Earth science focused program for teachers. The professional development program included 96 contact hours for 30 teacher participants. TTU partnered with five LEA's (Campbell County, Morgan County, Roane County, Scott County, and Union County) for this program. There were 10 summer workshop days conducted, along with six Saturday sessions.

The goal of the From Earth to Space project was to promote a change in teacher understanding and implementation of activities that enhance scientific and mathematical literacy, the nature of science, and embedded inquiry through the use of effective practices, technology, and networking.

The objectives of the From Earth to Space program included enabling teachers to:

1. Increase their science and mathematics content knowledge and their understanding of the nature of science as evidenced by scores on pre/post content and nature of science assessments.
2. Increase their pedagogical content knowledge as evidenced by pre/during/post videos, interviews of their teaching practices, and the Technological and Pedagogical Content Knowledge (TPACK) Survey.
3. Prepare and conduct lesson plans incorporating inquiry-based STEM within their classrooms.
4. Participate in ongoing Professional Learning Communities that have a STEM focus.
5. Conduct at least one professional development session on teaching STEM through inquiry and problem-based learning with peers in their school systems.
6. Prepare a proposal as a team to request funding for a problem-based STEM unit of study from the grant's STEM business partner, TVA.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The proposed From Earth to Space program aligned with the five components of the Core Conceptual framework, with a focus on science **content knowledge** delivered through inquiry-

based instruction and the nature of science (NOS). Geology is the primary content area focus and Tennessee Earth and space science content standards guided the program.

Active learning was a focus, including the use of cooperative learning groups, laboratories aligned with IB models, and guided inquiry (5E). The majority of time was devoted to actively engaging teachers in the role of the learner and building teacher pedagogical content knowledge through the use of iPad technology.

Coherence was addressed through a focus on addressing existing teacher beliefs through providing discrepant events in the workshop to challenge current notions of science teaching. There were indirect connections to state standards. The From Earth to Space program aligned the program with needs of the partnering school districts including enabling teachers to use inquiry pedagogy. The **duration** of the program included 96-hours of contact with participants, which is consistent with the framework. This was achieved through a 60-hour summer institute, and follow up work both online and in Saturday sessions. **Collective participation** was a focus as the From Earth to Space program recruited at least two teachers from each participating elementary school.

FINDINGS FROM OBSERVATIONS

The submission rate for teacher-provided videos for the From Earth to Space program included 31 participants who submitted at least one video and 19 of the 30 PD program participants who finished the program that submitted all three videos. The 19 participants are the focus of this analysis. Overall, results showed significant growth in all four constructs (e.g., design of lesson, implementation of lesson, classroom culture, and mathematics content) related to desired change in teacher practice and content knowledge across the program.

At baseline, the From Earth to Space program participants were characterized as being at the "elements of effective instruction" stage on the design of lesson construct (score of 2.67), increasing significantly by the end of program (3.15, "beginning stages of effective instruction"). The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

The From Earth to Space program participants began the program with an implementation of lesson score of 2.75 ("elements of effective instruction") and improved this significantly to 3.68 ("beginning stages of effective instruction") by the end of program. The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

Teachers in the From Earth to Space program began the program with content knowledge overall mean score of 3.31 ("beginning stages of effective instruction"). Again, teachers made significant improvements across the program, realizing a final mean score of 3.72 ("beginning stages of effective instruction"). This means that during observations, content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Participants occasionally used abstraction, theory building, and connections to other disciplines in observed lessons.

Classroom culture was the final area of significant improvement for From Earth to Space participants. At baseline, the mean score for teachers in the program was 3.33, which increased to a mean of 3.86 ("beginning stages of effective instruction") by the end of the program. Implementation of strategies, including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor, were evident through observations. Active participation of all students was also observed as being encouraged and respected in a consistent manner.

FINDINGS FROM SURVEYS

An examination of pre/post survey data for From Earth to Space participants revealed growth in findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 30 participants who completed the pre-survey and 28 who completed the post-survey.

Teacher opinions for From Earth to Space program participants demonstrated both growth and decline in various areas of the construct.

Areas of Increased Agreement – More teachers agreed with the following items after the program:

- Teachers have necessary supplies and/materials for mathematics (46 percent to 61 percent)
- Importance of having students work in cooperative learning groups (85 percent to 89 percent)
- Importance of having students prepare project/laboratory/research reports (68 percent to 79 percent)
- Importance of having students use computers (79 percent to 91 percent) Teachers in the school share a common vision of effective science/math instruction (25 percent to 33 percent)
- Importance of having students participate in appropriate hands-on activities (91 percent to 96 percent)
- Importance of having students participate in inquiry-oriented activities (88 percent to 93 percent)
- Importance of using portfolios (48 percent to 64 percent)
- Importance of using performance-based assessment (88 percent to 96 percent)
- Importance of engaging students in the application of science/math in a variety of contexts (94 percent to 96 percent)

Areas of Increased Disagreement – Fewer teachers agreed with the following items after the program:

- Importance of using informal questioning to assess student learning (100 percent to 96 percent)

Instructional Influences were a second area of focus in the survey. The From Earth to Space participants reported mixed experiences with variables in this area at the end of the program.

More Influence on Effective Instruction – The following influences were perceived as having a more positive relationship on teaching mathematics effectively by the end of the program:

- Quality of available materials (48 percent to 68 percent)
- Access to computers (39 percent to 46 percent)
- Funds for equipment and supplies (11 percent to 25 percent)
- System of managing instructional resources at district or school level (24 percent to 36 percent)
- Time available for teachers to plan and prepare lessons (30 percent to 35 percent)

Less Influence on Effective Instruction – The following influences were perceived as having a more negative relationship on teaching mathematics effectively by the end of the program:

- State and/or district curriculum frameworks (55 percent to 43 percent)
- State and/or district testing polices and practices (30 percent to 19 percent)
- Time to work with other teachers (31 percent to 19 percent)
- Time for professional development (41 percent to 27 percent)
- Public attitudes toward reform (19 percent to 11 percent)
- Importance of mathematics/science within the school (64 percent to 5 percent)
- Consistency of science/math reform efforts with other school/district reforms (38 percent to 22 percent)

Teacher Preparedness comprised the third construct of the survey. Participants in the From Earth to Space program experienced gains in all areas of perceived preparedness across the program, as indicated by a greater percentage of teachers indicating that they were fairly well or well prepared in the following construct areas:

- Providing concrete experiences before abstract concepts (73 percent to 86 percent)
- Developing student conceptual understanding (79 percent to 89 percent)
- Taking student prior understanding into consideration when planning curriculum and instruction (85 percent to 96 percent)
- Making connections between science/math and other disciplines (76 percent to 93 percent)
- Using cooperative learning groups (85 percent to 93 percent)
- Having students participate in appropriate hands-on activities (82 percent to 93 percent)
- Engaging students in inquiry-oriented activities (61 percent to 82 percent)
- Having students prepare project/laboratory/research reports

(52 percent to 75 percent)

- Using computers (67 percent to 89 percent)
- Engaging students in applying science/math in a variety of contexts (73 percent to 89 percent)
- Using performance based assessments (72 percent to 86 percent)
- Using portfolios (30 percent to 59 percent)
- Using informal questioning to assess student learning (79 percent to 100 percent)
- Leading a class using investigative strategies (73 percent to 89 percent)
- Helping students take responsibility for their own learning (73 percent to 89 percent)
- Recognizing and responding to student diversity (67 percent to 85 percent)
- Using strategies that encourage participation of females and minorities in science/math (67 percent to 75 percent)
- Encourage students' interest in science/math (88 percent to 96 percent)
- Managing a class of students engaged in hands-on/project-based work (85 percent to 89 percent)

Frequency of Use of Instructional Practices consists of teacher-reported frequency of use of specific instructional practices. From Earth to Space program participants reported more frequent use of all strategies by the end of the program:

- Introducing content through formal presentations (70 percent to 71 percent)
- Arranging seating to facilitate student discussion (67 percent to 89 percent)
- Using open-ended questions (91 percent to 96 percent)
- Requiring students to supply evidence to support claims (61 percent to 96 percent)
- Encouraging students to explain concepts to one another (76 percent to 86 percent)
- Encouraging students to consider alternative explanations (58 percent to 82 percent)
- Allowing students to work at their own pace (58 percent to 79 percent)
- Helping students see connections between math/science and other disciplines (52 percent to 86 percent)
- Using formative assessment (58 percent to 82 percent)
- Embedding assessment in regular class activities (70 percent to 93 percent)
- Assigning science/math homework (55 percent to 68 percent)
- Reading and commenting on student reflections in notebooks/journals (34 percent to 43 percent)

Student Activities are the activities that students are engaged in within the classroom. From Earth to Space participants were asked questions regarding the frequency of use of various student activities. Findings in regards to the frequency of use of effective student activities from baseline to end of program revealed an increased use of strategies in all of the areas of this construct.

- Participating in discussions with the teacher to further understanding (52 percent to 57 percent)
  Participating in student-led discussions (73 percent to 89 percent)
- Making formal presentations to the class (9 percent to 25 percent)
- Reading other (non-textbook) science/math related materials in class (27 percent to 52 percent)
- Working on solving a real-world problem (64 percent to 71 percent)
- Engaging in hands-on science/math activities (55 percent to 72 percent)
- Following specific instructions in an activity or investigation (45 percent to 64 percent)
- Designing or implementing his or her own investigation (9 percent to 21 percent)
- Working on extended science/math investigations or projects (0 percent to 18 percent)
- Working on models or simulations (6 percent to 29 percent)
- Recording, representing, and/or analyzing data (19 percent to 29 percent)
- Writing reflections in a notebook or journal (48 percent to 64 percent)
- Working on portfolios (18 percent to 21 percent)
- Taking tests requiring open-ended responses (45 percent to 57 percent)
- Participating in field work (0 percent to 14 percent)
- Working in cooperative learning groups (70 percent to 75 percent)
- Sharing student ideas or solve problems with each other in small groups (68 percent to 71 percent)
- Taking short-answer tests (39 percent to 68 percent)

Principal Perceptions are the impressions that participants have about their administrator's support for the teaching and learning of science/mathematics. The views of From Earth to Space participants decreased across the program regarding principal support. The only area that increased (48 percent to 54 percent) was in the area of support for teachers to observe other exemplary teachers in science/math.

Areas of Decreased Agreement – Teachers agreed their principal provided decreased encouragement and/or support in the following areas by the end of program:

- Encouraging selection of science/math content and instructional strategies to address individual students' learning (88 percent to 82 percent)
- Encouraging the implementation of current national standards in science/math education (82 percent to 71 percent)
- Encourages innovative instructional practices (94 percent to 86 percent)
- Providing materials/equipment for science/math (70 percent to 68 percent)
- Providing time for teachers to meet and share ideas (61 percent to 54 percent)
- Encouraging teachers to make connections across disciplines (94 percent to 82 percent)

- Acting as a buffer between teachers and external pressures (79 percent to 68 percent)

Parental Support was reported to be very low by participants in the From Earth to Space program, as only 41 percent of participants indicated parents attend parent-teacher conferences. Other areas were much lower, as only four percent of participants indicated that parents volunteer to assist with class activities, no parents donate money for materials, and only 11 percent of parents voice support for various instructional strategies and attend PTA or math/science nights.

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. The From Earth to Space participants (38 percent) reported positive impressions of the impact of the PD at the end of the program in regards to impact on content knowledge (an increase from 30 percent at baseline). The impact on understanding how students learn remained the same as baseline at the end of the program with only 30 percent agreeing there was an impact on them personally. Finally, participants reported an increase in the ability to implement high-quality science/math instructional materials (25 percent to 42 percent).

FINDINGS FROM CONTENT ASSESSMENT

Twenty-eight participants in the From Earth to Space program completed both the pre- and post-assessment. On the pre-test, teacher average percentage was 59 percent correct. This percentage increased to 79 percent on the post-test. This was considered a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGRAM

The From Earth to Space professional development program addressed the five components of the Core Conceptual Framework (e.g., content focus, active participation, duration, and coherence) in the grant proposal as part of their planned focus. Program outcomes indicate the From Earth to Space intervention had a statistically significant impact on teacher quality (e.g., ability to implement the lessons, classroom culture, and math content knowledge) and content knowledge (59 percent passing at baseline grew to 79 percent at program end). From Earth to Space was successful in having all 30 of the 30 projected participants complete the program.

There was growth for the From Earth to Space program in teacher opinions and perceptions of preparation, as well as frequency of use of strategies. In their self-reports, participants indicated increased use of some effective strategies for teaching (e.g., use of real-world contexts, alternative explanations, connections between mathematics/science and other disciplines, formative assessments). Additionally, participant's felt more prepared to implement effective teaching in their self-reports.

The From Earth to Space participant perceptions of administrative support were very positive. Agreement grew across the program regarding principal support of innovative instructional practices, provisions for materials and equipment, making connections across disciplines, time for collaboration, the noise level of active classrooms, and the level of administrative buffering between teachers and external forces. However, parental support was reported as very little in all but one area

(parent attendance at parent teacher conferences), which had 41 percent agreement. In regards to participant impressions of the PD program, 30 percent of teacher participants reported that they felt the program had more impact than previous PD experiences on their ability to understand how children think about/learn science and/or mathematics. From Earth to Space teachers (38 percent) also felt their content knowledge had improved due to the program, as well as their ability to implement effective mathematics instruction (42 percent agreement). Overall, this program produced significant growth in teacher quality, content knowledge, teacher opinions, and preparedness to teach STEM.

Program Narrative
University of Memphis
Franceschetti and Conley, Principal Investigators
Professional Development for Grades 5-8

PROGRAM SETTING AND PARTICIPANTS

The University of Memphis College of Arts & Sciences and College of Education collaborated to deliver the Professional Development for Grades 5-8 program, an intensive professional development program for 28 teachers of grades 5-8 science and mathematics. UM partnered with the 3 LEAs (Dyer County, Haywood County, and Tipton County) to recruit participants. Fourteen summer institute days were conducted along with four follow-up sessions for a total of 112 contact hours of instruction.

The goals of the Professional Development for Grades 5-8 program were to:

1. Increase teacher content knowledge of scientific content that will be presented in grades 5-8, as evidenced by pre and post-test data and journal entries.
2. Increase teacher pedagogical skills by incorporating inquiry based instructional lessons into their classrooms, as evidenced by videotaped lessons from the end of the 2011-12 school year (pre-training) and fall of the 2013-14 school year (post-training).
3. Increase teacher communication across STEM disciplines within a school, between schools in the same district, and across district lines via WordPress and professional relationships established through cooperative training sessions.

The objectives of the Professional Development for Grades 5-8 program included:

1. Teachers will be able to lead classroom discussions on reading assignments over various scientific topics.
2. Teachers will maintain a journal daily of the information that is new to them or the teaching technique that they believe was the most beneficial from each day of training.
3. Teachers will be able to teach science content in and inquiry based classroom setting.
4. Teachers will be able to facilitate classroom discussion and provide leading questions, rather than simply seeking yes or no answers or asking questions that simply have a one-word answer with no explanation.
5. Teachers will share lessons learned with others on the WordPress site.
6. Teachers will be able to research topics of interest using the links provided on the WordPress site.
7. Teachers will be able to actively seek assistance/knowledge by posting concerns on the WordPress site.
8. Teachers will build professional communities within their school, between schools, and across school districts using the WordPress site.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The proposed Professional Development for Grades 5-8 program was not aligned well with three of five aspects of the Core Conceptual framework with a focus on STEM **content knowledge** delivered using FOSS kits that were purchased for teachers in project. The specific content was not discussed. **Active learning** was vaguely described in the proposal, where it stated teachers would be expected to complete the hands-on activities and participate in classroom discussions. **Coherence** was achieved through a combination of alignment with state standard. However, there was no explicit focus on transforming teacher beliefs through the program. The **duration** of the program included over 100-hours of contact with participants, which is consistent with the framework. **Collective participation** was achieved by recruiting at least two teachers from each participating district.

FINDINGS FROM OBSERVATIONS

The submission rate for teacher-provided videos of their teaching for the Professional Development for Grades 5-8 program was less than optimal. Twenty-four teachers submitted at least one video. However, only three of the 28 program completing teachers submitted all three required videos, and this is the group that was examined for impact of the program on instructional practice. Overall, results showed no significant growth in any of the four constructs (e.g., design of lesson, implementation of lesson, classroom culture, and mathematics content) related to desired change in teacher practice and content knowledge across the program.

At baseline, the Professional Development for Grades 5-8 program participants were characterized as being at the "elements of effective instruction" stage on the design of lesson construct (score of 2.00), and slightly increased by the end of program (2.33), but the change was not statistically significant. The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

The Professional Development for Grades 5-8 program participants began the program with an implementation of lesson score of 2.18 ("elements of effective instruction") and slightly improved this to 2.36 by the end of program, which was determined to not be statistically significant. The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

Teachers in the Professional Development for Grades 5-8 program began the program with a content knowledge overall mean score of 2.52 ("elements of effective instruction"). Teachers made slight improvements across the program in this area (but were not statistically significant), realizing an improved mean score of 2.83 by the end of the program. This means that some of the time during observations, content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Participants did not incorporate abstraction, theory building, and connections to other disciplines in observed lessons.

Classroom culture rose with statistically significant improvement for the Professional Development for Grades 5-8 participants. At baseline, the mean score for teachers in the program was 2.25 ("elements of effective instruction"), which grew slightly and not significantly to a mean of 2.63 by the end of the program. Implementation of strategies, including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor, were not consistently evident through observations. Active participation of all students was rarely observed as being encouraged and respected in a consistent manner.

FINDINGS FROM SURVEYS

An examination of the surveys that participants completed pre- and post-program revealed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 28 participants who completed the pre-survey and 12 who completed the post-survey.

Teacher opinions for Professional Development for Grades 5-8 participants demonstrated growth in various areas of the construct. Many other areas participants were in 100 percent agreement at baseline. There were no areas of decline.

Areas of Increased Agreement in teacher opinions related to the teaching of chemistry:

- Teachers collaborated to share ideas more (44 percent to 50 percent)
- Teachers have necessary supplies and/materials for science (38 percent to 75 percent)
- Importance of having students uses computers (88 percent to 92 percent)
- Importance of having students prepare project/laboratory/research reports (84 percent to 100 percent)
- Importance of using performance-based assessments (84 percent to 92 percent)
- Teachers have time within the regular school week to collaborate with other colleagues (44 percent to 50 percent)

Instructional Influences were a second area of focus in the survey. The Professional Development for Grades 5-8 program more participants reported change in influences on their instruction at the end of the program.

More Influence on Instruction – The following influences were perceived as having a more of an influence on teaching at the end of the program:

- Access to computers (32 percent to 38 percent)
- Time for teachers to plan lessons (60 percent to 63 percent)
- Time for teachers to work with other teachers (52 percent to 75 percent)
- Time for teacher professional development (52 percent to 63 percent)

- Public attitudes toward reform (15 percent to 57 percent)
- Quality of instructional materials (52 percent to 75 percent)
- Funds for supplies (31 percent to 38 percent)
- Importance school places on science/math (39 percent to 50 percent)
- System of managing instructional resources at the district/school level (30 percent to 38 percent)

Less Influence on Instruction – The following influences were perceived as having less of an influence on teaching at the end of the program:

- State and/or district curriculum frameworks (50 percent to 38 percent)
- State and/or district testing policies and practices (35 percent to 25 percent)
- Consistence of science/math reform efforts with other school/district reforms (36 percent to 25 percent)
- Public attitudes toward reform (25 percent to 14 percent)

Teacher Preparedness comprised the third construct of the survey. Data from the Professional Development for Grades 5-8 program revealed teachers who participated in the program felt better prepared to enact many of the effective STEM strategies.

Growth in Preparation – Teachers who participated in the program felt better prepared in the following areas:

- Making connections between science/math and other disciplines (75 percent to 83 percent)
- Having students participate in appropriate hands-on activities (78 percent to 92 percent)
- Engaging students in inquiry-oriented activities (69 percent to 91 percent)
- Having students prepare project/laboratory/research reports (56 percent to 83 percent)
- Using computers (75 percent to 82 percent)
- Engaging students in applying science/math in a variety of contexts (59 percent to 75 percent)
- Leading a class using investigative strategies (72 percent to 92 percent)
- Using informal questioning to assess student learning (88 percent to 92 percent)
- Manage a class of students engaged in hands-on/project-based work (84 percent to 92 percent)
- Using strategies that encourage participation of females and minorities in science/math (69 percent to 75 percent)
- Using portfolios (25 percent to 36 percent)
- Considering student prior understanding when planning instruction (81 percent to 92 percent)
- Using performance based assessment (71 percent to 75 percent)
- Having students work in cooperative learning groups (88 percent to 92 percent)

- Helping students take responsibility for their own learning (81 percent to 91 percent)

Decline in Preparation – Participants perceived they were less prepared at the end of the program in these areas:

- Recognizing and responding to student diversity (84 percent to 75 percent)
- Developing student conceptual understanding (75 percent to 67 percent)

Frequency of Use of Instructional Practices consists of teacher-reported use of specific instructional practices. The Professional Development for Grades 5-8 program participants reported decreases in most areas of this construct.

Increased Use – For several practices participants reported increased use at the end of the program:

- Helping students see connections between math/science and other disciplines (63 percent to 67 percent)
- Embedding assessment in regular class activities (72 percent to 82 percent)

Decreased Use – More participants reported decreased use of the following practices over the course of the program:

- Introducing content through formal presentation (72 percent to 50 percent)
- Arranging seating to facilitate student discussion (75 percent to 50 percent)
- Using open ended questions (84 percent to 58 percent)
- Encouraging students to explain concepts to one another (63 percent to 58 percent)
- Encouraging students to consider alternative explanations (63 percent to 50 percent)
- Using assessment to find out what student know before or during a unit (72 percent to 64 percent)
- Reading and commenting on student reflections in journals (38 percent to 25 percent)

Student Activities are the activities in which students engage while in the classroom. Participants were asked questions regarding the frequency of use of various student activities. There was growth in regards to the frequency of use of effective student activities from baseline to end of program in most areas of this construct. However, most areas of growth included much fewer than 50 percent of participant agreement – indicating the majority of participants were not using these strategies.

Frequent Use – More participants reported frequent of use for the following student activities at the end of the program:

- Participating in student-led discussions (62 percent to 75 percent)
- Making formal presentations to the class (6 percent to 17 percent)
- Reading other (non-textbook) science/math related materials in class

(13 percent to 33 percent)

- Designing or implementing their own investigation (10 percent to 17 percent)
- Working on models or simulations (13 percent to 17 percent)
- Working on portfolios (3 percent to 17 percent)
- Participating in field work (0 percent to 8 percent)
- Taking short-answer tests (41 percent to 50 percent)
- Taking tests requiring open-ended responses (25 percent to 42 percent)

Decreased Use – More teachers in the Professional Development for Grades 5-8 program reported less frequent use of some student activities that are considered effective practice:

- Working in cooperative learning groups (72 percent to 58 percent)
- Sharing ideas or solve problems with each other in small groups (59 percent to 50 percent)
- Following specific instructions in an activity or investigation (53 percent to 42 percent)

Principal Perceptions are the impressions that participants hold regarding their administrator's perception of the teaching and learning of science/math. Participants in the program reported mixed agreement across all items in this area from pre- to post-survey administration.

Areas of Increased Agreement – Teachers who participated in the program felt better supported in the following areas:

- Encouraging the implementation of current national standards in science/math education (66 percent to 75 percent)
- Providing materials/equipment for science/math (50 percent to 58 percent)
- Providing time for teachers to meet and share ideas (72 percent to 82 percent)

Areas of Decreased Agreement – Teachers who participated in the program less better supported in the following areas:

- Accepting the noise that comes with an active classroom (94 percent to 75 percent)
- Encouraging innovative instructional practices (97 percent to 83 percent)
- Encouraging teachers to observe other science/math teachers (53 percent to 33 percent)

Parental Support was reported to be low in all areas by participants in the Professional Development for Grades 5-8 program. However, attendance at parent-teacher conferences was an area of 50 percent agreement, meaning about half of the program participants felt that parents attend these regularly. There was much less agreement in other areas, as only 17 percent of participants indicated that parents volunteer to assist with class activities and/or donate money for materials. University of Memphis participants also indicated only 25 percent agreement that parents

attend PTA or math/science nights, and only eight percent felt parents voiced support for various instructional approaches.

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. In all three areas some Professional Development for Grades 5-8 program teachers all reported slight gains, including improving content knowledge (25 percent to 30 percent of participants agreed), understanding of students (25 percent to 29 percent agreement) and ability to implement high-quality science/math instructional materials (25 percent to 35 percent).

FINDINGS FROM CONTENT ASSESSMENT

Twenty participants in the Professional Development for Grades 5-8 program completed both the pre- and post-assessment. On the pre-test, teacher average percentage was 60 percent correct. This percentage increased to 75 percent on the post-test. This was considered a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGRAM

The Professional Development for Grades 5-8 program was only aligned well with two of the criteria in the Core Conceptual Framework (duration, coherence). Data collected for the evaluation indicated UM program participants did not have significant growth from baseline to end of program on teacher quality in all four areas (design of lesson, implementation of lesson, classroom culture, content knowledge). The UM project was successful in having 28 of the 35 projected participants complete the program.

Teachers reported increased use of many effective strategies for teaching, but the use of open-ended instruction requiring explanations decreased. Professional Development for Grades 5-8 participants felt well prepared to engage students in effective instruction. However, there were some areas where teachers experienced a decline in their perceived preparation (e.g. working with diverse learners, developing student conceptual understanding). This may be due to the very scripted nature of the FOSS curriculum, which was the focus of the program, making it difficult to provide differentiated instruction for learners below and above the level of the developed curriculum. Use of most effective student activities increased across the program as well, except for the use of cooperative learning and having students solve problems in small groups, which was unexpected given the nature of the FOSS curriculum.

Participants felt better supported by their principals in most areas except for in the use of innovative instruction. The Professional Development for Grades 5-8 participants reported (30 percent) the program had a positive impact on their content knowledge (30 percent), and ability to implement high-quality STEM instructional materials (35 percent), though this was less than half of participants. Parental support reported was very low, except for in the area of attendance at parent-teacher conferences, where UM participants agreed (50 percent) that there was participation. Overall, this program did not produce significant gains on measured outcomes, outside of the content assessment, which may be related to the lack of alignment between the conceptual framework and program activities.

Program Narrative
University of Memphis
Grant and Windsor, Principal Investigators
MOBILES, MATH, INQUIRY, & DATA (mMIND)

PROGRAM SETTING AND PARTICIPANTS

The University of Memphis MOBILES, MATH, INQUIRY, & DATA (mMIND) program, was a partnership between Instruction & Curriculum Leadership and Mathematical Sciences at UM and two school districts (Tipton County, Lauderdale County). The program was designed to deliver a 12-month intensive professional development program for 29 mathematics and science teachers in grades 7-9. The summer institutes (2) included 8 total days, combined with monthly after-school PD sessions spread out across the academic year for a total of 84-hours of professional development programming.

The goals of the mMIND program were to:

1. Increase teacher mathematical content knowledge in algebra and data analysis.
2. Improve teacher pedagogy and pedagogical-content knowledge in algebra and data analysis.
3. Increase mobile technology integration.
4. Increase uses of inquiry strategies (i.e. problem-solving, problem-based learning, project-based learning).
5. Improve teacher attitudes toward interdisciplinary STEM problem- and project-based pedagogy.

Specific program objectives were to:

1. Apply mathematical knowledge for target CCSSM: Grade 7 and 8 Expressions and Equations, Grade 7 and 8 Statistics and Probability, Grade 8 Functions, High School Algebra: Reasoning with Equations and Inequalities and Creating Equations, and High School Functions: Building Functions and Linear, Quadratic & Exponential Models.
2. Integrate data analysis and multi-step problems.
3. Apply instructional strategies to solve multiple concepts problems.
4. Integrate teacher use of mobile technology with pedagogy.
5. Integrate student use of mobile technology for problem solving and representations of knowledge.
6. Match uses of inquiry with curriculum.
7. Integrate inquiry strategies with math and science curricula.
8. Solve interdisciplinary STEM problems.
9. Create interdisciplinary STEM problems.
10. Facilitate interdisciplinary STEM problems.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The mMIND program achieved alignment with the Core Conceptual framework in all five areas, detailed in the program proposal. A **content knowledge** focus was clear, as mathematics concepts of expressions, equations, statistics, probability, functions, and algebra were the main focus. Selected content was aligned with the CCSSM standards.

Active learning was a primary focus for the mMIND program, and problem-based learning (PBL) was a primary mode of delivery of workshop content. This approach was used to allow for in-depth investigations, to encourage collaborations, apply self-directed learning, and provide opportunities for reflection.

Coherence was achieved through a focus on teacher beliefs and attitudes, as well as alignment with standards and partnering district needs. Additionally, content of the program was aligned with state standards and buy-in was achieved from partnering LEAs regarding the content and approach of the program. The program included 48-hour summer institute and 12 hours of face-to-face follow up during the school year, as well as 24 hours of online contact, for total **duration** of the program that is aligned with the framework. **Collective participation** was achieved from including at least two teachers from each school, according to the proposal.

FINDINGS FROM OBSERVATIONS

Twenty-eight teachers in the mMIND program were observed at least once. Ten teachers submitted all three required videos (out of 29 who completed the program), and this is the group that was examined for impact of the program on their instructional practice. Overall, there was significant growth for participants in the UM program participants in all four measured areas: design, implementation, classroom culture and content knowledge.

At baseline, the mMIND program participants demonstrated "elements of effective instruction" on the design of lesson (score of 2.28). By the end of the program, design of lesson mean score had grown to 2.68, representing significant growth ("elements of effective instruction"). The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

mMIND participants' implementation of lesson rating also grew significantly for participants overall across the program from a baseline score of 2.59 ("elements of effective instruction") to a mean score of 3.18 at the end of the program ("beginning stages of effective instruction"). The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

Content knowledge was another area of significant growth for the mMIND program participants. At baseline, the mean score for teachers in the program was 2.89 ("elements of effective instruction"). By the end of the program, the mean had raised to 3.41 ("beginning stages of effective instruction").

This means that during observations, science content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Participants also incorporated some abstraction, theory building, and connections to other disciplines in observed lessons.

mMIND participants also significantly raised their score on the construct of classroom culture from a baseline score of 2.73 ("elements of effective instruction") to a final score of 3.48 ("beginning stages of effective instruction"). Implementation of strategies including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor were not evident through observations. All students were actively engaged in meaningful learning that respected ideas consistently in classroom observations conducted at the end of the program.

FINDINGS FROM SURVEYS

An examination of the surveys that mMIND participants completed in a pre/post manner revealed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 28 participants who completed the pre-survey and 24 who completed the post-survey.

Teacher opinions regarding the importance of use of effective instructional strategies and support necessary to be successful are included in this section of the survey.

Areas of Increased Agreement in teacher opinions related to the teaching of STEM disciplines:

- Importance of considering student prior understanding when planning instruction (93 percent to 100 percent)
- Importance of developing students' conceptual understanding of science/math (97 percent to 100 percent)
- Importance of making connections between science/math and other disciplines (93 percent to 96 percent)
- Importance of having students work in cooperative learning groups (75 percent to 86 percent)
- Importance of having students prepare project/laboratory/research reports (55 percent to 75 percent)
- Importance of engaging students in application of science/math in a variety of contexts (93 percent to 96 percent)
- Importance of using portfolios (34 percent to 42 percent)
- Importance of using informal questioning to assess students (86 percent to 96 percent)
- Importance of having time to collaborate with peers (52 percent to 71 percent)
- Importance of support of the school by local organizations, institutions, and/or business (7 percent to 42 percent)

Areas of Increased Disagreement –The areas of decreased importance for mMIND participants included the following:

- Importance of using computers (79 percent to 71 percent)
- Importance of having students participate in appropriate hands-on activities (97 percent to 92 percent)
- Importance of using performance-based assessments (90 percent to 79 percent)

Instructional Influences were a second area of focus in the survey. mMIND participants reported some shift in influences on STEM instruction at the end of the program. However, in many cases, the majority of participants still felt the same influences inhibiting effective science teaching.

More Influence on Instruction – The following influences were perceived as having a stronger influence on teaching by the end of the program:

- State and/or district curriculum frameworks (43 percent to 48 percent)
- Quality of instructional materials (41 percent to 48 percent)
- State and/or district testing policies and practices (34 percent to 39 percent)
- Management of instructional resources at the district level (18 percent to 50 percent)
- Access to computers for science instruction (31 percent to 61 percent)
- Time for collaboration with other teachers (54 percent to 65 percent)

Less Influence on Instruction – The following influences were perceived as having less of an influence on teaching by the end of the program:

- Consistence of science/math reform efforts with other school/district reforms (56 percent to 52 percent)
- Public attitudes toward reform (41 percent to 27 percent)
- Time for planning and preparing lessons (66 to 59 percent)
- Time for teacher professional development (76 percent to 70 percent)

Teacher Preparedness comprised the third construct of the survey. mMIND program participants experienced growth in perceptions of preparation to deliver effective science instruction in all areas besides one of this construct. That is, more teachers agreed that they were better prepared than when the program began:

- Providing concrete experiences before abstract concepts (76 percent to 88 percent)
- Considering prior understanding when planning curriculum & instruction (89 percent to 92 percent)
- Making connections between science/math and other disciplines (62 percent to 96 percent)
- Using cooperative learning groups (76 percent to 92 percent)

- Using hands-on activities (66 percent to 92 percent)
- Engaging students in inquiry-oriented activities (28 percent to 83 percent)
- Having students prepare project/laboratory/research reports (45 percent to 63 percent)
- Using computers (52 percent to 83 percent)
- Engaging students in applying science/math in a variety of contexts (52 percent to 83 percent)
- Using performance based assessments (10 percent to 79 percent)
- Using informal questioning to assess student understanding (72 percent to 88 percent)
- Leading a class using investigative strategies (72 percent to 83 percent)
- Managing students engaged in hands-on/project-based work (72 percent to 88 percent)
- Helping students take responsibility for their own learning (72 percent to 88 percent)
- Recognizing and responding to student diversity (79 percent to 88 percent)
- Encouraging students' interest in science/math (83 percent to 96 percent)
- Using strategies that encourage participation of females and minorities in science/math (54 percent to 71 percent)

The one area for mMIND participants did not report feeling more prepared at the end of the program was in the use of portfolios (76 percent to 38 percent).

Frequency of Use of Instructional Practices consists of mMIND participant reported frequency of use of specific effective instructional practices.

Increased Use – Teachers reported more frequent use of several practices by the end of the program:

- Using open-ended questions (79 percent to 83 percent)
- Requiring students to use evidence to support their claims (69 percent to 83 percent)
- Allowing students to work at their own pace (59 percent to 61 percent)
- Helping students to see connections between science/math and other disciplines (55 percent to 63 percent)
- Using pre-assessments (55 percent to 75 percent)
- Reading and commenting on student journals (14 percent to 21 percent)

Decreased Use – Teachers reported less frequent use of some practices by the end of the program:

- Encouraging students to consider alternative explanations (59 percent to 54 percent)
- Introducing content through formal presentations (90 percent to 71 percent)
- Embedding assessments in regular class activities (83 percent to 79 percent)

Student Activities are the activities that students are engaged in within the science classroom. mMIND teachers were asked questions regarding the frequency of use of various student activities. Findings revealed participants reported increases in most effective student activities.

Frequent Use – More participants reported frequent use of some student activities by the end of the program:

- Participating in student-led discussions (24 percent to 35 percent)
- Participating in discussions with the teacher to further understanding (66 percent to 71 percent)
- Making formal presentations in class (3 percent to 8 percent)
- Reading other (non-textbook) science/math related materials in class
- (3 percent to 18 percent)
- Working on extended science/math investigations or projects (3 percent to 8 percent)
- Writing reflections in a notebook or journal (7 percent to 21 percent)
- Taking tests requiring open-ended responses (25 percent to 42 percent)
- Working on portfolios (0 percent to 8 percent)
- Participate in field work (0 percent to 8 percent)
- Record, represent, or analyze data (21 percent to 38 percent)

Decreased Use – More mMIND program participants reported decreased use of four student activities that are considered effective practice:

- Taking short-answer tests (52 percent to 43 percent)
- Working in cooperative learning groups (62 percent to 57 percent)
- Sharing ideas or solve problems with each other in small groups (69 percent to 63 percent)
- Designing or implementing their own investigation (7 percent to 8 percent)

Principal Perceptions are the impressions that participants have regarding their administrator's perceptions of the teaching and learning of science/math. mMIND participants revealed very positive feelings regarding this construct.

Areas of Increased Agreement – Teachers agreed that their principal provides encouragement and/or support in the following areas:

- Selecting science/math content and strategies to address individual students' learning (90 percent to 96 percent)
- Encouraging innovative instructional practices (90 percent to 96 percent)
- Providing time for teachers to meet and share ideas (66 percent to 67 percent)
- Encouraging teachers to make connections across disciplines (72 percent to 75 percent)

Accepting the noise of an active classroom (83 percent to 88 percent)

- Providing materials/equipment for science/math (52 percent to 63 percent)
- Acting as a buffer between teachers and external pressures (72 percent to 75 percent)

Parental Support was reported to be very low by participants in the mMIND program. Only 8 percent of participants indicated that parents volunteer to assist with class activities. Additionally, none of the participants reported parents donating money for materials. Only 13 percent reported parents attending parent teacher conferences, and again no participants agreed that parents participate in PTA or math/science nights, or voice support for traditional instructional approaches.

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. mMIND participants' did experience some growth in positive attitudes toward PD across the program (20 percent to 33 percent). However, only 25 percent of participants felt the PD had impacted their content knowledge and only 20 percent agreed the program had great impact on their understandings of how children think about science/math.

FINDINGS FROM CONTENT ASSESSMENT

mMind content assessment data were not available for use for the THEC STEM PD evaluation. As a result, conclusions cannot be drawn for this report regarding the impact of the program on demonstrated teacher content knowledge.

CONCLUDING OBSERVATIONS FOR PROGRAM

The mMIND program delivered 84-hours of content to 29 teachers in secondary mathematics and science. The focus of the program was on mathematical content knowledge and interdisciplinary inquiry through problem-based and project-based learning (PBL) with the integration of mobile device technology. The mMIND project was successful in having 28 of the 30 projected participants complete the program.

Findings indicate that participation in the mMIND program had a significant impact on teacher quality. In addition to the integration of innovative curriculum and delivery, the mMIND program was designed to include the five criteria in the Core Conceptual Framework (content focus, active participation, duration, coherence, and collective participation).

In respect to classroom observation data, mMIND teachers experienced significant gains in all four domains (design, implementation, content, and classroom culture) across the program.

Teachers in this program reported implementation of effective instructional strategies, including those that require a high-level of ability to facilitate student discourse. Teachers also overwhelmingly felt more prepared to deliver effective instruction, with increased in all areas besides one (portfolios) of the constructs. Frequency of use of effective mathematics strategies also increased. Principal support is another area that experienced some growth across the program.

Of the mMind participants, only 25 percent reported the program improved their ability to implement high-quality mathematics instructional materials. Similarly, only 20 percent felt their understandings of how children learn improved, despite significant gains demonstrated in their observed teacher quality and self-reported use of practices. Finally, only 33 percent of participants reported the program had a positive impact on their science content knowledge. This is a second source of data that questions the outcomes of this program in regards to increasing content knowledge. However, in the classroom observations, teachers exhibited adequate knowledge during the three submitted lessons. It may be the case that these teachers did not make gains from where they were previously, which is reflective of the scoring on the pre/post assessment as well.

Overall, this program demonstrated significant gains in teacher quality, teacher opinions, and preparedness. Since mMind content assessment data were not available, no conclusions can be drawn regarding growth in teacher content knowledge.

Program Narrative
University of Memphis
Powell and Larsen, Principal Investigators
Water, Water Everywhere (WWE): Environmental Engineering in Mid-South Waters

PROGRAM SETTING AND PARTICIPANTS

The University of Memphis Water, Water Everywhere (WWE): Environmental Engineering in Mid-South Waters program was a partnership between the UM Education and Arts and Sciences faculty and the Memphis City Schools (MCS) and Shelby County Schools (SCS). This program was focused on development of pedagogical content knowledge for 18 teachers in grades 6-8 science. A ten-day summer workshop was combined along with 16 hours of online work, for a total of 80 contact hours for the program.

The goals of the Water, Water Everywhere project at UM included to:

1. Provide high-quality professional development to middle grades mathematics and science teachers in MCS and SCS.
2. Promote innovative, research-based instructional practices to improve students' learning and achievement in STEM.
3. Increase students' and teachers' engagement with community-based problem solving.

The objectives of the UM program included:

1. To improve teachers' content knowledge in STEM.
2. To improve teachers' pedagogical knowledge in STEM.
3. To increase teachers' awareness of and engagement with environmental issues in their community.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The proposed WWE program aligned four of five components of the Core Conceptual framework, with a focus on science and mathematics **content knowledge** aligned to TN science standards and Common Core State Standards in mathematics. The main focus was on water in the local context with problem-based and project-based learning (PBL) as the main pedagogy.

Active learning was a focus, as participants would learn about water through PBL then would be actively engaged in developing their own PBL units. It was not clear how the actual content and

pedagogy would be delivered to participants beyond the initial workshop, but it seems that a great deal of the time in this program is devoted to teacher development and refinement of curriculum.

Coherence included a focus on providing much-needed authentic learning environments for partnering schools. However, there was no explicit focus on addressing teacher beliefs. The **duration** of the program included a 15-month deployment of the program, including 89 hours of contact with participants, which is consistent with the framework. **Collective participation** was established through the recruitment of two-person teams from each participating school.

FINDINGS FROM OBSERVATIONS

The submission rate for teacher-provided videos for the WWE program had only three participants (out of 18 teachers who completed the program) who submitted all three videos. There were 20 participants who submitted at least one video. Overall, results showed significant growth in one of the four constructs (implementation of lesson) related to desired change in teacher practice and content knowledge across the program.

At baseline, WWE program participants were characterized as being at the "elements of effective instruction" stage on the design of lesson construct (score of 2.30), and slightly increased by the end of program (2.54), but the change was not statistically significant. The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

WWE program participants began the program with an implementation of lesson score of 2.66 ("elements of effective instruction") and significantly improved this to 3.11 ("beginning stages of effective instruction") by the end of program, which was determined to not be statistically significant. The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

Teachers in the WWE program began the program with a content knowledge overall mean score of 2.73 ("elements of effective instruction"). Teachers made slight improvements across the program in this area (but were not statistically significant), realizing an improved mean score of 3.13 ("beginning stages of effective instruction") by the end of the program. This means that some of the time during observations, content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Participants did not incorporate abstraction, theory building, and connections to other disciplines in observed lessons.

Classroom culture rose with statistically significant improvement for WWE participants. At baseline, the mean score for teachers in the program was 3.00 ("beginning stages of effective instruction"), which grew slightly and not significantly to a mean of 3.40 by the end of the program. Implementation of strategies, including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor, were not evident through observations. Active

participation of all students was not observed as being encouraged and respected in a consistent manner.

FINDINGS FROM SURVEYS

An examination of the surveys that WWE participants completed pre- and post-program revealed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 18 participants who completed the pre-survey and 17 who completed the post-survey.

Teacher opinions remained positive at the end of the program as compared to the baseline, prior to participation in the program. There were some areas of slight increase and decrease, which are listed below.

Areas of Increased Agreement – More teachers agreed with the following items after the program:

- Importance of making connections between mathematics and other disciplines (88 percent to 94 percent)
- Importance of having students prepare project/laboratory/research reports (79 percent to 81 percent)

Areas of Decreased Agreement – Less teachers agreed with the following items after the program:

- Importance of having students work in cooperative learning groups (91 percent to 88 percent)
- Importance of engaging students in appropriate hands-on activities (97 percent to 94 percent)
- Importance of engaging students in inquiry-oriented activities (100 percent to 94 percent)
- Importance of using performance-based assessment (97 percent to 94 percent)
- Importance of engaging students in applications of science/math in a variety of contexts (97 percent to 94 percent)
- Importance of using performance based assessment (97 percent to 94 percent)
- Importance of using informal questioning to assess student understanding (97 percent to 94 percent)

Instructional Influences were a second area of focus in the survey. The WWE participants reported growth in agreement regarding the influence of variables on instruction in two main areas: access to computers for instruction (65 percent to 71 percent) and time available for teachers to plan and prepare lessons (64 percent to 53 percent).

Less Influence on Instruction – Teachers reported that the following items had less influence on the use of effective instruction by end of program:

- State and/or district curriculum frameworks (79 percent to 65 percent)
- State and/or district tests policies (47 percent to 29 percent)
- Funds for equipment and supplies (55 percent to 47 percent)
- Time to work with other teachers (68 percent to 53 percent)
- Time for professional development (65 percent to 53 percent)
- Public attitudes toward reform (39 percent to 63 percent)
- Quality of available materials (62 percent to 35 percent)
- Importance that the school places on science/math (88 percent to 65 percent)
- Consistency of science/math reform efforts with other school/district reforms (74 percent to 50 percent)
- Time to plan and prepare lessons (64 percent to 53 percent)
- Public attitudes toward reform (38 percent to 27 percent)

Teacher Preparedness comprised the third construct of the survey. Participants in the WWE program experienced gains in most areas of preparedness across the program, as indicated by more teachers indicating that they were fairly well or well prepared on each construct:

- Providing concrete experiences before abstract concepts (86 percent to 88 percent)
- Developing student conceptual understanding (82 percent to 88 percent)
- Making connections between science/mathematics and other disciplines (74 percent to 76 percent)
- Using hands-on activities (81 percent to 82 percent)
- Engaging students in inquiry-oriented activities (73 percent to 76 percent)
- Having students prepare project/laboratory/research reports (59 percent to 71 percent)
- Using computers (79 percent to 94 percent)
- Engaging students in applying science/math in a variety of contexts (70 percent to 88 percent)
- Using performance-based assessment (74 percent to 76 percent)
- Leading a class using investigative strategies (77 percent to 88 percent)
- Managing a class of students engaged in hands-on/project-based work (83 percent to 94 percent)
- Helping students take responsibility for their own learning (80 percent to 94 percent)
- Using strategies that encourage participation of females and minorities in science/math (67 percent to 76 percent)
- Recognizing and responding to student diversity (83 percent to 94 percent)

There were two areas that the WWE participants experienced a decline in reported preparedness across the program. The first area was the use of cooperative learning groups (86 percent to 76 percent) and the second area was the use of portfolios (33 percent to 27 percent).

Frequency of Use of Instructional Practices consists of teacher-reported frequency of use of specific instructional practices. WWE program participants reported more frequent use of all but three strategies at the end of the program:

- Arranging seating to facilitate student discussion (68 percent to 76 percent)
- Using open-ended questions (88 percent to 100 percent)
- Requiring students to provide evidence to support their claims (91 percent to 100 percent)
- Encouraging students to explain concepts to one another (85 percent to 88 percent)
- Encouraging students to consider alternative explanations (76 percent to 94 percent)
- Allowing students to work at their own pace (65 percent to 76 percent)
- Helping students see connections between math/science and other disciplines (56 percent to 71 percent)
- Using formative assessment (82 percent to 88 percent)

The three strategies that WWE participants reported decreased use of included: introducing content through formal presentation (88 percent to 81 percent), assigning science/math homework (71 percent to 65 percent), and reading and commenting on student reflections from notebooks and/or journals (47 percent to 44 percent).

Student Activities are the activities that students are engaged in within the classroom. WWE participants were asked questions regarding the frequency of use of various student activities. Findings in regards to the frequency of use of effective student activities from baseline to end of program revealed an increase in most areas of this construct for program participants.

Frequent Use – Participants reported more frequent use for the following student activities by end of the program:

- Participating in discussions with the teacher to further science/math understanding (85 percent to 88 percent)
- Working in cooperative learning groups (74 percent to 94 percent)
- Making formal presentations to the class (24 percent to 47 percent)
- Working on solving a real-world problem (59 percent to 65 percent)
- Sharing student ideas or solve problems with each other in small groups (65 percent to 76 percent)
- Designing or implementing his or her own investigation (21 percent to 35 percent)
- Working on extended mathematics investigations or projects

(12 percent to 19 percent)
- Recording, representing, and/or analyzing data (26 percent to 41 percent)
- Working on portfolios (9 percent to 14 percent)
- Participating in field work (0 percent to 12 percent)

The three areas of decline of use of student activities for the WWE program included: reviewing homework (62 percent to 53 percent), following specific instructions in an activity or investigation (65 percent to 56 percent), and writing reflections in a notebook/journal (35 percent to 29 percent).

Principal Perceptions are the impressions that participants have about their administrator's perceptions of the teaching and learning of science/math. Participants in the WWE program had mixed views on support from their leadership from baseline to end of program in most areas.

Areas of Increased Agreement – Participant agreement regarding their principal increased across the program in the following areas:

- Accepting the noise that comes with an active classroom (79 percent to 82 percent)
- Encourages me to observe exemplary science/math teachers (50 percent to 59 percent)

Areas of Decreased Agreement – Participant agreement regarding their principal decreased across the program in the following areas:

- Encourages selection of science/math content and instructional strategies to address individual students' learning (97 percent to 88 percent)
- Encouraging innovative practice (97 percent to 82 percent)
- Enhances the science/math program by providing me with needed materials and equipment (82 percent to 71 percent)
- Provides time for teachers to meet and share ideas with one another (82 percent to 71 percent)
- Encourages teachers to make connections across the disciplines (88 percent to 76 percent)

Parental Support was reported to be very low by participants in the WWE program. None of the participants agreed that parents volunteer to assist with class activities (0 percent). Only a small percentage of WWE program participants agreed parents donate money or materials (12 percent), voice support for various instructional strategies (6 percent), or attend parent-teacher conferences (6 percent), and/or PTA or math/science nights (6 percent).

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. WWE participants reported positive impressions of the impact of the PD at the end of the program in regards to impact on content knowledge (29 percent to 57 percent), as well as the impact on understanding how students learn (50 percent to 83 percent), and ability to implement high-quality science/math instructional materials (50 percent to 78 percent).

FINDINGS FROM CONTENT ASSESSMENT

The seventeen participants in the WWE program completed both the pre- and post-assessment. On the pre-test, teacher average percentage was 56 percent correct. This percentage increased to 64 percent on the post-test. This was determined to be a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGRAM

The WWE professional development program addressed some of the components of the Core Conceptual Framework (e.g., content focus, active participation, duration, and coherence) in the grant proposal as part of their planned focus. As a result of this approach, as well as the format of the delivery of the program, the program failed to have an overall positive impact on teacher quality in more than one area (implementation). There was a significant gain in content knowledge reported on the pre/post assessment from 56 percent correct at baseline to 64 percent correct at the end of the program. WWE experienced some difficulty in recruitment, as only had 18 of the 30 projected participants complete the program.

Teacher survey findings were mostly positive for the WWE program. In their self-reports, participants indicated increased use of all effective strategies for teaching mathematics (e.g., arranging seating for discussion, alternative explanations, connections between mathematics/science and other disciplines, formative assessments) besides the use of portfolios. WWE participants' felt more prepared to implement effective mathematics teaching in their self-reports in all areas besides cooperative learning and student portfolios. There was a decline in perceived instructional influence across the program for WWE teachers in the area of state and local standards and testing, time for planning and collaborating, and the importance the school places on the teaching of science/mathematics.

Teacher perceptions of administrative support were mixed and parental support was reported as very little with 88-100 percent agreement by end of program that parents were not involved in school activities. In regards to participant impressions of the PD program, the majority of WWE participants (83 percent) reported that they felt the program had more impact than previous PD experiences on their ability to understand how children think about/learn science and/or mathematics. Additionally, 57 percent thought the program improved their mathematics content knowledge, and 78 percent believed WWE improved their ability to implement effective mathematics instruction. The WWE teachers did report some positive change in teacher beliefs and use of strategies, though it is unclear exactly why these apparent shifts did not translate into change in practice in more areas of teacher quality.

Program Narrative
University of Tennessee at Chattanooga
Ingraham, Ellis, and Carver, Principal Investigators
Learning Science through Writing

PROGRAM SETTING AND PARTICIPANTS

The Learning Science through Writing program at the University of Tennessee at Chattanooga was a partnership between the Department of English and the School of Education to deliver a grade 6-12 science focused program including the integration of literacy. The professional development program included 100 contact hours for 23 teacher participants. UTC partnered with five LEA's (Tullahoma City, Marion County, McMinn County, Sequatchie County, and Hamilton County) for this program. The program included several virtual online modules, which were completed prior to the summer workshop, which was followed by additional virtual modules and a Saturday workshop.

The objectives of the Learning Science through Writing program included:

1. Introduce Writing to Learn concepts and strategies appropriate for science teaching.
2. Employ the 5E instructional design model, as designed by the Biological Science Curriculum Study.
3. Engage participants in laboratory research and companion writing strategies to model the role of WTL in developing science content knowledge.
4. Use hands-on projects to teach teachers how technology tools can revitalize their teaching and motivate students to develop science knowledge and literacy.
5. Introduce specific methods to assess students' ability to read/view, understand, and apply scientific content in both print and non-print sources.
6. Guide teachers to develop substantial Learning Modules that demonstrate the participants' understanding of how to use WTL methods and the 5E model.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The proposed Learning Science through Writing program aligned with some aspects of the five components of the Core Conceptual framework, with a focus on science **content knowledge** topics including energy, matter, forces in nature, Earth systems, and magnetism. Content was clearly aligned with Tennessee standards. **Active learning** was a focus, including the use of virtual community for the completion of virtual learning modules. In addition, laboratory work and immersion in 5E as pedagogy were included. It is unclear how interactive the online environment was.

Coherence was addressed through an intensive focus on activities designed to challenge current conception of science teaching. However, there was no discussion in the proposal regarding alignment with needs of partnering districts. The **duration** of the program included 100-hours of contact with participants (mostly virtual), which is consistent with the framework. **Collective participation** was described as including teacher-teams from individual schools, which supports sustainability and fidelity of implementation of the program.

FINDINGS FROM OBSERVATIONS

The submission rate for teacher-provided videos for the Learning Science through Writing program was less than desirable, as only seven participants (out of 23 who completed the program) submitted all three videos. There were 18 participants who submitted at least one video. Overall, results showed significant growth in all four constructs (e.g., design of lesson, implementation of lesson, classroom culture, and mathematics content) related to desired change in teacher practice and content knowledge across the program.

At baseline, the Learning Science through Writing program participants were characterized as "elements of effective instruction" on the design of lesson (score of 2.52). However, by the end of the program, the overall score had significantly increased to 3.33 ("beginning stages of effective instruction"). The design of lesson examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

Learning Science through Writing participants began the program with an implementation of lesson at an "elements of effective instruction" level (score of 2.71). At the end of the program the score had increased significantly to 3.69, which is classified as "beginning stages of effective instruction". The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

Teachers in the Learning Science through Writing program began with science content knowledge rated in the "beginning stages of effective instruction" range (score of 3.00), which increased significantly to 3.84 by the end of the program. This means that most of the time during observations, science content delivered was significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Teacher participants occasionally incorporated abstraction, theory building, and connections to other disciplines in observed lessons.

Learning Science through Writing participants also experienced significant change across the program in the final area of classroom culture. The overall group began with a score of 3.03 ("beginning stages of effective instruction") and ended at 3.77. Implementation of strategies including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor were not evident during observations. Active participation of all students was not observed as being encouraged and respected in a consistent manner.

FINDINGS FROM SURVEYS

An examination of pre/post survey data for Learning Science through Writing participants revealed mixed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 23 participants who completed the pre-survey and 18 who completed the post-survey.

Teacher opinions for Learning Science through Writing participants demonstrated both growth and decline in various areas of the construct.

Areas of Increased Agreement – More teachers agreed with the following items after the program:

- Teachers collaborated to share ideas more (42 percent to 68 percent)
- Teachers have necessary supplies and/materials for mathematics (42 percent to 58 percent)
- Teachers have time to collaborate with peers (50 percent to 78 percent)
- The school mathematics program is supported by local organizations, institutions (25 percent to 69 percent)
- Planned to use performance-based assessment (60 percent to 68 percent)
- Importance of developing student's conceptual understanding of mathematics (78 percent to 83 percent)
- Importance of having students prepare project/laboratory/research reports (17 percent to 43 percent)
- Importance of having students use computers (17 percent to 50 percent)
- Importance of having students participate in appropriate hands-on activities (28 percent to 50 percent)
- Importance of having students participate in inquiry-oriented activities (52 percent to 67 percent)
- Importance of engaging students in applications of science/math in a variety of contexts (15 percent to 33 percent)
- Importance of using performance based assessment (58 percent to 69 percent)

Areas of Increased Disagreement – Fewer teachers agreed with the following items after the program:

- Teachers in the school share a common vision of effective science/math instruction (25 percent to 13 percent)
- Importance of connecting math/science to other disciplines (38 percent to 25 percent)

Instructional Influences were a second area of focus in the survey. The Learning Science through Writing participants reported more influence of external variables in this area at the end of the program.

More Influence on Effective Instruction – The following influences were perceived as having a more of an influence by the end of the program:

- State and/or district curriculum frameworks (36 percent to 59 percent)
- State and/or district testing polices and practices (33 percent to 48 percent)
- Access to computers (41 percent to 57 percent)
- Funds for equipment and supplies (50 percent to 79 percent)
- Time to work with other teachers (58 percent to 78 percent)
- Time for professional development (50 percent to 87 percent)
- Public attitudes toward reform (25 percent to 48 percent)
- Quality of available materials (27 percent to 47 percent)
- System of managing instructional resources at district or school level (50 percent to 77 percent)
- Importance of mathematics/science within the school (25 percent to 63 percent)
- Consistency of science/math reform efforts with other school/district reforms (50 percent to 77 percent)

Teacher Preparedness comprised the third construct of the survey. Participants in the Learning Science through Writing program experienced gains in most areas of perceived preparedness across the program, as indicated by a greater percentage of teachers indicating that they were fairly well or well prepared in the following construct areas:

- Providing concrete experiences before abstract concepts (88 percent to 100 percent)
- Developing student conceptual understanding (93 percent to 100 percent)
- Using hands-on activities (71 percent to 100 percent)
- Engaging students in inquiry-oriented activities (63 percent to 100 percent)
- Having students prepare project/laboratory/research reports (58 percent to 100 percent)
- Using computers (62 percent to 100 percent)
- Engaging students in applying science/math in a variety of contexts (82 percent to 97 percent)
- Using performance based assessments (90 percent to 93 percent)
- Leading a class using investigative strategies (73 percent to 78 percent)
- Helping students take responsibility for their own learning (82 percent to 90 percent)
- Recognizing and responding to student diversity (82 percent to 91 percent)
- Using strategies that encourage participation of females and minorities in science/math (73 percent to 88 percent)

Decline in Preparation – In two areas Learning Science through Writing participants' felt less prepared following participation in the program: use of cooperative learning groups (28 percent to 9 percent) and managing a class of students engaged in hands-on/project-based work (35 percent to 11 percent).

Frequency of Use of Instructional Practices consists of teacher-reported frequency of use of specific instructional practices. Learning Science through Writing program participants reported more frequent use of most strategies by the end of the program:

- Introducing content through formal presentations (82 percent to 96 percent)
- Teaching mathematics in real-world contexts (67 percent to 71 percent)
- Encouraging students to explain concepts to one another (82 percent to 89 percent)
- Encouraging students to consider alternative explanations (72 percent to 86 percent)
- Helping students see connections between math/science and other disciplines (71 percent to 87 percent)
- Using formative assessment (64 percent to 88 percent)
- Embedding assessment in regular class activities (77 percent to 89 percent)

Decline in Frequency of Use – A greater percentage of Learning Science through Writing participants reported less frequent use of the following effective instructional practices across the program: arranging seating to facilitate student discussion (31 percent to 18 percent), using open-ended questions (40 percent to 18 percent), and allowing students to work at their own pace (43 percent to 21 percent).

Student Activities are the activities that students are engaged in within the classroom. Learning Science through Writing participants were asked questions regarding the frequency of use of various student activities. Findings in regards to the frequency of use of effective student activities from baseline to end of program revealed an increase of use of strategies in most of the areas of this construct.

Frequent Use – Participants reported more frequent use for these student activities by end of the program:

- Participating in discussions with the teacher to further understanding (82 percent to 88 percent)
- Making formal presentations to the class (9 percent to 43 percent)
- Reading other (non-textbook) science/math related materials in class (0 percent to 37 percent)
- Working on solving a real-world problem (82 percent to 91 percent)
- Engaging in hands-on science/math activities (55 percent to 62 percent)
- Following specific instructions in an activity or investigation (55 percent to 76 percent)
- Designing or implementing his or her own investigation

(27 percent to 48 percent)
- Working on models or simulations (27 percent to 48 percent)
- Recording, representing, and/or analyzing data (9 percent to 37 percent)
- Writing reflections in a notebook or journal (18 percent to 47 percent)
- Working on portfolios (9 percent to 45 percent)
- Taking tests requiring open-ended responses (36 percent to 76 percent)
- Participating in field work (0 percent to 23 percent)

Decreased Use – Teachers reported less frequent use of some effective student activities by the end of the program:

- Working in cooperative learning groups (43 percent to 27 percent)
- Sharing student ideas or solve problems with each other in small groups (39 percent to 20 percent)
- Taking short-answer tests (48 percent to 30 percent)

Principal Perceptions are the impressions that participants have about their administrator's support for the teaching and learning of science/mathematics. Participants in the Learning Science through Writing program had very positive views of their leadership.

Areas of Increased Agreement – Teachers agreed their principal provided encouragement and/or support in the following areas:

- Encouraging selection of science/math content and instructional strategies to address individual students' learning (33 percent to 61 percent)
- Encouraging the implementation of current national standards in science/math education (67 percent to 78 percent)
- Providing materials/equipment for science/math (33 percent to 40 percent)
- Providing time for teachers to meet and share ideas (33 percent to 40 percent)
- Encouraging teachers to observe other exemplary teachers (33 percent to 40 percent)
- Acting as a buffer between teachers and external pressures (50 percent to 70 percent)

Parental Support was reported to be very low by participants in the Learning Science through Writing program. In fact, participants indicated (baseline and end of program) that few parents volunteer to assist with class activities, donate money for materials, voice support for various instructional strategies, or attend parent-teacher conferences, and/or PTA or math/science nights (80 percent agreement).

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. Learning Science through Writing participants (23 percent) reported positive impressions of the impact of the PD at the end of the program in regards to impact on content knowledge (an increase from 18 percent at baseline).

The impact on understanding how students learn (18 percent to 33 percent), and ability to implement high-quality science/math instructional materials (20 percent to 41 percent) grew from baseline at the end of the program.

FINDINGS FROM CONTENT ASSESSMENT

The Learning Science through Writing program had 13 participants that completed both the pre- and post-assessment. On the pre-test, teacher average percentage was 81 percent correct. This percentage increased to 85 percent on the post-test. Though this was a slight increase, it was not considered a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGRAM

The Learning Science through Writing professional development program addressed some aspects of the components of the Core Conceptual Framework (e.g., content focus, active participation, duration, and coherence) in the grant proposal as part of their planned focus. Program outcomes indicate the Learning Science through Writing intervention had a significant impact on teacher quality (e.g., ability to implement the lessons, classroom culture, and math content knowledge) but did not have a significant impact on content knowledge. Learning Science through Writing was successful in having 23 of the 25 projected participants complete the program.

Teacher reported opinions and perceptions of preparation, as well as frequency of use of strategies revealed some growth for participants in the Learning Science through Writing program. However, one area that was seen as a decline in preparedness, frequency of use, and student activities across the program was in the use of cooperative learning environments. There was less frequency of use of open-ended questioning, arranging seats to facilitate discussion, and allowing students to work at their own pace. Further, management of the classroom was an area that also decreased in perceptions of preparation for participants in the Learning Science through Writing program.

Teacher perceptions of administrative support were positive. Agreement grew across the program regarding principal support of innovative instructional practices, provisions for materials and equipment, making connections across disciplines, time for collaboration, the noise level of active classrooms, and the level of administrative buffering between teachers and external forces. However, parental support was reported as very little on all constructs by end of program (80 percent agreement). In regards to participant impressions of the PD program, one-third of teacher participants (33 percent) reported that they felt the program had more impact than previous PD experiences on their ability to understand how children think about/learn science and/or mathematics. Additionally, 41 percent agreed the PD program had improved their ability to implement effective instruction. However, only 23 percent of Learning Science through Writing teachers felt the PD program had improved their content knowledge. Overall, the Learning Science through Writing program made gains in teacher quality and increased reported use of effective instructional strategies in most areas. The program did not significantly impact content knowledge. This may be due to the high percentage of participants who passed the pre-test (81percent) and the level of or focus of content not being closely aligned with the content needs of participants.

Program Narrative
University of Tennessee at Martin (UTM)
Cox and Withmer, Principal Investigators
STEM Integration for Middle School Teacher Academy (SIMS-TA)

PROGRAM SETTING AND PARTICIPANTS

The STEM Integration for Middle School Teacher Academy (SIMS-TA) program at the University of Tennessee at Martin was a partnership between the Educational Studies Department and the Engineering Department to deliver a grade 5-9 focused program. The professional development program included 120 contact hours for 28 teacher participants. UTM partnered with three LEA's (Dickson County, Henderson County, and Jackson-Madison County) for this program. There were summer workshop days conducted, along with attendance at TSTA, and a spring workshop day, as well as online discussion boards and wikis.

The goals of the SIMS-TA project included:

1. To increase teacher understanding of the interconnection of STEM and provide instructional strategies for teaching integrated STEM in the middle grades.
2. Increase teacher content knowledge of STEM.
3. Establish Professional Learning Communities within and among participating schools, which can expand to include other educators across the state after the program ends.
4. To construct a model of professional development that can be duplicated with other groups of teachers and shared with the Tennessee STEM Innovation Network.
5. To develop and test lessons for teaching integrated STEM in the middle grades 5-9 that will be shared with the Tennessee STEM Innovation Network.

The objectives of the SIMS-TA program included enabling teachers to:

1. Develop integrated STEM lessons that address standards for science and common core math and language arts fort he grade levels at which they teach.
2. Deliver integrated STEM lessons using inquiry, problem-based learning, and higher order thinking skills.
3. Effectively use technology in their teaching including iPads, SMARTBoards, student response systems, and electronic communication.
4. Assess student learning through student pre/post-tests of content knowledge and analyze the results using basic statistics.
5. Establish professional learning communities through which they will collaborate with other teachers in their school and district and teachers in other districts.

PROGRAM ALIGNMENT WITH CORE CONCEPTUAL FRAMEWORK

The proposed SIMS-TA program aligned with four of the five components of the Core Conceptual framework, with a focus on science **content knowledge** delivered in all three main areas (life, physical, and Eath/space) and aligned with the Tennessee science standards. The program also had a secondary focus on technology, engineering, and mathematics driven by the Common Core State Standards in mathematics and English/language arts. **Active learning** was a focus, including the use of inquiry-based and problem solving as the foundation for all content delivery in the PD. Teachers developed integrated STEM model lessons using the 5E Learning Cycle. Technology was also infused to further establish the active learning environment through the use of STEM notebooks for example.

Coherence was only discussed vaguely in the proposal in terms of changing teacher practice with no attention to addressing beliefs or aligning with needs of partnering districts in very specific ways. The **duration** of the program included 120-hours of contact with participants, which is consistent with the framework. **Collective participation** was approached through a district level PLC strategy, rather than school level. Three teachers from science and math from each district in each grade level comprised the PLC.

FINDINGS FROM OBSERVATIONS

The submission rate for teacher-provided videos for the SIMS-TA program had 18 participants who submitted all three videos (out of 28 who completed the program). There were 29 participants who submitted at least one video. Overall, results significant growth in all of the four constructs (e.g., design of lesson, implementation of lesson, classroom culture, and mathematics content) related to desired change in teacher practice and content knowledge across the program.

At baseline, SIMS-TA program participants were characterized as being at the "elements of effective instruction" stage on the design of lesson construct (score of 2.45), increasing significantly by the end of program to "beginning of effective instruction" (3.69). The design of lesson construct examines the extent of planning, organization, resources, equity, collaboration, flow, assessments, and sense making that takes place in the lesson delivery.

The SIMS-TA program participants began the program with an implementation of lesson score of 2.62 ("elements of effective instruction") and improved this to 3.44 ("beginning of effective instruction") by the end of program, which was determined to be statistically significant. The implementation of lesson construct examines level of investigative mathematics/science in the lesson, quality of classroom management strategies, pace of the lesson, ability to modify instruction based upon student understanding, teacher questioning strategies, and formative assessments.

Teachers in the SIMS-TA program began the program with a content knowledge overall mean score of 2.92 ("elements of effective instruction"). Teachers made statistically significant improvements across the program in this area, realizing an improved mean score of 3.66 ("beginning of effective instruction") by the end of the program. This means that during observations, content delivered was

significant and worthwhile and appropriate for the developmental needs of students. Teacher-provided content was accurate, and some connections to real-world contexts were used. Participants often incorporated abstraction, theory building, and connections to other disciplines in observed lessons.

Classroom culture rose with statistically significant improvement for SIMS-TA participants. At baseline, the mean score for teachers in the program was 2.84 ("elements of effective instruction"), which grew significantly to a mean of 3.64 ("beginning of effective instruction") by the end of the program. Implementation of strategies, including collaborative learning, centering instruction on student generated questions, and ideas and intellectual rigor, were evident in observations. Active participation of all students was observed as being encouraged and respected in a consistent manner.

FINDINGS FROM SURVEYS

An examination of pre/post survey data for SIMS-TA participants revealed mixed findings related to teacher opinions, frequency of use in instructional practices, student activities, instructional influences, teacher preparedness, principal perceptions, parental support, and professional development experiences. There were 28 participants who completed the pre-survey and 28 who completed the post-survey.

Teacher opinions for SIMS-TA participants demonstrated both growth and decline in various areas of the construct.

Areas of Increased Agreement – More teachers agreed with the following items after the program:

- Importance of considering students prior understanding when planning curriculum and instruction (94 percent to 100 percent)
- Importance of having students participate in inquiry-oriented activities (96 percent to 100 percent)
- Importance of having students use computers (78 percent to 87 percent)
- Teachers collaborated to share ideas more (82 percent to 90 percent)
- Teachers have time to collaborate with peers (30 percent to 47 percent)
- The school mathematics program is supported by local organizations, institutions (14 percent to 30 percent)

Areas of Increased Disagreement – Fewer teachers agreed with the following items after the program:

- Importance of having students prepare project/laboratory/research reports (78 percent to 73 percent)
- Importance of engaging students in application of science/math in a variety of contexts (96 percent to 90 percent)
- Importance of using informal questioning to assess student learning (100 percent to 93 percent)

Instructional Influences were a second area of focus in the survey. The SIMS-TA participants reported mixed experiences with variables in this area at the end of the program.

More Influence on Effective Instruction – The following influences were perceived as having a more of an influence by the end of the program:

- State and/or district curriculum frameworks (37 percent to 45 percent)
- System of managing instructional resources at district or school level (23 percent to 39 percent)
- Importance of mathematics/science within the school (42 percent to 50 percent)

Less Influence on Effective Instruction – The following influences were perceived as having less of an influence on the program by the end of the program:

- State and/or district testing polices and practices (27 percent to 23 percent)
- Funds for equipment and supplies (35 percent to 29 percent)
- Time to work with other teachers (43 percent to 27 percent)
- Time to plan and prepare lessons (48 percent to 30 percent)
- Time for professional development (54 percent to 23 percent)
- Public attitudes toward reform (17 percent to 15 percent)
- Quality of available materials (48 percent to 37 percent)
- Consistency of science/math reform efforts with other school/district reforms (36 percent to 32 percent)

Teacher Preparedness comprised the third construct of the survey. Participants in the SIMS-TA program experienced gains in most areas of perceived preparedness across the program, as indicated by a greater percentage of teachers indicating that they were fairly well or well prepared in the following construct areas:

- Providing concrete experiences before abstract concepts (82 percent to 87 percent)
- Considering student prior understanding when planning curriculum and instruction (78 percent to 87 percent)
- Making connections between science/math and other disciplines (82 percent to 87 percent)
- Using hands-on activities (82 percent to 87 percent)
- Having students prepare project/laboratory/research reports (58 percent to 63 percent)
- Using computers (82 percent to 83 percent)
- Engaging students in applying science/math in a variety of contexts (66 percent to 87 percent)
- Using performance based assessments (70 percent to 80 percent)
- Using portfolios (38 percent to 43 percent)

- Leading a class using investigative strategies (78 percent to 83 percent)
- Helping students take responsibility for their own learning (80 percent to 90 percent)
- Recognizing and responding to student diversity (78 percent to 87 percent)
- Using strategies that encourage participation of females and minorities in science/math (64 percent to 77 percent)
- Encouraging student interest in science/math (92 percent to 97 percent)

Decline in Preparation – In two areas SIMS-TA participants' felt less prepared following participation in the program: use of informal questioning to assess student learning (96 percent to 83 percent) and managing a class of students engaged in hands-on/project-based work (90 percent to 83 percent).

Frequency of Use of Instructional Practices consists of teacher-reported frequency of use of specific instructional practices. SIMS-TA program participants reported more frequent use of most strategies by the end of the program:

- Introducing content through formal presentations (82 percent to 86 percent)
- Arranging seating to facilitate student discussion (62 percent to 80 percent)
- Using open-ended questions (80 percent to 83 percent)
- Requiring students to supply evidence to support their claims (72 percent to 83 percent)
- Encouraging students to explain concepts to one another (76 percent to 93 percent)
- Encouraging students to consider alternative explanations (72 percent to 83 percent)
- Allowing students to work at their own pace (70 percent to 73 percent)

Decline in Frequency of Use – A greater percentage of SIMS-TA participants reported less frequent use of the following effective instructional practices across the program: introducing content through formal presentations (84 percent to 69 percent), using pre-assessments (82 percent to 70 percent), and assigning science/math homework (64 percent to 59 percent).

Student Activities are the activities that students are engaged in within the classroom. SIMS-TA participants were asked questions regarding the frequency of use of various student activities. Findings in regards to the frequency of use of effective student activities from baseline to end of program revealed an increase of use of strategies in most of the areas of this construct.

Frequent Use – Participants reported more frequent use for these student activities by end of the program:

- Participating in student led discussions (59 percent to 83 percent)
- Working in cooperative learning groups (78 percent to 87 percent)
- Making formal presentations to the class (20 percent to 37 percent)
- Reading other (non-textbook) science/math related materials in class

(50 percent to 63 percent)

- Sharing student ideas or solve problems with each other in small groups (63 percent to 87 percent)
- Designing or implementing his or her own investigation (14 percent to 37 percent)
- Working on models or simulations (16 percent to 40 percent)
- Working on extended science/math investigations or projects (12 percent to 27 percent)
- Recording, representing, and/or analyzing data (40 percent to 47 percent)
- Writing reflections in a notebook or journal (46 percent to 53 percent)
- Participating in field work (4 percent to 17 percent)

Decreased Use – Teachers reported less frequent use of some effective student activities by the end of the program:

- Taking tests requiring open-ended responses (42 percent to 37 percent)
- Taking short-answer tests (54 percent to 37 percent)

Principal Perceptions are the impressions that participants have about their administrator's support for the teaching and learning of science/mathematics. Participants in the SIMS-TA program had mostly positive views of their leadership despite decline in some areas across the program.

Areas of Increased Agreement – Teachers agreed their principal provided encouragement and/or support in the following areas:

- Providing materials/equipment for science/math (43 percent to 60 percent)
- Encouraging teachers to observe other exemplary teachers (56 percent to 63 percent)

Areas of Decreased Agreement – Fewer teachers agreed their principal provided encouragement and/or support in the following areas at the end of the program:

- Encouraging selection of science/math content and instructional strategies to address individual students' learning (86 percent to 73 percent)
- Encouraging the implementation of current national standards in science/math education (82 percent to 77 percent)
- Providing time for teachers to meet and share ideas (60 percent to 57 percent)
- Encourages teachers to make connections across the disciplines (80 percent to 67 percent).

Parental Support was reported to be very low by participants in the SIMS-TA program. At the end of the program, only three percent of participants indicated parents volunteer to assist with class activities, and only 10 percent indicated parents donate money for materials. Further, only 30 percent of participants reported parents attend parent-teacher conferences and 13 percent agreed

parents attend PTA or math/science nights. Finally, 17 percent of participants agreed parents voice support for STEM instruction.

Professional Development (PD) Experiences is an area of the survey where participants indicate their impressions of the ability of the PD program to increase their skills. SIMS-TA participants (31 percent) reported positive impressions of the impact of the PD at the end of the program in regards to impact on content knowledge (an increase from 14 percent at baseline). The impact on understanding how students learn was also an area of growth for SIMS-TA (18 percent to 33 percent). Finally, the ability to implement high-quality science/math instructional materials was also an area of growth for participants (19 percent to 30 percent).

FINDINGS FROM CONTENT ASSESSMENT

The SIMS-TA program had 28 participants who completed the pre/post assessment developed by the SIMS-TA program. On the pre-test, teacher average percentage was 56 percent correct. This percentage increased to 71 percent on the post-test. This was considered a statistically significant increase.

CONCLUDING OBSERVATIONS FOR PROGRAM

The SIMS-TA professional development program addressed four of five aspects of the components of the Core Conceptual Framework (e.g., content focus, active participation, and duration) in the grant proposal as part of their planned focus. Program outcomes indicate the SIMS-TA intervention had a statistically significant impact on teacher quality (e.g., ability to implement the lessons, classroom culture, and math content knowledge) and content knowledge (increase from 56 percent at baseline to 71 percent at end of program). UTM was successful in having 28 of the 30 projected participants complete the program.

Teacher reported opinions and perceived preparedness showed mostly positive growth. Additionally, frequency of use of instructional activities aligned with effective teaching also increased except for in the areas of assessing student progress through formative and open-ended means. Teacher perceptions of administrative support were positive in most areas except for: encouragement to make connections across disciplines, providing time for collaboration, and support for differentiating instruction.

Parental support was reported as minimal, as only 30 percent of participants reported parents attend parent-teacher conferences, which was the strongest area of agreement in this construct. All other items were reported to be much lower. In regards to participant impressions of the PD program, nearly a third of teacher participants (31 percent) reported that they felt the program had more impact than previous PD experiences on their ability to understand how children think about/learn science and/or mathematics. Only 33 percent felt the PD improved their content knowledge, and even less (30 percent) reported the PD improved their ability to implement effective instruction. Overall, the SIMS-TA program was viewed as having a significant impact on teacher quality, content knowledge, and some aspects of teacher preparedness and use of effective instructional strategies.