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
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.
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
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
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
$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

- 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
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.
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
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)
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.
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.

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
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.
Math-Science Partnerships

Current Projects

- Atlanta Public Schools
  - 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
- Gwinnet County Schools
  - Elementary School Math & Science – Build Content Leadership
$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
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
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
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
Calculus at a Distance

Calculus II Content

• Taylor polynomials and approximation
• Infinite series & power series
• Numerical integration and ordinary differential equations
• Vectors and matrices
• Systems of linear equations
• Determinants and cross products
• Eigenvalues and eigenvectors

Calculus III Content

• Linear approximation and Taylor’s theorems
• Lagrange’s multiples
• Vector analysis including the theorems of Green, Gauss and Stokes.
## Calculus at a Distance

### Table 1—Enrollment in Distance Calculus Program 2005-2009

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Withdrawn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

## Enrollment in 2011 - 304
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
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.
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
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)
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.
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.
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

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