



# Improving K-12 STEM Education

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**CEISMC**

Georgia Tech Center for Education Integrating  
Science, Mathematics, and Computing

# CEISMC History

- Founded in 1991 as outreach center of College of Sciences at Georgia Tech
- Initial state budget \$630K; 6 FTE
- Played significant role in GA Race to the Top Grant 2010-2015; first NSF grants—expanded scope and size; 30 FTE; \$2.3M
- Adopted partnership model and expanded scope in GA in 2016; 38 FTE; \$7.4M
- Moved to Provost Office in 2018; 75 FTE; \$14.0M
- Moved to the Division of Lifetime Learning in 2023; 105 FTE; \$17.9M

CENTER FOR EDUCATION INTEGRATING  
SCIENCE, MATHEMATICS, AND COMPUTING



CELEBRATING OVER 30 YEARS OF  
EDUCATIONAL RESEARCH AND OUTREACH



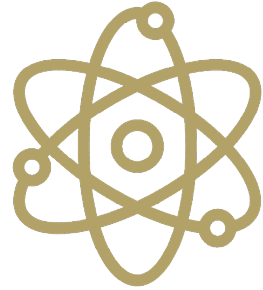
# Mission

**The Center for Education Integrating Science, Mathematics, and Computing (CEISMC) enhances PreK-12 and postsecondary STEM education by drawing upon the expertise and scholarly contributions of the Georgia Tech community. CEISMC advocates for and leads systemic changes to increase STEM interest and achievement for all students, especially those underrepresented in STEM. CEISMC's research efforts allow for the identification and dissemination of evidence-based best practices in STEM education.**

# Vision

**CEISMC will define and exemplify effective STEM education to maximize students' readiness to excel in a rapidly changing world. We are leaders in influencing significant curricular, pedagogical, social and policy reform efforts that will shape STEM education and workforce development.**

# Goals



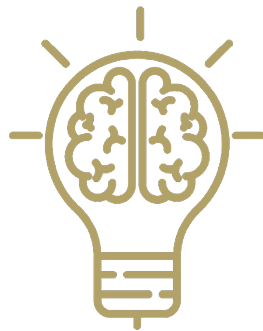
**Inspiring STEM  
Enrichment and  
Outreach for  
Students**



**Intensive  
Professional  
Development for  
STEM Educators**



**Local and  
Sustainable  
Community  
Partnerships**



**Innovative  
STEM  
Education**



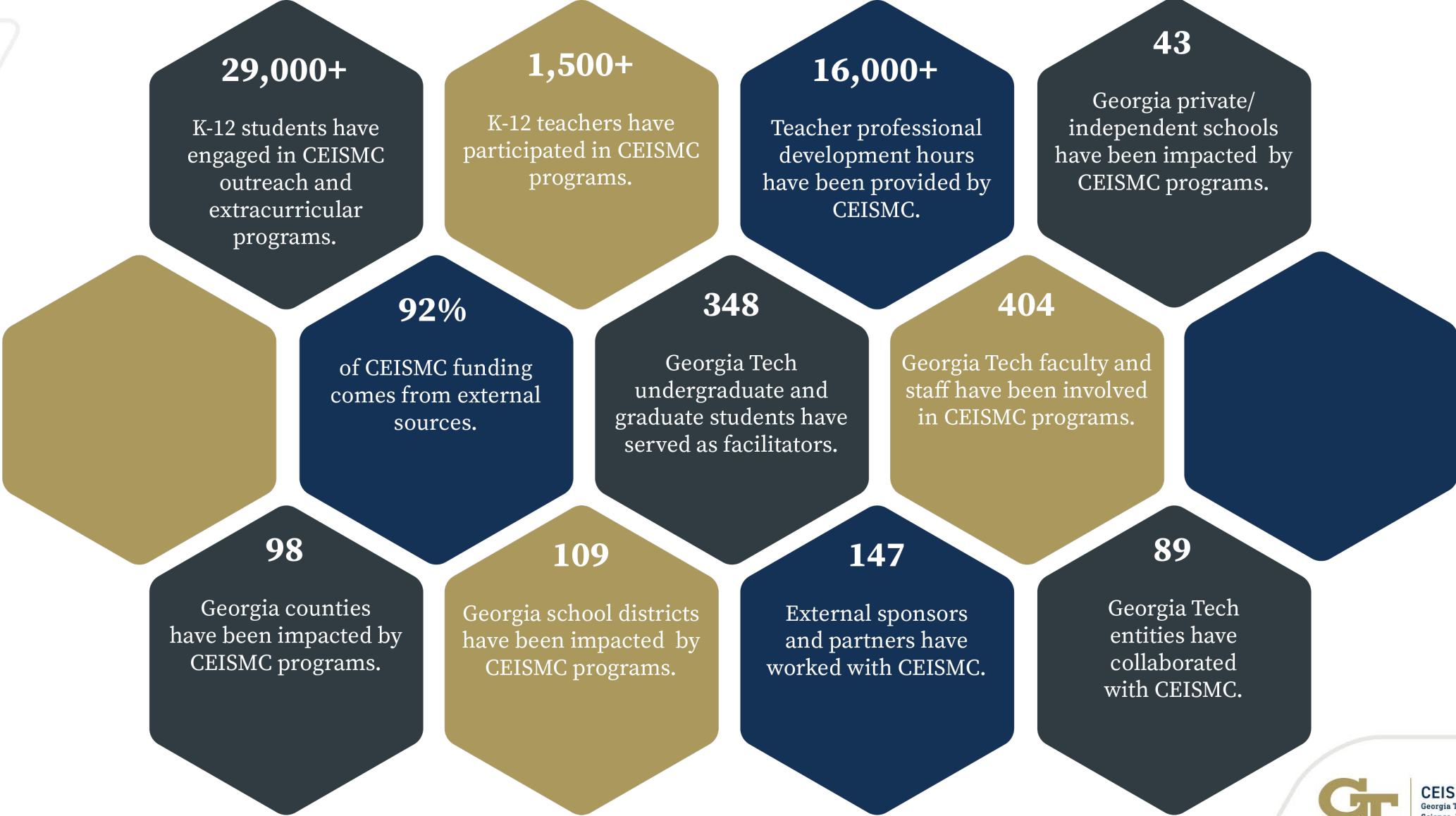
**Crucial Research  
and Impactful  
Evaluation of  
STEM Education**

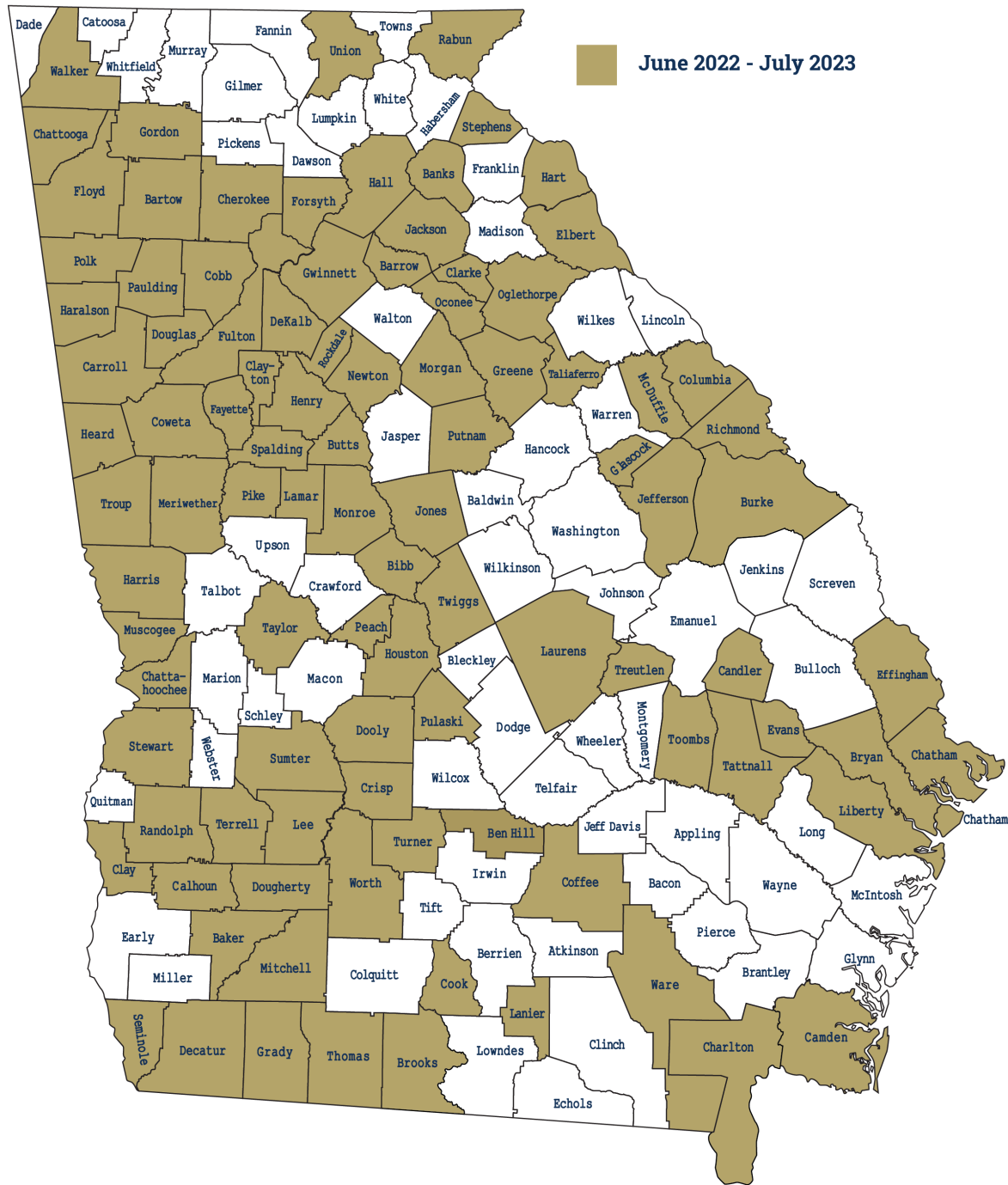


**Dynamic  
Opportunities  
For Georgia Tech  
Community  
Engagement**



# CEISMC by the Numbers 2022-2023





# CEISMC Impact throughout Georgia

# Sampling of CEISMC Sponsored Programs

- **AMP-IT-UP (Advanced Manufacturing and Prototyping Integrated to Unlock Potential)**– National Science Foundation, \$7.5M
- **STEM-ID (STEM Innovation and Engineering Design)** – National Science Foundation, \$2.7M
- **CAPACiTY (Culturally Authentic Practice to Advance Computational Thinking in Youth)** – National Science Foundation, \$2.5M
- **REMEZCLA (Collaborative Research Broadening Participation of Latinx Students in Computer Science by Integrating Culturally Relevant Computational Music Practices)** with University of Puerto, Río Piedras – National Science Foundation, \$2.9M
- **Retention of Noyce Teachers** – National Science Foundation, \$485K
- **Your Voice is Power** – Amazon Future Engineer, \$1.1M
- **GoSTEAM** – The Goizueta Foundation, \$5M
- **Expanded Learning Programs in Atlanta and Savannah** – Building Opportunities in Out-of-School Time (BOOST) funding from American Rescue Plan, administered by Georgia Department of Education in partnership with Georgia Statewide Afterschool Network, \$934K



# Sampling of CEISMC Sponsored Programs

- **Georgia Artificial Intelligence Manufacturing Corridor (Georgia AIM)** – U.S. Department of Commerce, \$65M total with Georgia Tech as lead with multiple partners across the state, involving K-12 InVenture Prize & GoSTEM – combining AI & manufacturing innovations with transformational workforce development and K-12 outreach
- **Rural CS Initiative with STEM@GTRI** – Georgia General Assembly, \$2M
- **K-12 Programming for Military Families in Savannah** – U.S. Department of Education, \$215K, CEISMC Savannah training stakeholders who directly work with military families to implement K-12 InVenture Prize and FIRST LEGO League programming
- **Retention of Noyce CS & Engineering Teachers in High-Need Schools** – National Science Foundation, \$830K
- **Georgia Tech AmeriCorps Academic Mentoring Program** – AmeriCorps federal funding provided by the Georgia Department of Community Affairs & Georgia Serves, \$172K
- **Regional Partner for Code.org** - Code.org provides funding for qualifying teachers; professional development for teachers interested in computer science education; K-5, one-day workshop, 6-12, 5-days during the summer and 4 Saturdays throughout the academic year

# Sampling of CEISMC Initiatives Supporting Georgia Tech's Strategic Goal of Expanding Access

- **Georgia Tech Anchor Institute Initiative** – Engaging with communities & organizations near campus and abroad to support social and economic mobility by advancing the public interest through partnerships for education, knowledge production, community engagement, economic development, and strategic management of our operations and physical spaces.
  - Summer Bridge Program (Talent Development Program)
  - STEM/STEAM Certification School Support
  - Washington Cluster STEM Programming Support
- **Talent Development Program** -- Initiative, in collaboration with Enrollment Management, supporting Georgia Tech Anchor Institute -- designed to be a multi-year effort that students will return to over their middle and high school years, maintaining engagement with Georgia Tech all the way through graduation (Summer Bridge, programming throughout school year), advancing their knowledge in math & computer science

# Problem Based or Project Based Inquiry Learning

## What is PBIL?

- Inquiry driven instruction
- Teacher as a Facilitator
- Student Centered
- Critical Thinking
- 21<sup>st</sup> Century Skills
- Mistakes are encouraged
- Application to real-life settings

- The online Project-Based Inquiry Learning (PBIL) Course was developed through the Electronic Professional Development Network (EPDN).
- EPDN was established in February 2009 as a collaborative agreement between NASA Langley's Research Center and the Georgia Institute of Technology.
- Since then, the online course served to thousands of teachers.



# Online PBIL Course

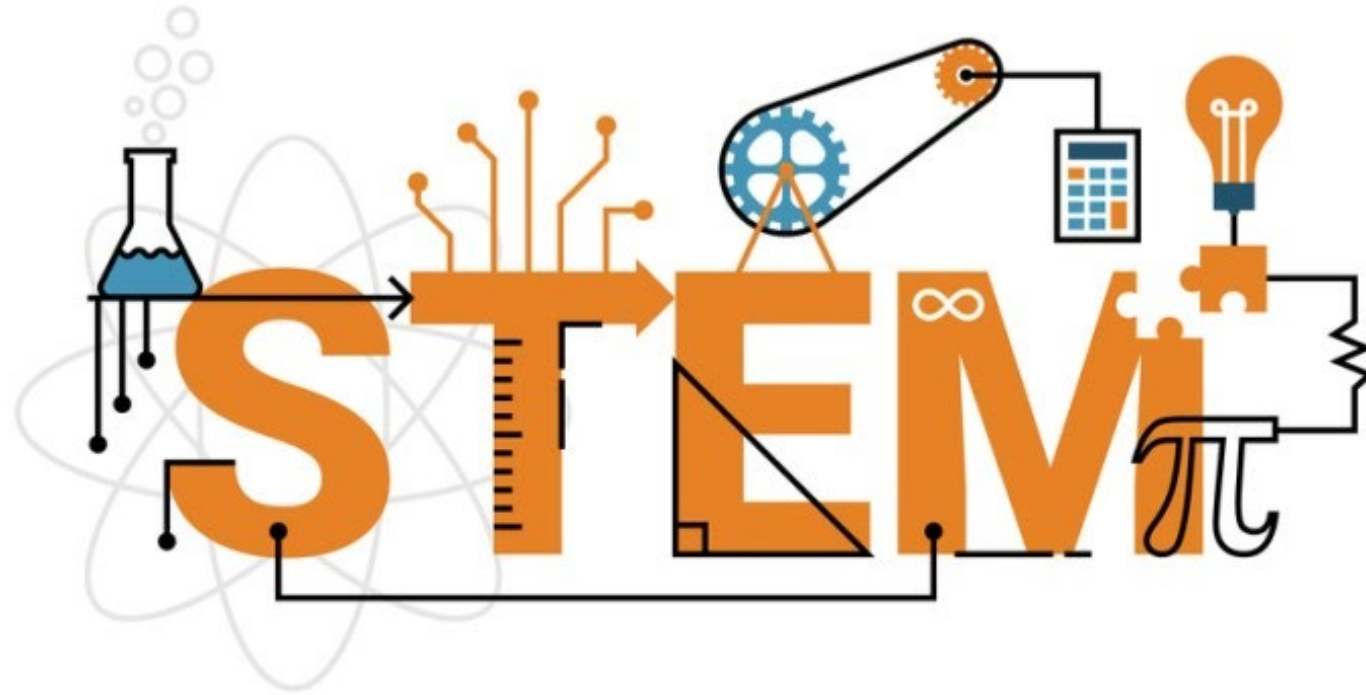
- Supports teachers using project learning and sustainability concepts to enhance conceptual understanding, critical thinking, scientific reasoning, and problem solving.

## Learning Objectives:

- The basic concepts of PBIL and the skills to analyze and craft PBIL materials effectively.
- How to align learning goals, student products, and standards in a PBIL experience.
- Develop a PBIL module for use in the classroom
- Range between 15-30 hrs. of work across multiple weeks (flexible)



# Integrated STEM Learning



# STEM-Innovation & Engineering Design Middle School Curricula

- **Original NSF Project**

- 7.4 M
- Middle School Engineering
  - The Science, Technology, Engineering, and Mathematics Innovation and Design (STEM-ID) Curriculum (4 Middle Schools)
  - Math-Science Modules



Advanced Manufacturing & Prototyping Integrated to Unlock Potential

- **Current NSF Project**

- Scaling up STEM-ID
- 29 Middle schools (Mainly GCPS)
- Research:
  - Replication of the initial study
  - Fidelity of Implementation



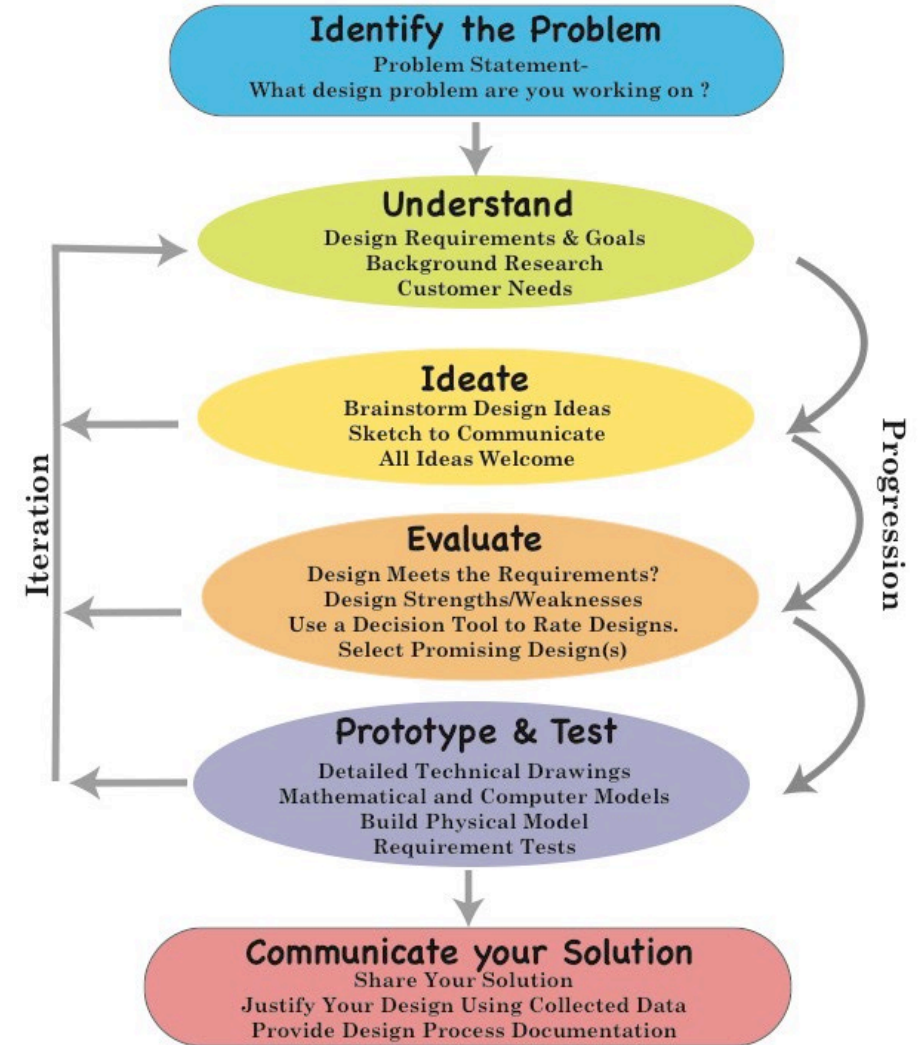
<https://stem-id.ceismc.gatech.edu/engineering/>



# STEM-ID Curriculum

- Semester-long (18-week) course in engineering classrooms, for 6th, 7th and 8th grade.
- Can be taught as either an engineering or an integrated STEM connections course sequence
- Curriculum focuses on:
  - Contextualized challenges, focusing on broad themes: data, systems, visualization, design
  - Focus on engineering design process and reinforcement of foundational math and science skills.
  - Advanced manufacturing skills such as 3D modeling and 3D printing

## Engineering Design Process



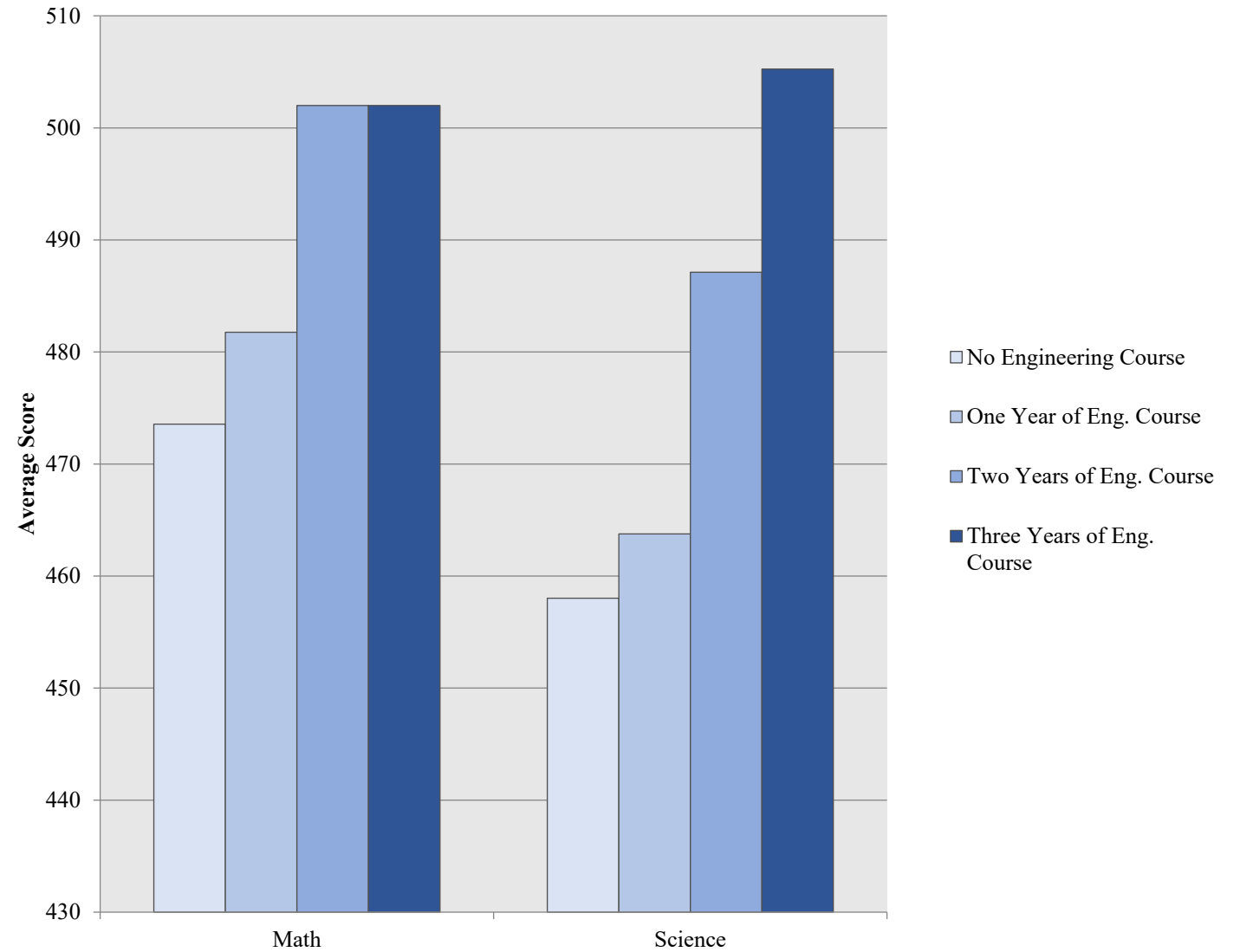
# Results



TRANSFERRING KNOWLEDGE  
BETWEEN STEM-ID AND CORE  
MATH AND SCIENCE COURSES



STUDENTS' ACADEMIC  
PERFORMANCE ON THE  
MILESTONES ASSESSMENT IS  
SIGNIFICANTLY HIGHER  
AMONG THOSE STUDENTS  
WHO ATTENDED  
ENGINEERING COURSES FOR  
AT LEAST TWO YEARS  
COMPARED TO THOSE WHO  
HAVE ATTENDED ONE YEAR  
AND THOSE WHO  
EXPERIENCED NO  
ENGINEERING COURSE



## Mathematics and Science Modules

- Nine 1-week **Science** Modules
  - Promote 3-dimensional teaching and data-related practices
  - Are situated in earth, life and physical science contexts
- Nine 1-week **Mathematics** Modules
  - Promote problem-based learning within mathematics
  - Cover topics in statistics, algebra, and geometry.

All modules require students to collect, visualize and interpret data





## 1. Experimental Design

- Planning and Carrying Out Investigations (NGSS Practice 3)
- Make Sense of Problems (SMP #1); Use Appropriate Tools Strategically (SMP #5)

## 2. Data Visualization

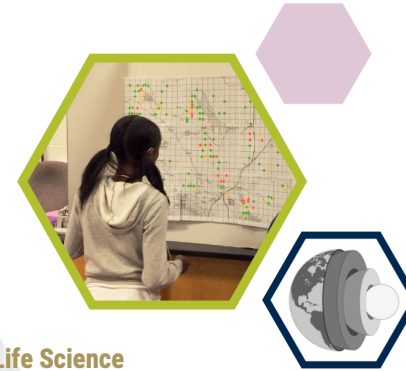
- Analyzing and Interpreting Data (NGSS Practice 4)
- Make Sense of Problems (SMP #1); Model with Mathematics (SMP #4)

## 3. Data Driven Decision Making

- Constructing Explanations and Designing Solutions (NGSS Practice 6)
- Engaging in Argument from Evidence (NGSS Practice 7)
- Make Sense of Problems (SMP #1); Construct Viable Arguments (SMP #3)

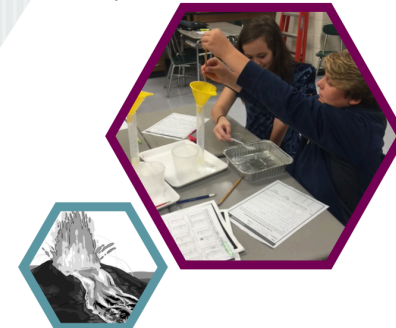
# Science Modules

- Require approximately one week of instructions
- Are designed to introduce students to data-related science practices while they pursue an inquiry focused problem or challenge rooted in core disciplinary content.
- All science modules provide opportunities for students to practice important foundational math skills while solving a challenge.



## Life Science

- » **Oil Spill Challenge:**  
Students engage as environmental engineers to develop a procedure that removes the largest amount of spilled oil from the ocean in the shortest time possible. The module introduces concepts of how human actions impact an ecosystem.
- » **Deep Sea Ecosystems Challenge:**  
Students engage as scientists to analyze sequential images of deep-sea corals to evaluate recovery of an ecosystem after a major oil spill. The module introduces concepts of ecosystems, abiotic and biotic factor, and benthic environments.
- » **Coral Reef Challenge:**  
Students engage as biologists advising the government of Fiji as they establish fishing permit policies and grapple with the trade-offs between the health of the coral reef and the needs of other economic sectors. The module introduces concepts of ecosystems, food web/chains, and predator prey relationships.



## Earth Science

- » **Lava Challenge**  
Students engage as earth scientists to help a small town that is adjacent to a volcano develop evacuation plans in the event of an eruption. The module introduces concepts of volcanoes, lava, and igneous rock formation.
- » **Earthquake Challenge**  
Students engage as earth scientists to help a company decide where to build its new cell phone manufacturing plant in northern California. The module introduces concepts of seismology, plate tectonics, and the earth's structure.
- » **Winter Weather Challenge**  
Students play the role of school officials and need to decide whether to close school or keep it open based on weather forecasts. The module introduces weather concepts and terminology, and forecasting basics.



## Physical Science

- » **Marine Snow Challenge:**  
Students engage as environmental engineers to develop a procedure to determine how the oil from the Deepwater Horizon Oil Spill landed at the bottom of the ocean. The module introduces concepts of density and the movement of particles in fluids.
- » **Helmet Challenge:**  
Students engage as crash-test scientists for the SkateTech company to test helmets for skateboarders. The module introduces concepts regarding energy, <sup>18</sup> energy transfer, linear and non-linear graphs and brain injuries in sports.
- » **Skate Park Challenge:**  
Students engage as product reviewers for the SkateTech website and craft reviews of skate helmets considering price, effectiveness, and the differing abilities and inclinations of individual skateboarders. The module introduces concepts of energy, energy transfer and brain injuries in sports.

# Math Modules

- Require approximately one week of instructions and emphasize standards of mathematical practice related to mathematical reasoning, sense-making, data representation and construction viable arguments
- Each module introduces a problem or challenge that requires students to use grade level math skills.
- Problem contexts are designed to be engaging to middle schoolers, and vary from solving manufacturing quandaries, to saving whales, building solar-thermal power plants, and fighting forest fires.

[https://mediaspace.gatech.edu/media/AMP-IT-UP+Packaging+Challenge+Math+Module/1\\_4zqnrnl2](https://mediaspace.gatech.edu/media/AMP-IT-UP+Packaging+Challenge+Math+Module/1_4zqnrnl2)

## Statistics Modules

### » Packaging Challenge (Measures of Center/Spread)

Students reason quantitatively using measures of center and variability to construct and defend arguments regarding the best procedure for packaging a hardware kit.

### » Automated Packaging Challenge (Quartiles, Boxplots)

Students use measures of center, spread, interquartile range and box plots to determine which new manufacturing equipment they should purchase for a candy packaging plant.

### » Manufacturing Quality Control Challenge (Inference, Random Samples)

Students use inference and measures of center and variability to investigate the error rate of random samples from a manufacturing plant, and learn how sample size affects results.

## Algebra Modules

### » Whale Challenge (Coordinate Systems, Variables)

Students construct coordinate graphs of oceanographic data to explore independent and dependent variables, linear vs non-linear data, and to determine whether a research ship is likely to hit feeding whales.

### » Crab Aquarium Challenge (Rate of Change, Equation of a Line)

Students model and graph data, analyze rate of change and use proportional reasoning to select the mix of predators that will balance the ecosystem of an aquarium display.

### » Hot Shot Challenge (Linear Equation, Pythagorean Theorem)

Students simulate a Hotshot Firefighters planning team as they define extraction logistics using the Pythagorean Theorem and the linear equation for distance, rate and time.

### » Clean Energy Challenge (Linear function, Slope)

Students reason quantitatively using linear rates of change to determine the most effective insulation material to use in the construction of a solar-thermal power plant.

### » Power Finance Challenge (Systems of Equations)


Students use linear systems of equations to explore the finances of funding and building a solar-thermal power plant. They calculate the break-even point given different starting conditions.

## Geometry Module

### » Board Game Piece Challenge (Area, Volume, Surface Area)

Students use different measurement tools and create procedures to determine the area, surface area, and volume of geometric solids to determine which pieces best satisfy the requirements for a new board game piece.

# Math and Science Modules



AMP IT UP  
Advanced Manufacturing & Prototyping Integrated to Unlock Potential

**RATIOS AND PROPORTIONAL RELATIONSHIPS,  
EXPRESSIONS & EQUATIONS**

*Data Visualization*

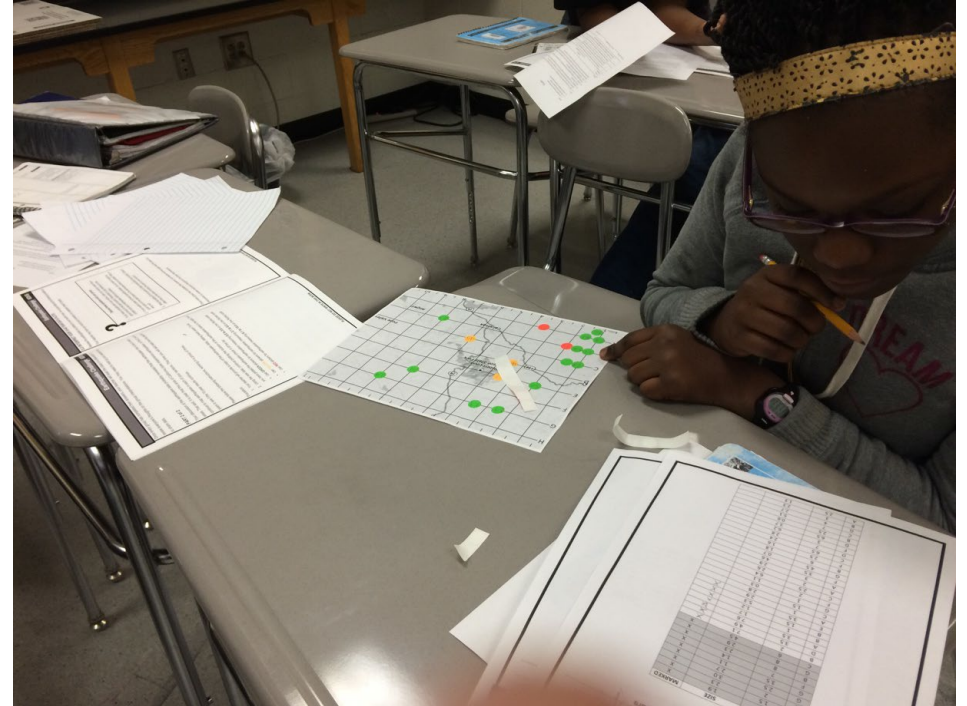
**DATA SAVES THE WHALES!**  
*Whale Challenge*  
Annotated Teacher's Edition

Fall 2018 6DVM





- **Students who attended multiple years of the course had:**
- Significant Increase in science interest\*
- Significant increase in behavioral and cognitive engagement\*
- Higher rates of academic self-efficacy
- Lower rates of science and math anxiety



# Rural Computer Science

Partnership between CEISMC and STEM@GTRI

"Growing and Nurturing Georgia's Newest Crop"

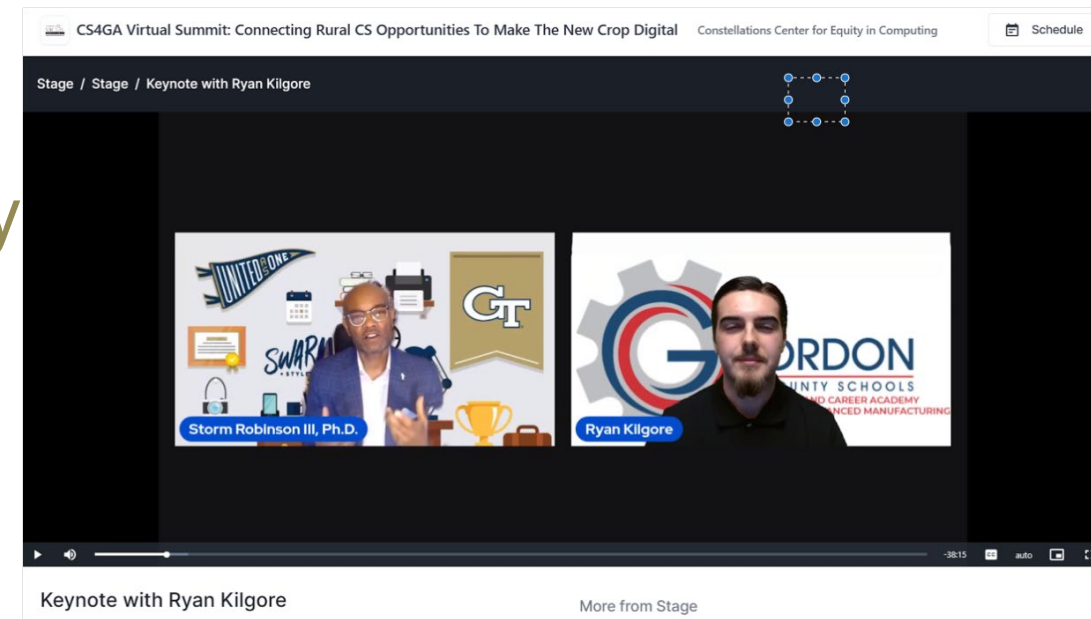


**CEISMC**

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# Rural CS - Program Goals

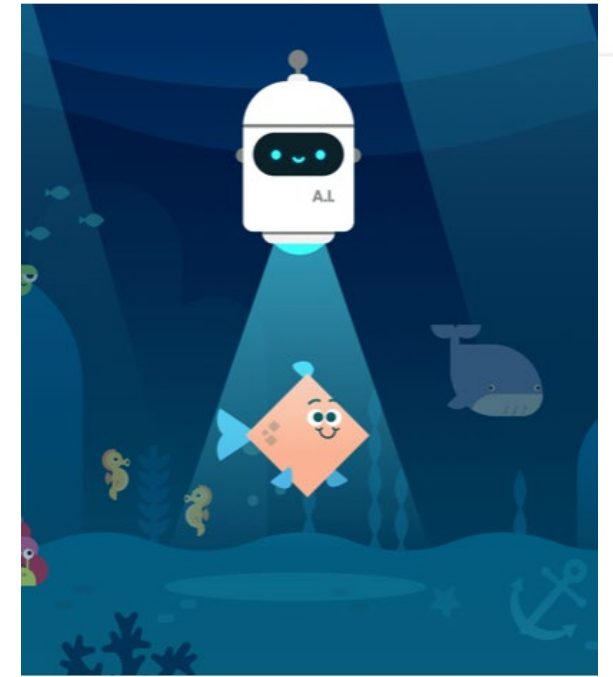
- Increase awareness and knowledge in key areas of computer science education among high school students in rural Georgia
- Increase students' intent to persist in study of computer science
- Create Community of Learning among educators in participating rural schools
- Increase capacity of rural school districts to offer innovative CS courses





# Rural CS – Program Structure

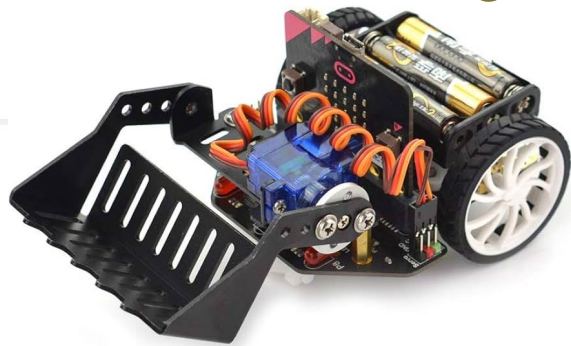
## Cyber Security



## Artificial Intelligence



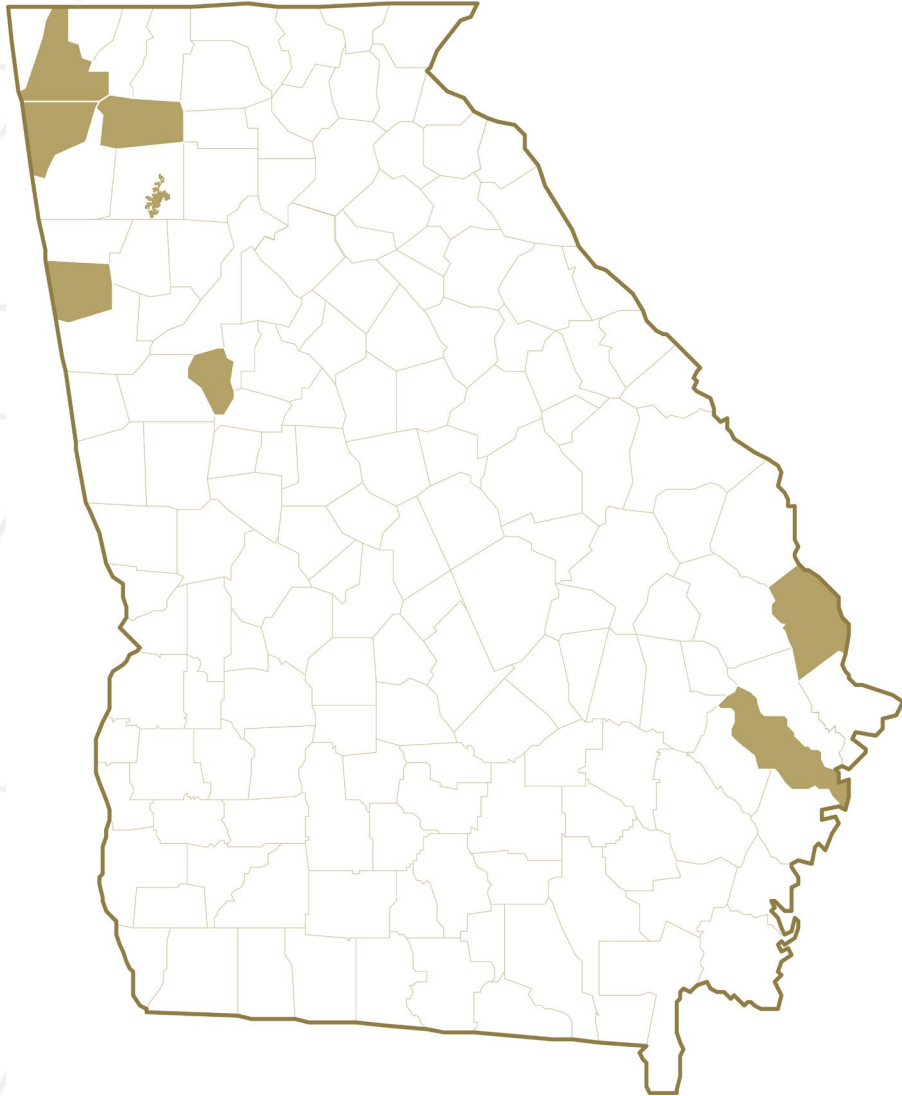
## Intro to Coding



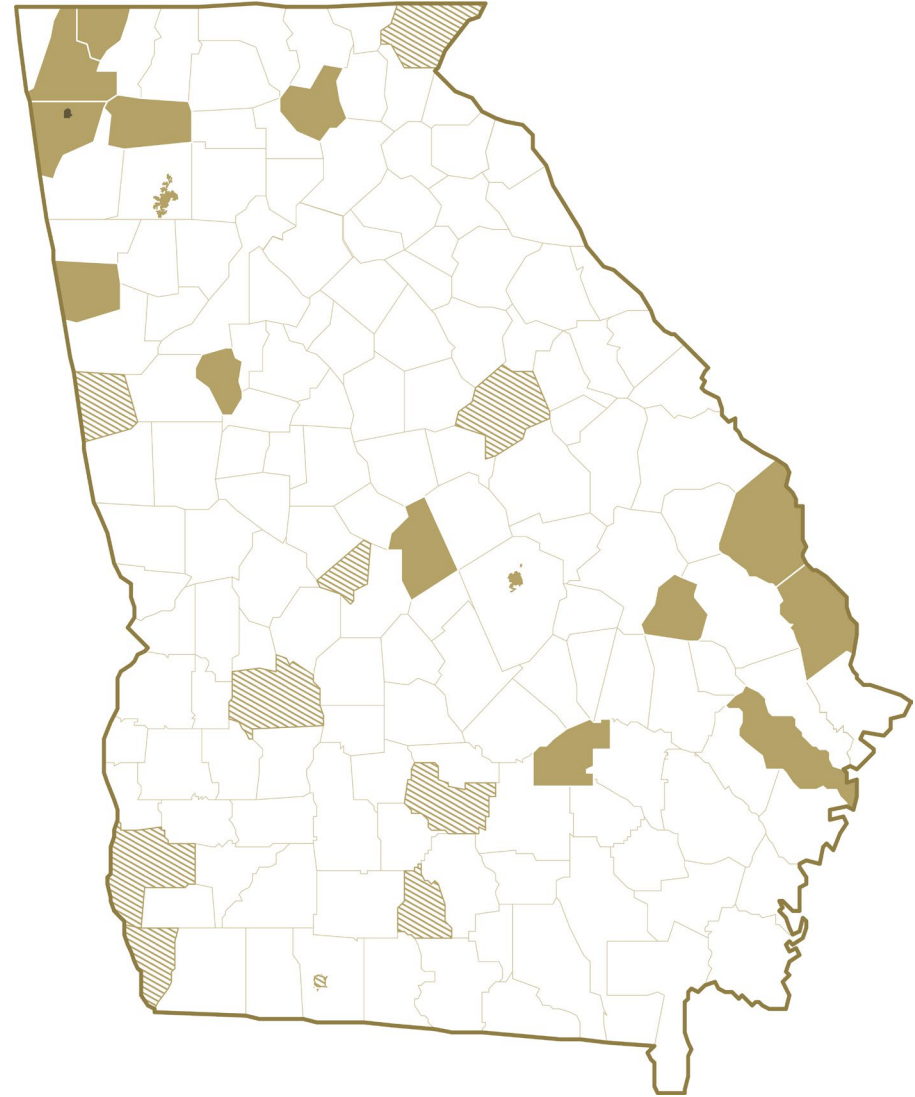
## Advanced Coding



## Sensors Data Visualization



Academic Year 22  
8 School Districts



Academic Year 23  
24 School Districts



# EarSketch

- A curriculum experience and coding competition where students learn computer science and entrepreneurship by developing an understanding of messaging in music, and coding using the EarSketch platform.
- Website: <https://ears sketch.gatech.edu/landing/#/>

**YOUR  
VOICE  
IS POWER**



amazon  
**future >>  
engineer**

**YELLOW™**



## 2022 Your Voice is Power Impact

**31**  
STATES &  
WASHINGTON, D.C.

**1**  
TERRITORY

**1,779**  
STUDENTS

**1,654**  
SUBMISSIONS

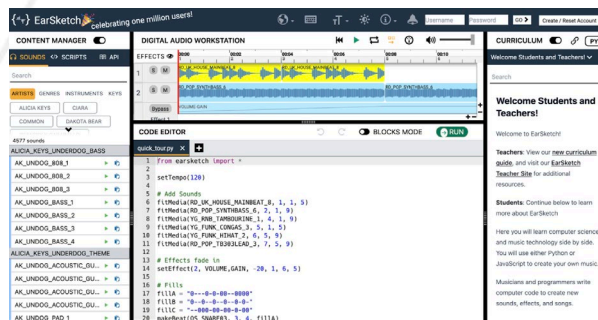
**1,055**  
FIRST TIME  
EARSKETCH USERS

**466**  
FIRST TIME  
CODERS

**K-5**  
K-5 STUDENTS  
ELEMENTARY SCHOOL

**614**  
6-8 STUDENTS  
MIDDLE SCHOOL

**1,020**  
9-12 STUDENTS  
HIGH SCHOOL



# Anchor Institution: APS Washington Cluster Partnership

## Michael Hollis Innovation Academy

- CEISMC staff developed a high-quality STEM curriculum (grades Pre-K through 8th) that is problem-based, aligned with Georgia state standards, and integrated into the EL framework.
- CEISMC staff conduct observations during STEM time and provide feedback on implementation in the classroom.
- Collaborating with a network of community providers, CEISMC staff created a STEM focused array of after-school, Saturday, and summer programs for Hollis' students.



# Anchor Institution: APS Washington Cluster Partnership

## M. Agnes Jones

- CEISMC staff collaborated with administration and teachers to provide mathematics enrichment for students who are at or above grade level in mathematics.
- Weekly “Math Circle” professional development was implemented for MAJ teachers to review and discuss student work and make pedagogical and curriculum improvements.
- Supported and guided school to achieve STEAM certification from Georgia Department of Education.

## Cluster – Wide

- CEISMC organized collaborative meetings involving principals, support units, and partners.





# APS Washington Cluster Partnership

## Highlights

- CEISMC has engaged more than 30 teachers in more than 5000 hours of professional development on STEM content and pedagogy.
- Approximately 50 teachers from the Washington Cluster are engaged in several other CEISMC programs designed to develop STEAM instructional capacity.
- Full STEAM Ahead served approximately 1,000 students either face-to-face or with virtual programming.
- In response to the pandemic, CEISMC staff developed STEAM modules for each grade level and created 878 kits containing all materials necessary to complete the modules.



# Enrichment Programming for K-12 Youth

We served over 5500 K-12 youth during the 2022-2023 school year.

## CEISMIC Expanded Learning Programs

- **KIDS Club/STEAM Workshops** – 8 Saturdays during school year
- **Summer PEAKS** – weeklong programs during summer
- **STEAM Whistle Workshops** – virtual programs during summer and school year
- **Horizons at Georgia Tech** – year-round program with a six-week summer component
- **Programs offered in Atlanta and Savannah**
- **Website:** <https://expandedlearning.ceismc.gatech.edu/>

## Outcomes

- Participants consistently report increases in content knowledge, intent to persist in STEM, & positive attitudes about STEM.





# Thank you!



CEISMC faculty and staff at their 2023 annual retreat.





## Fall 2023 CEISMC Impact Magazine

Explore –  
<https://bit.ly/CEISMCImpact2023>