January 2026

GEORGIA PATHWAYS
MAGAZINE

STEM Education
Time for a ReBrand

Quantum Thinking In K-12

Step Zero

Particle Physics Discoveries

The Technology Association of Georgia Education Collaborative (TAG-Ed) strengthens the future workforce by providing students with relevant, hands-on STEM learning opportunities and connecting them to Technology Association of Georgia (TAG) resources.

Formerly the TAG Foundation, TAG-Ed is a 501(C)(3) non-profit organization formed by TAG in 2002. Later, the organization's name was re-branded to TAG Education Collaborative to facilitate our role as the leaders for K-12 STEM education in Georgia.

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Welcome to the January 2026 edition of Georgia Pathways Magazine, your monthly guide to the talent shaping Georgia's economy through leadership in STEM development.

The start of a new year offers an opportunity to reflect on our achievements and our ability to innovate before moving forward. This reflection allows us to evaluate and adapt, whether we are rethinking education strategies or considering the factors that guide analytical decision-making. This issue of Georgia Pathways emphasizes the importance of taking that critical moment to assess the road ahead.

Georgia's innovation economy begins with access to strong STEM education. The design and delivery of these programs today will shape tomorrow's tech-forward workforce. Taking a deliberate pause, known as STEP Zero, to reconsider our approach to STEM education initiatives helps us make informed, strategic decisions that create meaningful opportunities for learners and prepare them for future challenges.

One example of this evolving approach is Quantum Thinking in classrooms from kindergarten through 12th grade. By encouraging students to engage with complexity rather than rely on simple either-or answers, this model develops the critical thinking skills needed to address real-world problems.

This issue also highlights how computer science is driving discovery in fields such as particle physics and nutritional science, including new insights into how food dyes affect health. These advances point to growing opportunities in pharmacy, nutrition, and advanced research.

As the speed of STEM innovation grows, our workforce must keep pace. To help meet this need, TAG Education Collaborative is expanding its partnership with IBM SkillsBuild, offering 7,500 no-cost certificates in areas including data analytics, AI, cybersecurity, and more. Together, we are turning reflection into action to support economic growth and strengthen Georgia's future. Learn more about earning certifications at no cost through TAG-Ed's IBM SkillsBuild Certificate Program at https://tagedonline.org/ibm-skillshare-certificates/.

Larry K. Williams
President
TAG / TAG-Ed

Larry K. Williams serves as the President and CEO of the TAG and the TAG Education Collaborative. TAG-Ed's mission is to strengthen Georgia's future workforce by providing students with relevant, hands-on STEM learning opportunities by connecting Technology Association of Georgia (TAG) resources with leading STEM education initiatives.

From Superheroes to Superposition:
Bringing Quantum Thinking to K–12

By Shelly A. Muñoz

Quantum computing is no longer confined to university labs or secret research facilities. It's moving fast, reshaping medicine, climate modeling, cybersecurity, and more. And while today's students won't necessarily build a quantum computer tomorrow, they will need a sense of quantum literacy—a foundational understanding of the ideas powering this technological revolution.

Across the country, initiatives are encouraging schools to introduce quantum thinking early. The challenge is clear: how do we make concepts like superposition, entanglement, and quantum logic accessible, playful, and exciting for young learners? The answer may surprise you: quantum thinking can be as fun as storytelling and as hands-on as a simple classroom game.

Why Quantum Matters for Kids

Quantum computing may sound intimidating, but the skills it develops—flexible thinking, problem-solving, and curiosity—are universal. Engaging with quantum ideas encourages students to explore the strange and surprising ways the universe works. They learn that the world doesn't always follow common sense, and that's okay. In fact, that's the point.

Introducing these ideas early doesn't require advanced math or physics. It's about fostering a mindset that embraces wonder, asks questions, and persists through complexity. And that mindset will serve students in every area of STEM—and beyond.

Superposition: A Superhero Analogy

Take *superposition*, for example—the idea that a particle can exist in multiple states at once. For many, it's mind-bending. But for kids, it can be playful.
Imagine this: "Quantum particles are like superheroes who can be in two places at once—and only pick a place when someone looks."

Try a classroom activity: place two cards face down, each with a different symbol. Tell students the "quantum coin" is both cards at the same time. When they flip the card, it picks a state—just like measurement collapses a quantum particle into one possibility. In minutes, students grasp a core idea of quantum physics without needing equations.

Entanglement: A Cosmic Connection

Entanglement is another fascinating concept: particles become linked so deeply that what happens to one affects the other, even across distances. Kids can experience this in a fun, hands-on way:

- Pair up students and give them matching tokens.
- Have them sit back-to-back and secretly pick a token.
- When they reveal their choices simultaneously, they might be surprised at how often they "match."

Through play, students begin to understand that the universe has mysterious, surprising connections waiting to be explored.

Quantum Logic: Maybe is Powerful

Unlike classical logic, which is all true or false, quantum logic thrives in the realm of "maybe." Students can explore this through probability games or design challenges that allow multiple paths to a solution.

Activities like this shift the focus from memorization to exploration. They encourage children to embrace uncertainty, make predictions, and see the value in creative problem-solving—skills that are at the heart of STEM.

"Quantum thinking teaches us that the world is full of possibilities, and the most important skill a student can have is the courage to explore them."

— Shelly A. Muñoz

The Quantum Teacher Toolkit

Practical ways to bring quantum concepts to life in any K–12 classroom.

1. Superposition in a Box

- Concept: A particle can exist in multiple states at once until observed.
- Activity: Place two cards or coins face down. Explain that the "quantum coin" is in both states at once. Flip to reveal how measurement collapses possibilities.
- Purpose: Helps students visualize multiple possibilities and understand superposition.

2. Entanglement Partners

- Concept: Two particles can become linked so that the state of one instantly influences the other.
- Activity: Pair students with matching tokens. They sit back-to-back, secretly pick a token, then reveal simultaneously.
- Purpose: Demonstrates the concept of entangled systems in a tangible way.

3. Maybe Logic Games

- Concept: Quantum logic thrives in probabilities rather than strict true/false outcomes.

- Activity: Present scenarios with "definitely," "definitely not," and "maybe" outcomes. Students explore multiple paths to find solutions.

- Purpose: Encourages flexible thinking and comfort with uncertainty.

4. Quantum Storytime

- Concept: Stories make abstract quantum ideas accessible.

- Activity: Read or create stories where particles are superheroes or characters that exist in multiple states. Students can draw or write their own quantum adventures.

- Purpose: Connects imagination with learning and reinforces concepts like superposition.

5. Interactive Online Tools

- Concept: Simulations make invisible quantum phenomena visible and tangible.

- Activity: Use free platforms like IBM Quantum, Quirk, or Quantum for Everyone to experiment with superposition, entanglement, and quantum circuits.

- Purpose: Provides hands-on, visual learning opportunities to explore abstract concepts safely.

Tip: Keep activities short, playful, and discussion-focused. Quantum concepts stick best when students experience the "wow" moment themselves.

The Future Belongs to Quantum Thinkers

Introducing quantum concepts early isn't about creating mini physicists. It's about cultivating curiosity, resilience, and imagination. When students experience the mystery and beauty of quantum thinking, they gain a new lens for understanding the world—and a confidence to tackle challenges in any field.

The next generation of innovators, problem-solvers, and trailblazers is already in classrooms today. By giving them a playful introduction to superposition, entanglement, and quantum logic, we're not just teaching science—we're nurturing the kind of thinkers who will shape the future.

And who knows? One of those students might just be the next person to unlock the secrets of the quantum universe.

Shelly A. Muñoz is a STEM educator and instructional leader dedicated to advancing innovative teaching practices in K–12 classrooms. With experience designing and implementing project-based learning, coding, robotics, and 3D design initiatives, she helps teachers integrate research-based strategies that promote critical thinking, collaboration, and real-world problem solving.

Shelly also works closely with administrators and instructional coaches to support evidence-based professional development and coaching cycles, ensuring that STEM education is engaging, equitable, and impactful for all students.

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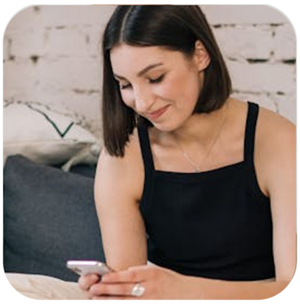

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STEM Education; Time for a *ReBrand*

By Dr. Jeff Weld

Public awareness is one of eight grand challenges besetting STEM education today. Not because Americans haven't heard of STEM. Indeed most are familiar with the acronym STEM and what it means at school. The problem is that the U.S. STEM movement employs scattershot marketing and stale messaging. It is time to refresh STEM with a rebrand tuned in to prevailing priorities and politics.

American STEM education is a polycephalic creature, and the heads are not in sync. Just imagine the potential impact of STEM over the last decade across the country, fueled by an estimated $100 billion total investment, if local, state and federal leaders alongside corporate, philanthropic and government investors shared the same priorities. Instead, the nation's STEM education system, like the education system writ large, has a decentralization problem of different funding sources pushing various goals and messages.

State and Federal grants for STEM education have long prioritized broadening the pipeline of talent by reaching the underserved. Corporate investments seek to inspire youth toward specific career pathways like healthcare, computing, or manufacturing. Nonprofits and philanthropic donors aim to support a particular subfield of STEM like ecology or engineering, or to amplify a component of the STEM infrastructure like teacher training or early childhood STEM.

Well, vive la difference for these and other often overlapping STEM efforts. The cost though is a lot of chefs in the STEM kitchen baking their favorite dishes: inclusion, careers, the E in STEM, new teachers, tinkering tikes, and myriad more menu items, violating a restaurant maxim: a short, simple menu, lest the service be slower, the items more costly, and customer overwhelmed. STEM customers, all Americans, deserve more effective and less costly STEM education focused on a shared mission aligned with the times in which we live.

Most people back STEM education. They understand the geo-political imperative for the U.S. to remain a leader in the STEM realm, and they certainly

want their kids to be STEM-literate.

But they also see shortcomings like U.S. youth underperforming in STEM compared to counterparts across the world. They know that many high school graduates require remediation in post-secondary STEM study. They hear business and industry lament talent shortages and decry the state of job readiness in new hires. They observe persistent underrepresentation of women and minorities in STEM professions despite significant public investment.

And an ugly companion has come along—more Americans are growing distrustful of STEM professionals when it comes to health care (e.g. vaccines), energy (e.g. renewable), transportation (e.g. EVs), nutrition (e.g., school lunch), technology (e.g. AI), and the environment (e.g., paper straws). Thus a new administration can come to Washington and dismantle the federal STEM infrastructure—mothball a guiding STEM strategy required by Congress, RIF (reduction in force) scientists across agencies, and slash STEM education budgets of NASA, NSF and other agencies, to a deafeningly quiet public reaction.

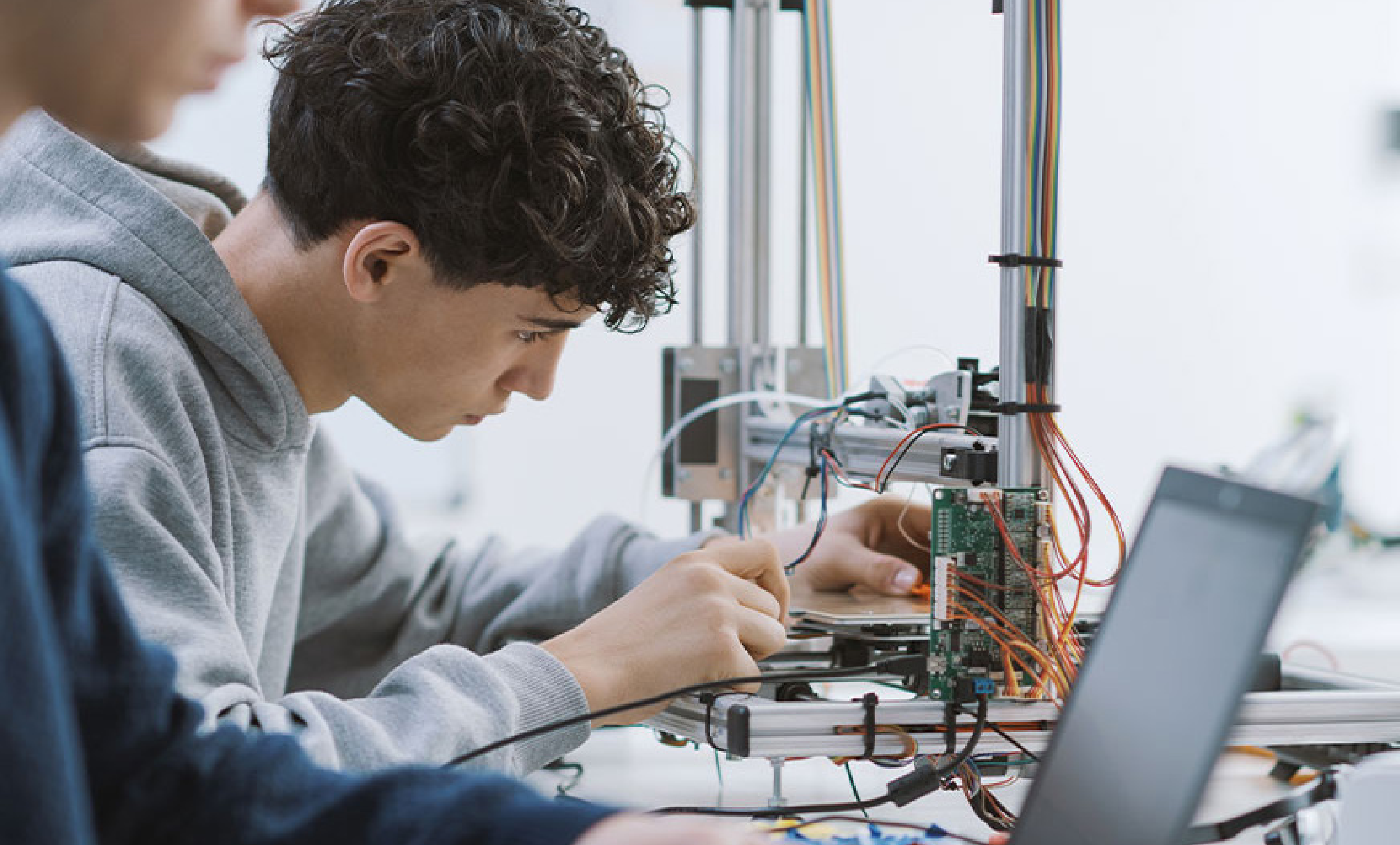
What is the STEM education community to do with such a mishmash of skeptics and mixed messages? Citizens want STEM education, just not the prevailing version, apparently. Time to consider rebranding along with programmatic retooling.

The nation's STEM army of tens of thousands of professionals spanning hundreds of local, regional and national STEM education organizations could have enormous collective influence over public opinion. To shatter myths elevated to recent policies, or to address legitimate critiques of STEM, begins with aligning STEM advocates and organizations to a unified mission and message. STEM education executives and practitioners across industry, academia, nonprofits, and government would do America a seismic favor by picking, and sticking to, a main goal.

But not just any goal, rather one that owns shortcomings while framing a future vision for STEM education that inspires all Americans. Something that reaches down to the essential rungs of Maslow's hierarchy of needs, like economic prosperity and national security. These are and have been nonpartisan national goals to which STEM was tightly tethered until lately. How about a mission redux?

Back to the basics, with a twist. STEM conception in the 20th century hinged on reversing waning interest among youth for careers of high importance to our economy and national security. Except that now instead of electronics technicians, FORTRAN programmers , statisticians and physicists, the in-demand jobs are cybersecurity guards, mega-data analysts, fintech (crypto) engineers, AI specialists, and autonomous vehicle technicians.

What's more, the encyclopedic depth of knowledge we now have about how people learn through contextual, personally meaningful, applied experiences —is a second major twist to modern STEM education.



Models across the country are doing exactly that—P-TECH (Pathways in technology early college high schools), CAPS (Centers for Advanced Professional Studies), STEM BEST (Business Engaging Students and Teachers), and others. They're covering all the goals of special interests— inclusion, careers, the E in STEM, new teachers, tinkering tikes, etc., by just doing STEM.

These and similar models are working toward a unified goal of individual and collective economic prosperity leading to national security. It is the only option needed on the menu. It is efficient, broadly effective, and aligned to prevailing priorities and politics of our time. STEM education community, it is time for a rebrand.

About the author -

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Formerly, founding director of Iowa Governor's STEM Council 2012-2023 (retired); White House Office of Science and Technology Policy STEM Education director 2017-2019; Author of "Charting A Course for American Education" (2021 Torchflame), "Creating a STEM Culture for Teaching and Learning" (2017 NSTA), and The Game of Science Education (2004, Pearson)

Article Audio Version

Step Zero: A Vital Pause for Success

By Dr Cas Olivier

Most breakthroughs don't begin with an answer — they start with a question that refuses to let go. Step Zero or 0 itself was discovered inside a Step 0 moment: a pause before action, a quiet space where the seeds of insight take root.

Step 0 was discovered Inside Its Own Space

For me, the question was simple but persistent: Why can students solve a sum confidently in class, yet struggle with the very same type of sum during an exam? Drawing on phenomenological thinking, I paused and imagined what unfolds inside a student's mind the moment they open an exam paper and read the first sum. I saw three "characters" playing out a mental drama:

1. The student — a human being carrying exam anxiety and emotional stress.

2. The sum — an external challenge demanding immediate attention.

3. The brain's working memory — struggling to hold, process and solve the question under pressure.

At that moment, the brain is so absorbed in confronting the immediate challenge that recalling how the teacher once explained the sum isn't even on the radar. The memory of the teacher's explanation becomes like a distant island, far beyond the horizon, causing the brain to go into fibrillation.

Function- Like the heart in fibrillation, which isn't dead, but it cannot perform its normal function, the brain's normal rhythm is disrupted, sending chaotic signals that prevent clear thinking and focused recall. Instead of smoothly retrieving prior knowledge, the mind races in confusion, struggling to organize thoughts and make sense of the problem.

This mental turmoil blocks access to stored explanations, leaving the student overwhelmed and stuck — unable to bridge what they know with what they need to solve the sum.

But the brain has an inborn logical thinking defibrillator called the Mothership of All Thinking — a natural system designed to restore order amid mental chaos. It works to realign thoughts and bring clarity when confusion threatens to take over.

Yet, already deeply engaged in the problem, anxiety spikes as the Mothership tries, often unsuccessfully, to make sense of the chaos. This signals the need for the brain to take a step backward — to fully understand the question before jumping to solutions. This is where the idea of "planning before you plan" comes in, calming the brain and preparing it for logical engagement.

This led to the concept of Pre-planning that became Step 0 — an essential, invisible precursor that initiates and prepares the brain for the logical steps that follow.

My Step 0 Insights

- First insight: Learning can't just about planning and executing — there's a hidden Pre-Plan stage before the plan.

- Second insight: Practice alone cannot replace this stage — without it, knowledge crumbles under pressure.

- Final realization: Step 0 isn't limited to mathematics; it's universal — a cognitive placeholder that drives success across all disciplines.

When we give ourselves and our students space to pause before action, we open the door to seeing what has always been there but never named. The beauty is that Step 0 was born in a Step 0 moment itself.

Why Step 0 Matters in STEM and Beyond

In STEM fields — where formulas, experiments, and coding converge — Step 0 is the mental "hush" before the storm of ideas. It is the moment of pre-planning when the brain anticipates, frames, and ignites creative thought.

Discipline	Traditional Start	Step 0 Activation
Mathematics	Insert formula, compute	Pause and sense the question deeply
Engineering	Begin blueprint design	Start with understanding problem context
Coding	Open IDE, start writing code	Sit with intent — define the aim
Science	Begin experiment, follow protocol	First think systems and purpose

Without Step 0, students often leap into methods without clarity, making learning fragmented and inefficient. With Step 0, they pre-plan cognitively, aligning their intent with the problem's landscape.

The Science Behind Step 0

Neuroscience shows that the brain's default mode network — associated with deep insight and self-reflection — activates during pre-task pauses. This network doesn't focus on formulas or actions; it thinks in context, connection, and meaning. That's Step 0's secret power: a space for reflection that fuels insight.

Famous Step 0 Moments in Discovery & Innovation

Throughout history, Step 0 moments have quietly powered humanity's greatest breakthroughs:

Historical Examples:

- Archimedes' Bathtub (3rd century BCE) — a relaxing pause led to the principle of buoyancy.
- Newton's Apple (1666) - sitting still and wondering about gravity sparked universal laws.
- James Watt's Kettle (1760s) — observing a kettle lid inspired steam engine innovation.
- Charles Darwin's Galapagos Pause (1835) — reflective comparison of finch beaks birthed evolutionary theory.

- Einstein's Thought Experiments (1905) - imagining light beams created relativity.
- Rosalind Franklin's Photo 51 (1952) — careful reflection on X-ray patterns revealed DNA's structure.

Modern Examples:

- SpaceX Reusable Rockets — engineers paused to rethink rockets like airplanes.
- CRISPR Gene Editing — envisioning bacterial defenses repurposed as genetic tools.
- Tesla's Gigafactory - reimagining battery supply chains before assembly.
- Apple iPhone — Steve Jobs envisioned the entire user experience before prototyping.
- Dyson Cyclone Vacuum - airflow concepts sketched long before thousands of prototypes.

Why Step 0 Outperforms 'Learning by Doing' Alone

Traditional STEM education emphasizes hands-on work. While practice is important, it's the thinking before doing that transforms repetition into innovation. Cultivating Step 0 encourages students to:

- Map connections
- Design with clear intent
- Anticipate challenges
- Build mental models that endure beyond a single problem

How to Foster Step 0 in STEM teaching

1. Pause before questions: Ask, "What is this really about?"
2. Activate mental frames: Encourage sketches, analogies, or diagrams before diving in.
3. Teach reflection as practice: Build mini breaks into tasks for cognitive re-balancing.
4. Model your own Step 0: Show students how you prepare before solving or explaining.

Before diving into a new theme or problem, it is essential to help students enter a relaxed, brainstorming mode. Encourage them to start by creating a bubble mind map, guided by Edward de Bono's thinking tools. This map should focus first on identifying visible, factual information—what de Bono calls the "white hat" facts. Students write these facts in connected bubbles, organizing what they observe clearly and objectively.

Equally important is guiding students to consider the "invisible" elements—those underlying principles or laws that might not be explicitly stated but are crucial to understanding the problem. For example, when tackling a geometry problem, students should list relevant laws or theorems that could support their thinking. These invisible factors should also be linked to related bubbles, helping students form a connected mental framework.

Crucially, students must resist the urge to jump into solution steps or attempt answers during this stage. Engaging prematurely in solving distracts their minds from fully scanning and comprehending the challenge. By postponing solution attempts, students can better grasp the problem's scope, leading to more focused, logical, and effective problem-solving later on.

This approach helps cultivate Step 0 thinking—preparing the brain to engage meaningfully and reducing anxiety, ultimately fostering deeper understanding and better outcomes.

Step 0 isn't an optional extra — it's foundational. It's where curiosity meets vision, where desire meets design, and where students become true thinkers. Step 0 is the invisible spark connecting Newton's apple, Einstein's thought experiments, SpaceX's reusable rockets, and every breakthrough yet to come.

Why is Step 0 important

Step 0 is not just a new term. It's a new paradigm

It protects the thinking brain from over-complicating.
It equalizes the thinking and prior knowledge.
It dislodges stuck thinking. Provides linguistic clarity to decode the question
Pre-planning or Step 0 is a cognitive placeholder for think It shakes the kaleidoscope, not to act but to see differently.
It clears the noise, connects the dots.
It combats cognitive blindness — the fixation on surface detail.
It activates executive memory — for planning, sequencing, and regulating.
It builds mental adaptability.
It connects scattered information.
It dislodges stuck thinking.
It shakes the kaleidoscope, not to act but to see differently.
It's about undoing, unhooking from what you thought was the problem — until the insight reveals itself.
It is a moment to de-frame and to re-frame.
It is orientation in complexity.
It switches the brain from reaction to reflection — the birthplace of strategic clarity.

Step 0 During the Exam: A Vital Pause for Success

The power of Step 0 does not end in the classroom—it is perhaps most crucial during exams, when pressure and anxiety are at their peak. Students must be taught and encouraged to consciously activate Step 0 the moment they receive their exam paper. By taking that deliberate pause to fully understand the question before rushing to solve it, they can calm their minds, reduce mental chaos, and engage the Mothership of All Thinking to regain clarity.

This essential cognitive pause helps prevent the fibrillation of the brain's working memory and allows students to connect what they know with what the question demands. Integrating Step 0 as a regular part of exam strategy transforms exams from moments of panic into opportunities for strategic, confident thinking—turning potential breakdowns into breakthrough.

Explore the full journey here:

- Why Students Should Plan the Plan in Mathematics

- Why Students Who Practice Sums Still Struggle in Exams

- Why Step 0 Is a Game-Changer for Mankind

Oak Ridge National Laboratory

Celeritas code sets fast pace for particle physics discoveries

By Dawn Levy / ORNL

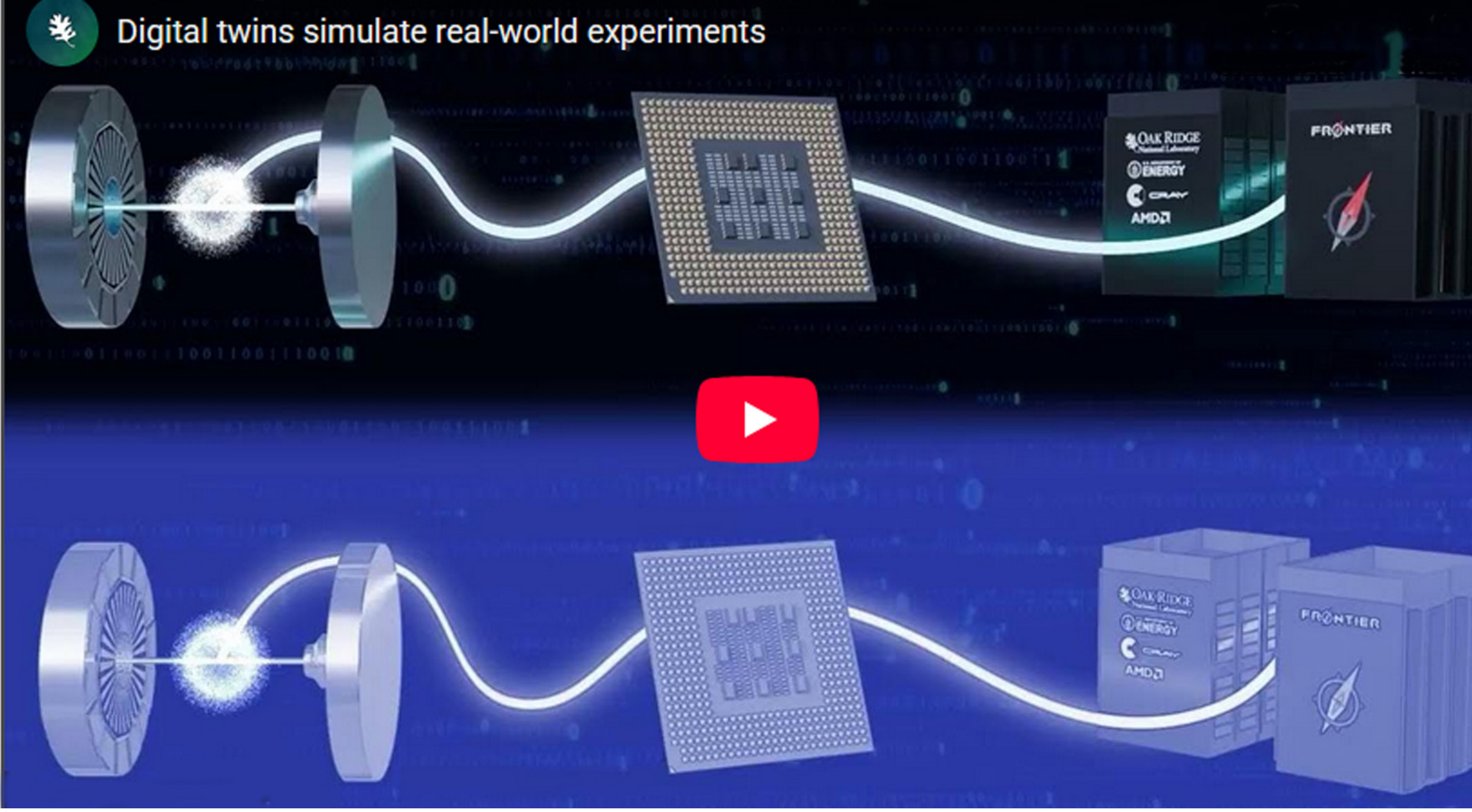
High energy physicists run on a treadmill that keeps speeding up. Their collider experiments smash particles at dazzling speeds and energies. Detectors identify and track the multitudes of smaller particles that fly out. With powerful new colliders crashing particles at ever-increasing energies, even more daughter particles are produced. The innovative Celeritas project, led by the Department of Energy's Oak Ridge National Laboratory, provides a software tool that makes sure simulations used to analyze particles can run on the fastest supercomputers, accelerating answers about the nature of the universe.

Celeritas is Latin for speed. The Celeritas code stands out for its ability to run primarily on graphics processing units (GPUs), which excel at parallel processing. It is a major upgrade from simulations relying on traditional central processing units (CPUs), which shine at sequential tasks. If Celeritas can quickly crunch big data, it could accelerate knowledge acquisition from some of the world's biggest physics experiments.

"Celeritas establishes ORNL as a focal point for high-performance computing in high energy physics," said Seth Johnson of ORNL's Computational Sciences and Engineering Division, who develops tools that optimize simulations running on leadership-class supercomputers.

From reactor models to particle experiments

The effort originated with nuclear reactor simulations led by Tom Evans, of ORNL's Computational Sciences and Engineering Division, for DOE's Exascale Computing Project. Marcel Demarteau, director of ORNL's Physics Division, launched the project and was its principal investigator. Johnson currently leads the project. Partners include DOE's Argonne National



Supercomputers step particles through a virtual world to give a history of their movement. The results are compared to physical experiments. Credit: Jacquelyn DeMink/ORNL, U.S. Dept. of Energy

Laboratory and Fermi National Accelerator Laboratory (Fermilab).

Celeritas supports major experiments that rely on ginormous detectors. In the United States, Celeritas supports the Deep Underground Neutrino Experiment (DUNE), which shoots neutrinos from Fermilab in Illinois to the Sanford Underground Research Facility in South Dakota. Each of DUNE's two detector modules is as tall as a five-story building. Combined, they weigh as much as nearly four Eiffel Towers.

In Europe at CERN's Large Hadron Collider (LHC), Celeritas supports the Compact Muon Solenoid (CMS) and A Toroidal LHC Apparatus (ATLAS). CMS is as tall as a five-story building and heavier than the Eiffel tower. ATLAS is bigger but about the same weight.

Simulations create digital twins of these physical experiments. They step each particle through a virtual world to generate a history of its movement. Every second, up to a billion collisions produce particles. Because tracking this volume and variety of data is impossible, a "trigger" system filters potentially interesting events for further analysis. Even after down-selection, every day the CERN Data Center processes a petabyte (one million gigabytes) of data on average.

Tackling big data in high energy physics

Big data is a big problem for big science. However, thanks to DOE national labs, Celeritas is having a big impact. The CMS, ATLAS and DUNE collaborations each include thousands of researchers from hundreds of institutions and dozens of countries. Celeritas helps these communities make the most of their data.

"With our effort, the United States has been leading the way developing new methods to take advantage of GPUs," Johnson said. "American corporations developed GPU hardware in Silicon Valley, and DOE provided the major investment in GPU-led hardware for supercomputers.

Because of those investments, our group at Oak Ridge made the connection between the GPU hardware and a gap in capability in these international physics projects."

For five years, ORNL-led researchers have collaborated with CERN scientists on Celeritas. "We rely on scientists at CERN to implement our work into their analysis code," Johnson said. "We've been competing and collaborating simultaneously. This dynamic has been productive for everyone involved."

Ensuring supercomputers can make the most of advanced GPU computer chips is an urgent need. A major upgrade of the LHC, the world's most powerful particle accelerator, is underway.

Completion of the High-Luminosity LHC is expected in 2030. "They're making the LHC brighter," Johnson said. "The brighter it is, the more data it makes. Because more particle events are happening at once, we have to do many more simultaneous calculations to see what might be going on."

Current codes calculate electromagnetic interactions of particles as they move through detectors. Celeritas is a critical step in reworking the way simulations and analyses are done in high energy physics. Johnson and colleagues performed initial simulations on ORNL's GPU-accelerated Frontier supercomputer at the Oak Ridge Leadership Computing Facility, a DOE Office of Science user facility. Boosting data throughput, the Celeritas code uses GPUs for massive parallel processing to simulate particle interactions based on state-of-the-art physical models.

In one second, Frontier can complete a task that would take humanity more than five years, assuming each person on Earth could complete one calculation per second.

Testing on Frontier, the world's fastest supercomputer for open science

Researchers plug the Celeritas software tool into existing toolkits developed for large physics experiments. "Traditionally, the toolkits ran on CPUs only, which limits their ability to do large computations," Johnson said. "To use the newer hardware that's on every new supercomputer, they need to use our software to run on GPUs." To validate theories of the Standard Model of particle physics, Celeritas researchers simulate the movements of particles crossing a detector and compare them with real data emerging from that detector.

CMS and ATLAS experiments follow particles produced in the collisions, and Celeritas has focused on the simulation of high-energy electromagnetic particles — photons, electrons and positrons. By contrast, for DUNE Celeritas will track low-energy photons, or light particles generated when neutrinos interact with liquid argon inside the detector.

"The interactions generate millions of light particles that we need to track to different detectors characterizing their energies and where they're going," Johnson said. "That's what makes this an especially good problem for GPUs. A lot of things are happening at the same time and about the same place." The researchers have performed scoping-level simulations on Frontier. "We're doing things that are very new and have applications across multiple fields," Johnson said. "It's a really exciting thing to be doing for that reason alone."

Preparing for next-generation experiments

Looking ahead, the researchers aim to integrate Celeritas into existing software frameworks for production-level simulations. Stefano Tognini, a Celeritas team member from ORNL's Computational Sciences and Engineering Division, works closely with physicists of the COHERENT experiment.

Jason Newby leads the experiment at ORNL, working with Physics Division colleagues Lorenzo Fabris, Brennan Hackett, Matthew Heath, Alfredo Galindo-Uribarri and Chang-Hong Yu, along with dozens of researchers from about 30 other institutions. This 2017 experiment at ORNL was the first to measure coherent scattering of low-energy neutrinos off nuclei.

Because Celeritas is new software, the researchers had to develop many fundamentally new algorithms to get it working. "Ultimately, we're going to use Celeritas to generate data to train new AI models," Johnson said.

Red Alert!

FDA Bans Toxic Dye in Your Food & Medicine!

By Komalpreet Kaur, PharmD, Touro College of Pharmacy-NY, Class of 2025
Edited by: Anastasiya Shor, PharmD, BCPS, Irene Cokro, PharmD

On January 15, 2025, the U.S. Food and Drug Administration (FDA) issued an order revoking the use of Federal Food, Drug, and Cosmetic (FD&C) Red No. 3, a synthetic food dye, in food and drugs. This change was supported by recent studies linking Red No. 3 to cancer in male laboratory rats. Manufacturers who use Red No. 3 in food will have until January 15, 2027 to change their products; manufacturers who use this dye in their ingested drugs have until January 18, 2028.[1]

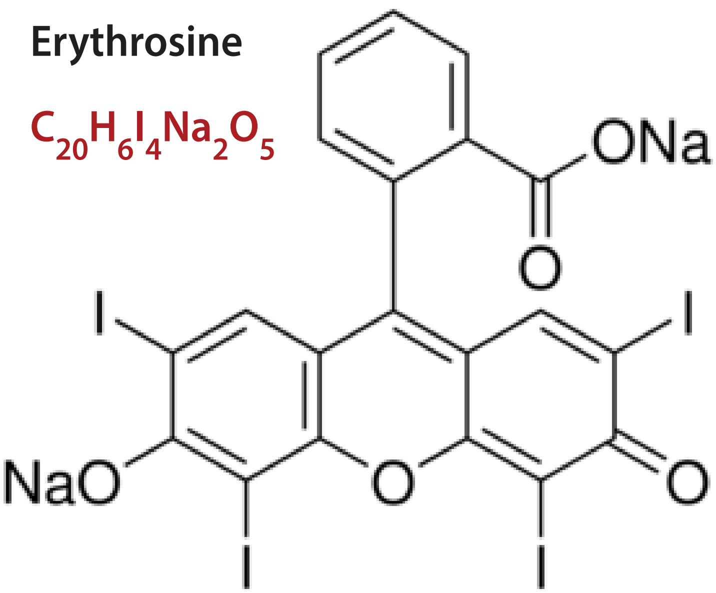
FD&C Red No. 3, also labeled as Red 3 or Red No. 3, was approved for use in food in 1907. Chemically known as erythrosine, it is derived from petroleum and is commonly used to give foods and drinks a bright cherry-red color, which is visually appealing.[2,3]

Red 3 appears in candy, cakes and cupcakes, cookies, frozen desserts, and frostings and icings, as well as certain ingested drugs for cosmetic appeal.[3]

A recent study examined the effects of oral erythrosine on the pituitary thyroid axis in rats. Previous research has shown an increase in the incidence of thyroid adenomas and adenocarcinoma in rats fed a 4% erythrosine diet for 30 months. In this study, rats were randomly divided into 6 groups, each with 15 rats, and fed diets containing varying amounts of erythrosine (0.5%, 1.0%, 4.0%), sodium iodide (0.16%), or fluorescein (1.6%) for 3 weeks.

Erythrosine

$C_{20}H_6I_4Na_2O_5$



The results showed that erythrosine produced a dose-dependent increase in serum T4 levels. In the group that consumed the 4% erythrosine diet, both serum T4 and T3 levels, along with free-T4 index, were significantly increased. These data demonstrate that dietary ingestion of 4% erythrosine disrupts the normal functioning of the pituitary-thyroid axis. Therefore, it raises concerns that chronic erythrosine ingestion may promote thyroid tumor formation in rats.[4]

The ban is a result of a petition filed in 2022 by a food safety advocacy group, the Center for Science in the Public Interest (CSPI). CSPI also urged the FDA to require warning labels on products containing other synthetic food dyes. They argued that Red 3 should be banned due to its links to cancer and its widespread use by U.S. consumers, particularly children.[7]

There is currently no available evidence showing this effect in humans yet, however, the FDA has still required manufacturers to remove Red 3 from ingested drugs based on the Delaney Clause of FD&C Act.5 The Delaney Clause, enacted in 1960 as part of the Color Additives Amendment to the FD&C Act, requires a ban if any link to cancer is found in humans or animals.[6]

California became the first U.S. state to ban Red 3 in 2023. Since then, 10 other states have moved to ban the food dye.8 It is also banned or severely restricted in places like Australia, New Zealand, and most countries in the European Union.[7]

The FDA currently requires manufacturers to list Red No. 3 in the statement of ingredients when added to food. Consumers could see Red No. 3 as an ingredient, in a food or drug product on the market past the effective date in the order if that product was manufactured before the effective date.[1]

As experts in medication, pharmacists can inform patients about potential health risks linked with synthetic dyes like Red No. 3 and can assist patients in reviewing their medications that contain this artificial additive, which may appear under different names, such as erythrosine, Red Dye 3, FD&C Dye #3. Additionally, pharmacists can provide guidance on dye-free options and safe alternatives, helping patients make informed choices to protect their health.

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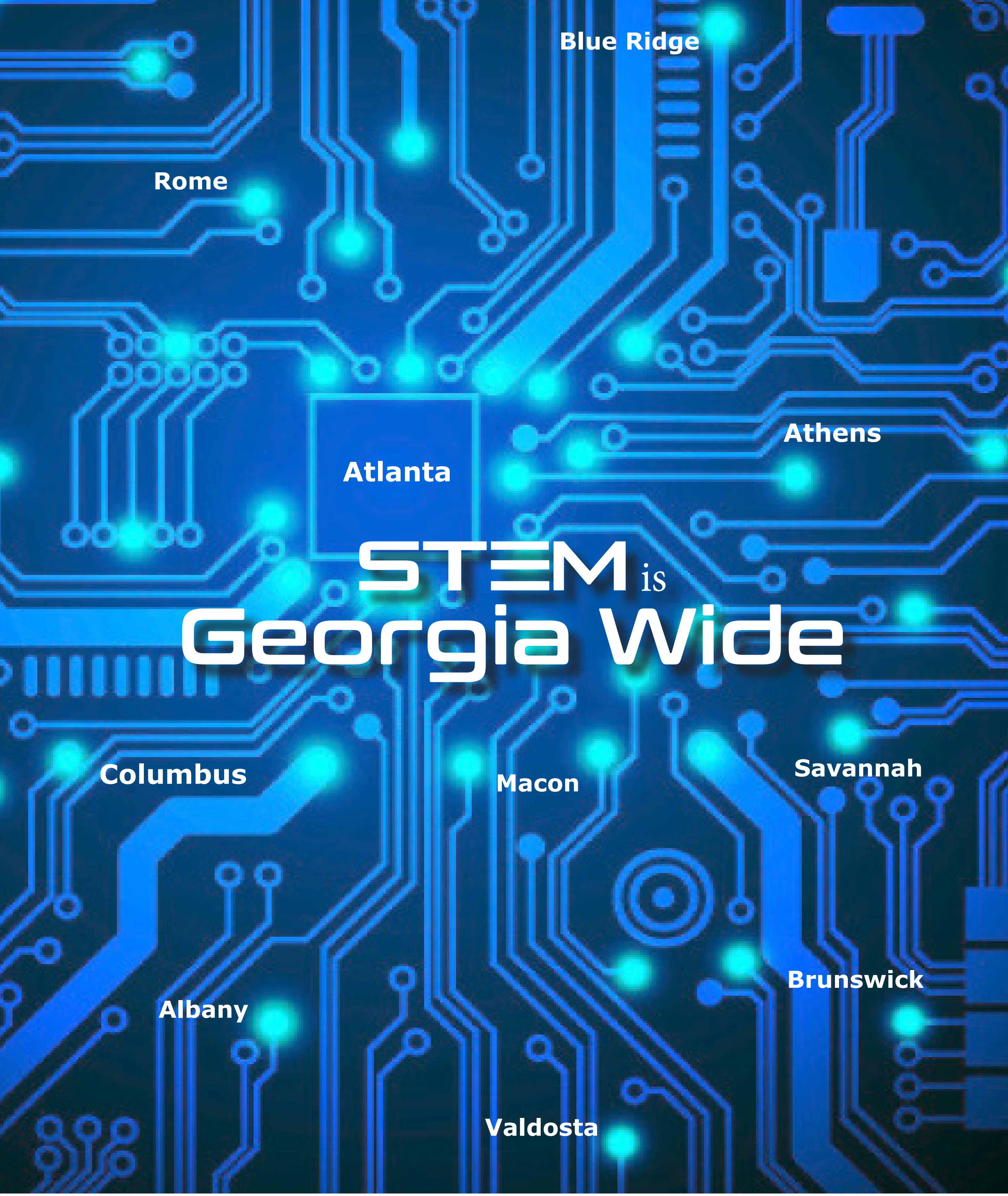

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