CEISMC = Center for Education Integrating Science, Mathematics and Computer Science (and Engineering)

Building on STEM OUTREACH TO K-12, especially in Mathematics

October 4, 2011

This work is partially funded through the Georgia Race to the Top Award from the U.S. Department of Education

Who We Are

- Unit in the Georgia Tech, College of Sciences
- Created in 1991—3 staff
- Last Year –26 staff
- June 2011—40 staff
- Payroll FY12 of $2.5 Million
- Much collaboration within and without GT

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Mission

- To ensure that K-12 students in Georgia receive the best possible preparation and opportunities in science, technology, engineering and mathematics (STEM) as they seek their place in the modern world.

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Rationale (Scary Stuff)

- *Rising Above the Gathering Storm*
- K-12 student rankings vs. international peers
- National Assessment of Educational Progress
- STEM literacy of general population
- STEM teacher shortage

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Major Emphases of CEISMC

- #1 - Depth and breadth of STEM teacher content knowledge and understanding for the Common Core Standards
- #2 - Student Engagement and Interest in STEM Fields

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Teacher Certification Partnerships

- NSF Robert Noyce Scholarship Grants
  - Kennesaw State University
    - Chemistry and Physics
    - Mathematics
  - Georgia State University (GSU)
    - Broad-field Science
- Joint GT-GSU BS/MAT Program

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SLIDER

- $3.5 million, five year grant from NSF's Discovery Research K-12 Program (SLIDER)
- Design 8th Grade Physical Science Curriculum
  - Robotics & Engineering Design
  - LEGO Mindstorm
  - Project-based Learning (Learning by Design)

SLIDER®
Science Learning Integrating Design, Engineering, & Robotics

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SLIDER

- Study effectiveness in different settings.
  - Content Knowledge
  - Student Engagement
  - Higher order thinking skills
  - Differences between demographic groups
  - Creativity
  - Longitudinal effect
  - Implement in 3 "real" schools

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Science Learning Integrating Design, Engineering, & Robotics

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Mentoring Programs

- All Kids Count (AKC): Mathematics tutoring of K-8 students

- Pathways Program: Weekly 1-on-1 sessions by GT students with high school juniors and seniors.

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Georgia Race to the Top (RT3)

- **Georgia Race to the Top Program**
  - US Department of Education--$400 million to Georgia
  - $7.5 million sub-award to GT (through CEISMC) over 4 years
  - Online Professional Development for Teachers
    - High School Math 4 Course (Based on Operations Research, MINDSET Project)
    - Algebra
    - Data Analysis & Probability
  - Engineering-based middle school course (8th Grade Integrated STEM)
  - Online Courses for Students
    - Math 4 Course (Based on Operations Research, MINDSET Project)
    - Others (Coming Soon!)
  - Support for Use of Educational Technology

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Teacher Professional Development

- Research Experiences for Teachers
  - Georgia Intern Fellowships for Teachers (GIFT)
- Traditional face-to-face programs
  - GA Department of Education Math/Science Partnership and Teacher Quality Grants
- Online professional development
  - NASA Electronic Professional Development Network (and also currently part of RT3)

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Georgia Intern Fellowships for Teachers (GIFT)

- Created in 1991
- Goal: To increase teacher content knowledge and to gain practical examples for application in the classroom.
- Paid 4-7 week summer internships for STEM teachers in university research labs and industrial labs. High School students can be included.
- Offers real world immersion into STEM.
- Over 1,500 teachers total, with 90 in 2011.

Teacher at Georgia Tech MSE lab .

GIFT
GEORGIA INTERN FELLOWSHIPS TEACHERS

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Georgia Intern Fellowships for Teachers (GIFT)

Teachers, Schools, and Students
Summer 2011

- 90 Middle and High School Teachers
- 34 School Districts represented
- 27 High School Students conducted research along side teachers at laboratories at Georgia Tech.

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Georgia Intern Fellowships for Teachers (GIFT)

Corporate and Academic Lab Placements 2011

- **2011 Corporate Fellowship Partners:** Arch Chemicals, Arizona Chemical Company, Bold Formulators, LLC, CAMotion, Inc., CBJ Industries, ConAgra Foods, DuPont Crop Protection Industries, Georgia Power, Integrated Science Systems, NASA/ORBIT Education, Inc., PCC Airfoils LLC, Tift Regional Medical Center, and United Parcel Service (UPS)

- **2011 University Fellowship Partners:** Emory University, Georgia Tech, University of Georgia's Tifton, Griffin and Athens campuses, and Valdosta State University

- **2011 Foundation/Agency Fellowship Sponsors:** Cisco Foundation, National Science Foundation, Siemens Foundation, The UPS Foundation, Teacher Quality – Higher Education Program (State of Georgia), Tellus Science Museum, USDA/ARS, and the United States Department of Transportation

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Math-Science Partnerships

Goals

- Improve the content knowledge of teachers
- Improve performance of students in the areas of mathematics and science
- Improve and upgrade the status and stature of mathematics and science teaching
- Focus on the education of mathematics and science teachers as a career-long process;
- Bring mathematics and science teachers together with scientists, mathematicians, and engineers to improve their teaching skills
- Provide summer institutes and ongoing professional development for teachers to improve their knowledge and teaching skills.

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Math-Science Partnerships

Current Projects

- Atlanta Public Schools
  - High School Math – Probability, Statistics & Operations Research
  - Middle & High School Science – Physical Science & Physics
- DeKalb County Schools
  - Elementary & Middle School Math – Various Common Core Standards
  - 9th Grade Math – Probability & Data Analysis
  - Middle School Science – Earth Science & Physical Science
- Rockdale County Schools
  - Elementary, Middle & High School Math
  - Middle School Science
- Gwinnett County Schools
  - Elementary School Math & Science – Build Content Leadership

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NASA ePDN

Electronic Professional Development Network

Georgia Tech

- $3 million contract for 4 years to develop online courses for teachers
- GT Partner—DLPE (Nelson Baker PI)
- 33 courses and 829 total enrollments since start (Oct, 2009)
- Teachers have come from 46 of the states and Puerto Rico as well as Mexico, Brazil and the Ukraine

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NASA ePDN

Electronic Professional Development Network

Georgia Tech

Asynchronous online courses

- 4-5 week courses; 5 hours/week
- Emphasis is on collaboration & interactions
- No fees; continuing education units awarded

Topics

1. Robotics
2. Project-Based Inquiry Learning
3. Technology Integration
4. Statistics & Data

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Statistics & Data Analysis

- Course I – One-Variable Data Analysis, Sampling & Survey Design
- Course II – Two-Variable Data Analysis & Experimental Design
- Course III – Probability
- Course IV – Classroom Practicum
- Course V – Statistical Inference

Calculus at a Distance

In 2004, a discussion between a CEISMC staff member and a Fulton County curriculum coordinator revealed a need for students needing advanced preparation beyond AP Calculus.

In 2005, two semester-long college post AP calculus courses were offered.

- Georgia Tech Calculus II – Linear Algebra & Series
- Georgia Tech Calculus III – Multivariable Calculus

Textbooks (at the level of)

- Calculus, One and Several Variables by Salas, Hille, and Etgen
- Beginning with Linear Algebra by Carlen and Carvalho

Synchronous Environment

- Live video-teleconferencing equipment (classes captured for later playback)
- Tablet PCs to support handwritten as well as software-based problem solving

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Calculus at a Distance

Calculus II Content

- Taylor polynomials and approximation
- Infinite series & power series
- Numerical integration and ordinary differential equationsvectors and
- Matrices
- Systems of linear equations
- Determinants and cross products
- Eigenvalues and eigenvectors

Calculus III Content

- Linear approximation and Taylor's theorems
- Lagranage multiples
- Vector analysis including the theorems of Green, Gauss and Stokes.

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Calculus at a Distance

Table 1—Enrollment in Distance Calculus Program 2005-2009

Table 2—Calculus Grades for Distance and On-Campus Students, 2005-2009

Semester	Type	# Students	A	B	C	D/F/I	Withdrew
Fall 2005-06	Distance	34	79.4%	20.6%			
Spring 2005-06	Distance	32	81.3%	15.6%		3.1%	
Fall 2006-07	Distance	79	89.9%	7.6%	2.5%		
Spring 2006-07	Distance	71	90.1%	7.0%	1.4%	1.4%	
Fall 2007-08	Distance	95	83.2%	15.8%			1.1%
Spring 2007-08	Distance	82	85.4%	13.4%	1.2%		
	On-campus	200	35.5%	44.5%	16.5%	3.5%	
Fall 2008-09	Distance	205	87.3%	9.3%	2.0%	1.5%	

Enrollment in 2011 - 304

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Proofs and Problem Solving in Number Theory and Algebra

- The Course: PPNTA (Proofs and Problem Solving in Number Theory and Algebra)
- Location: A HS in Metro-Atlanta focusing on Math Science and Technology School
- Personnel
  - Daniel Connelly (a Georgia Tech graduate student) taught the one semester course under the direction of
  - Dr. Richard Millman (Professor of Mathematics at GT, and PI on the RT3 grant).
  - Dr. Cher Hendricks is the evaluator of PPNTA subproject.
- Funded completely by RT3

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Proofs and Problem Solving in Number Theory and Algebra

Students

- There were 19 students consisting of one junior and 18 seniors in HS

- All students have done well in Georgia Tech's 2nd and 3rd semester of calculus and a high school differential equations course.

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Proofs and Problem Solving in Number Theory and Algebra

Topics Covered (Initially):

- Basic properties of integers including Divisibility and prime numbers
- The Fundamental Theorem of Arithmetic
- Diophantine equations
- Equivalence relations and their applications
- Basic properties of polynomials
- Divisibility of polynomials, divisibility methods, and polynomial roots
- Applications to combinatorics
- Other subjects may appear depending on time
- (Unpublished Text): Problems in Numbers and Algebra by Richard S. Millman, Peter Shiue, and Eric B. Kahn, revised 7/2011

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Proofs and Problem Solving in Number Theory and Algebra

Topics Covered (additions):

- introduction to group theory
- equivalence relations
- cryptology (an applied area coming from a theoretical background)
- an introduction to modular arithmetic as a more abstract part of number theory
- Introduction of Klein's Erlangen Program and Lie Groups (to be a surface and a group is exciting)

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Proofs and Problem Solving in Number Theory and Algebra

Goals

- Be able to construct valid proofs and identify the fallacious reasoning of incorrect proofs.
- Learn a variety of methods to construct proofs (direct, reduction ad absurdum, etc.)
- Recognize the notion of elegance in proofs
- Be able to construct examples that provide insights into (and a platform for) designing proofs (called "synecdoche" in literature.)
- Have the ability to argue intellectually about mathematics with others. Conversations could cover oral proofs or directions of where to go.

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Proofs and Problem Solving in Number Theory and Algebra

- Understand what idea motivated their proofs.
- Recognize that proofs and problem solving are not an "ask/immediate answer" phenomenon. (The depth of mathematics.)
- Learn/revisit some facts from elementary number theory and algebra in more depth.
- Be able to work individually and in teams to solve mathematical problems from number theory and algebra.
- Be prepared for higher-level abstract mathematics courses (or, said in a fancy way to impress parents and siblings) begin to prepare for the culture of meta-mathematics.
- Develop a mathematical habit of the mind and discuss what it means to you.

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Proofs and Problem Solving in Number Theory and Algebra

Some References/Presentations

- "Advanced High School Course in Number Theory on Students' Mathematical Self-Efficacy", Psychology of Mathematics Education (PME/NA), Reno, NV (C. Hendricks, R. Millman), 10/11

- "A Meta-analysis of mathematics Teachers n the Industrial Internship GIFT Program", Psychology of Mathematics Education (PME), Ankara, Turkey, (R. Millman, M. Alemdar B. Harris), 7/11

- "A Meta-analysis of Mathematics Teachers of the GIFT Program Using Success Case Methodology", Educational Interfaces Between Math and Industry, ICMI-ICIAM (R. Millman, M. Alemdar and B. Harris), Lisbon, Portugal, *Proceedings of the ICMI-ICIAM Study Conference*, "Educational Interfaces between Mathematics and Industry", ed. Araujo, Fernandes, Azevedo, Rodrigues, 2010, p. 369-376.

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Contacts

Richard Millman and Paul Myers
CEISMC, Georgia Tech
richard.millman@ceismc.gatech.edu
paul.myers@ceismc.gatech.edu
www.ceismc.gatech.edu

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