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GEORGIA PATHWAYS

MAGAZINE

Apprenticeship v/s Internship

Georgia Day Of Code 2024

Careers In Space Junk

Integrative STEM

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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Internships and Tech Apprenticeships:

Technology Career Pathways Internships and tech apprenticeships serve as valuable stepping stones in a career, especially in technology, but they differ significantly in structure, purpose, and outcomes. Internships are typically short-term experiences lasting a few months. They provide students and entry-level candidates with exposure to real-world work environments. Internships are generally less formal and focus on observational learning, allowing participants to network and gain insight into specific roles or industries. In technology, interns might assist with software projects, data analysis, or development tasks under supervision. However, internships often do not guarantee job placement, and the skills gained may remain at a foundational level.

On the other hand, tech apprenticeships are formal, long-term commitments that combine paid on-the-job training with structured education, usually lasting a year or more. Apprentices develop hands-on, in-depth skills under the guidance of mentors, preparing them for specific technical roles such as software development, cybersecurity, or cloud operations. Unlike internships, apprenticeships are designed to ensure job readiness, often leading directly to permanent positions within the company.

The Technology Association of Georgia (TAG) offers a Registered Technology Apprenticeship Program, addressing skill gaps and creating accessible career paths for Georgia's tech workforce. Notably, 92% of TAG apprentices come from diverse backgrounds (women, veterans, and minorities), demonstrating the program's commitment to inclusivity. Additionally, 88% of apprentices are retained by their hiring companies after training, showcasing its effectiveness.

TAG's Registered Tech Apprenticeship program does not require a college degree or prior technical experience, making it ideal for those seeking career changes or entering the workforce without traditional qualifications. Once chosen by a hiring partner, apprentices receive salary and benefits, technical training, structured mentorship, and a year of on-the-job training, gaining hands-on experience and a portable credential.

TAG's Registered Tech Apprenticeship program goes beyond teaching entry-level skills, delivering a comprehensive, immersive learning experience that includes technical and soft skills—essential assets in the fast-evolving technology field. This initiative helps create an innovative, non-traditional pipeline of tech talent while fostering a more inclusive tech ecosystem in Georgia. For more information, visit https://www.tagonline.org/bridge-builders/tech-registered-apprentice.

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.

Apprenticeship v/s Internship

By Wayne Carley

There's no substitute for hands-on experience, and if you're fortunate to have choices, internships and apprenticeships both offer valuable learning opportunities. Internships are often required for many, allowing students to apply what they've learned in a actual environment. Due to their short-term nature, interns can experience different jobs and companies before committing.

In comparison, apprenticeships prepare workers for one specific job. Apprentices work in skilled trades like construction or roles like cybersecurity specialists, electricians, and healthcare assistants. Interns and apprentices both have the opportunity to gain experience and confidence as they learn career-ready skills.

But these two training programs differ in many other aspects, most notably in duration, pay and outcome.

Regulated programs last about a year, often result in full-time employment, and may only require a high school diploma, depending on the industry. While training, you'll earn a paycheck and possibly receive employment benefits. An internship on the other hand is far less structured, and full-time employment is not guaranteed. As an intern, you assist in a team function more efficiently by tackling smaller tasks.

This valuable support role lets you peak into possible career paths and learn professional etiquette. Internships may or

may not be paid, and employers may offer college credit. While both programs are valuable, there isn't much overlap between the two. Here are some of the main differences between apprenticeships and internships.

Duration

Apprenticeship: Apprenticeships typically last four years, the U.S. Bureau of Labor Statistics (BLS) notes, though they range from one to six years. The longer length allows apprentices to solidify their skills before embarking on independent work.

Internship: Internships typically last between one and three months. College students may work during summer breaks or immediately after graduating.

Structure

Apprenticeship: The U.S. Department of Labor regulates apprenticeships to ensure compliance and effectiveness. Dozens of trades employ apprentices through programs sponsored by employers or union partnerships.

Internship: Each one looks different. Larger companies may have consistent, structured programs, while small businesses might ask temporary hires to be flexible and hop in as needed.

Cost

Internship: Companies aren't required to pay interns, but interns may receive college credits instead of a paycheck, but an hourly wage or a stipend may be available.

Apprenticeship: Apprenticeships are paid; the rate usually increases as participants gain more expertise. After completing a registered apprenticeship, 92% of participants in 2023 earned full-time employment with an average salary of $75,000, according to Apprenticeship USA.

Professional Credentials

Internship: Interns don't receive credentials for their work, but their work experience could count toward earning a professional certificate. As an exception, teaching interns may receive a temporary credential that allows them to teach.

Apprenticeship: At the end of their assignment, apprentices in registered programs earn a national, industry-recognized credential in the area of participation.

College Credit

Internship: Many degree programs require students to complete an internship to graduate. Very often employers may offer college credit instead of payment.

Apprenticeship: While apprenticeships aren't usually associated with degree programs, workers do complete classroom instruction, learning regulations, best practices and technical skills in a controlled environment, alongside hands-on opportunities.

Who Should Complete an Apprenticeship?

Depending on the career field, an apprenticeship can offer guaranteed income, benefits and stable employment opportunities to people without a college degree. Before applying for an apprenticeship, you should know your desired career path. It's best if you already have a strong interest—say, you love fixing things or working with computers. Becoming an apprentice can translate those skills into a fulfilling career.

These are some of the many jobs you can learn by apprenticing:

- Carpenter / construction
- Electrician
- Auto Mechanic
- Dental assistant
- Paramedic
- Hotel and lodging manager
- Cook
- Truck driver
- Roofer
- Soil and plant scientist / agriculture
- Cybersecurity analyst
- Information technology
- Bank teller

Who Should Complete an Internship?

You may not have a choice in completing an internship if your degree requires it and this experience is a great opportunity to explore career paths of interest within your field.

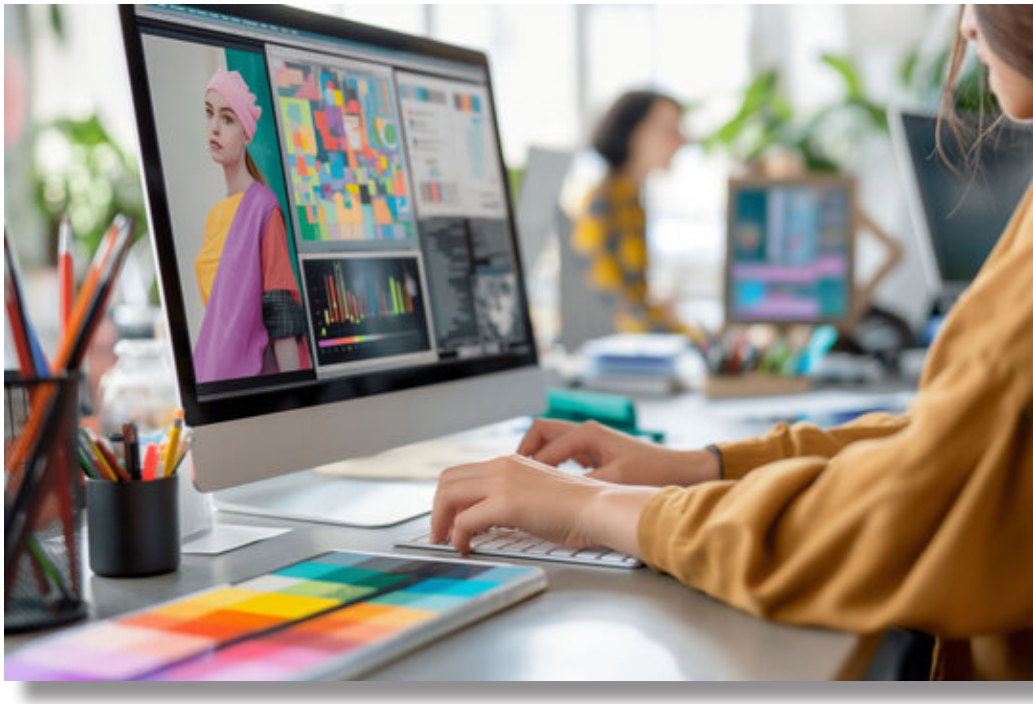
On-the-job experience is very different than learning in a classroom, and during your internship, you might be surprised by new areas of interest you haven't previously considered.

Unlike an apprenticeship, you don't need to find an internship that exactly matches your career goals. Being accepted into an internship is an opportunity to boost your résumé and prove your value to potential employers. If you do receive a full-time offer, you're likely to stay at the company longer than non-intern employees.

Career fields that prefer internships may include:

- Human resources coordinator
- Biologist
- Graphic designer
- Financial analyst
- Public relations representative
- Journalist
- Lawyer
- Engineer
- Software developer
- Marketing associate
- Sales manager
- Accountant

Having choices is great. Considering that this generation of high school graduates will likely experience 3-4 different careers in their lifetime, options and hands-on experience will most certainly be valuable and provide flexibility for future, unknown decisions to be made.



Space Debris:
A problem you need to solve

By The European Space Agency

Satellites in orbit underpin our modern lives. They are used in many areas and disciplines, including space science, Earth observation, meteorology, climate research, telecommunication, navigation and human space exploration. They offer a unique perspective, a resource for collecting scientific data, commercial opportunities and various essential applications and services, which lead to unrivaled possibilities for research and exploitation.

60 Years Of Space Activity

In more than 60 years of space activities, more than 6050 launches have resulted in some 56450 tracked objects in orbit, of which about 28160 remain in space and are regularly tracked by the US Space Surveillance Network and maintained in their catalogue, which covers objects larger than about 1/2 foot in low-Earth orbit (LEO) and one foot in diameter geostationary (GEO) altitudes. Only a small fraction - about 4000 - are intact, operational satellites today. This large amount of space hardware has a total mass of more than 9300 tons.

GEO or geostationary orbit is a circular orbit around Earth's equator where a satellite's orbital period matches Earth's rotation period. A satellite in a geostationary orbit is about 22,236 miles above Earth's equator. The satellite moves in the same direction as Earth's rotation, which is west to east. From Earth, a satellite in a geostationary orbit appears to be stationary in the sky.

Geostationary orbits are used for satellites that need to stay above a specific location on Earth, such as weather monitoring and telecommunications satellites. These satellites are useful because they allow Earth-based antennas to remain fixed on the satellite, without

needing to move.

The term geostationary orbit was first mentioned in popular literature by American science fiction author George Oliver Smith. However, British science fiction author Arthur C. Clarke is credited with popularizing the idea in his 1945 paper, "Extra-Terrestrial Relays". The first object to be placed in a geostationary orbit was the U.S. communications satellite Syncom 3, which launched in 1964.

About 24% of the cataloged objects are satellites (less than a third of which are operational), and about 11% are spent upper stages and mission-related objects such as launch adapters and lens covers.

More than 560 in-orbit fragmentation events have been recorded since 1961. Only 7 events were associated with collisions and the majority of the current events were explosions of spacecraft and upper stages. It is however expected that in the future collisions will become the dominant source of space debris.

Explosions of satellites and rocket bodies

Sources of space debris include explosions of rocket bodies Sources of space debris include explosions of rocket bodies. These fragmentation events are assumed to have generated a population of objects larger than 1 cm numbering on the order of 900000.

The main cause of in orbit explosions is related to residual fuel that remains in tanks or fuel lines, or other remaining energy sources, that remain on board once a rocket stage or satellite has been discarded in Earth orbit.

Over time, the harsh space environment can reduce the mechanical integrity of external and internal parts, leading to leaks and/or mixing of fuel components, which could trigger self-ignition. The resulting explosion can destroy the object and spread its mass across numerous fragments with a wide spectrum of masses and imparted velocities.

The most important non-fragmentation debris source have been more than 2460 solid rocket-motor firings, which have released aluminium oxide (Al_2O_3) in the form of micrometre-sized dust and mm- to cm-sized slag particles.

A second important source was the ejection of reactor cores from Buk reactors after the end of operation of Russian radar ocean reconnaissance satellites in the 1980s. In 16 such ejection events, numerous droplets of reactor coolant liquid (a low-melting sodium potassium alloy) were released into space.

Under the influence of extreme ultra-violet radiation, impinging atomic oxygen and impacting micro particles erode the surfaces of space objects. This leads to mass loss of surface coatings and to the detachment of paint flakes with sizes from micrometer to mm.

Observations with ESA's telescope at Teide Observatory, Tenerife, Spain, have found a population of objects with extremely high area-to-mass ratios. The origin and nature of these objects is not yet fully understood. It is generally agreed now that these objects have been created in the GEO region, possibly from thermal covering material of disposed satellites.

Satellites launched into Low Earth Orbit (LEO) are continuously exposed to aerodynamic forces from the upper reaches of Earth's atmosphere. Depending on the altitude, after a few weeks, years or even centuries, this resistance decelerates the satellite sufficiently so that it reenters the atmosphere. At higher altitudes, above 800 km, air drag becomes less effective and objects will generally remain in orbit for many decades.

At any given altitude, the generation of debris through normal launch operations, breakups and other release events is counteracted by natural cleansing mechanisms, such as air drag and luni-solar gravitational attraction. The result of these balancing effects is an altitude and latitude-dependent concentration (spatial density) of space debris objects.

As a consequence of the rising debris object count, the probability for catastrophic collisions will also grow progressively; doubling the number of objects will increase the collision risk by approximately four times. As the debris population grows, more collisions will occur.

If solutions are not found to deal with space junk, such collisions will start prevailing over the now-dominating explosions within a few decades from now. Ultimately, collision fragments will collide with collision fragments, until the entire satellite population is reduced or destroyed.

This self-sustained process is known as the 'Kessler syndrome'. It must be avoided by the ability to reduce space pollution and prevent the continued growth of space junk.

What are your solutions?

Navigating Pharmacy School: Tips for Success

By Toni Mikhael, PharmD, Touro College of Pharmacy Class of 2024

Pharmacy school is a challenging but rewarding journey. As students embark on this demanding path, it becomes crucial to equip themselves with a toolkit for success. Moving from out of state to attend pharmacy school here at Touro University required significant effort to adapt to the new city life while managing the demands of coursework.

Despite these challenges, I persevered and thrived, honing my ability to adapt and succeed in unfamiliar environments. Having personally navigated through the rigorous curriculum of pharmacy school, I found that following specific tips and strategies played an important role in my success.

Based on my personal experiences and supported by relevant studies, I will share insights into key aspects that can significantly enhance your pharmacy school experience.

Mental Health and Well-being:
A Balancing Act

Maintaining mental health is crucial throughout pharmacy school, given the challenging and demanding curriculum. The rigorous coursework and the expectation of adopting a more professional demeanor can contribute to increased stress levels, which could lead to psychological distress and burnout. Studies have shown that there is high rate of psychological distress among college students, highlighting the importance of prioritizing mental well-being in academic settings.[1]

Studies have also revealed an association between burnout among students and low GPA or poor performance, spanning from high school to medical school.[2,3] Therefore, it is imperative to address mental health concerns proactively to ensure academic success.

Rochester Institute of Technology offers 12 tips to avoid burnout and maintain good mental health.[4] One of the tips that I follow is "make time for things that make you happy". I make time for spending with my family and friends, as well as reading for pleasure, because these activities uplift my spirits.

Another tip that I have been utilizing is "get some exercise in". Having a swim routinely in the morning improves my mental health. Whether it's a brisk walk, a gym session, or a yoga class, physical activity serves as a powerful tool for managing stress and enhancing overall well-being.

Importantly, incorporating activities that do not involve screen time can provide a much-needed break from the digital demands of academic life. If you are an outdoor person, activities like hiking or nature walks allow you to connect with the natural world. If you are an indoor person like me, activities such as board games or puzzles can provide enjoyable experiences. These strategies contribute significantly to overall well-being and ensure sustained success in academia and beyond.

Study Strategies:
Mastering Pharmacology and Pathophysiology

One effective study strategy that I personally explored throughout my didactic studies is to group drugs by class, as it facilitates memorization by taking advantage of the similarities in drug names. For example, drugs within the same class often share common prefixes or suffixes, making the learning process more intuitive. This approach proved highly effective for me and significantly contributed to my success in mastering pharmacology.

Understanding pharmacology concepts and pathophysiology is the cornerstone of building a solid foundation for therapeutic decision-making. This understanding not only aids in memorization but also enhances critical thinking skills essential in the short run for therapeutic classes and in the long run for real-world applications in patient care. Implementing this strategy not only helped me excel academically but also prepared me for the practical challenges of patient care in my advanced pharmacy practice experiences (APPE).

Test-Taking Strategies:
Beyond the Basics

Test days can indeed be nerve-wracking, but strategic planning can significantly enhance your performance. Ensuring a good night of sleep before the exam is crucial, as studies have shown an association between higher grades with longer durations of sleep on nights prior to examinations.[5] Institutions like the University of Surrey in the UK provide valuable tips for achieving good sleep before exam day.[6] Personally, I have found two of their suggestions particularly helpful: (1) watching what and when I eat; and (2) clearing my head before bed by writing down all my thoughts in my notes.

Regarding exam-day strategies, I have developed some techniques that have proven beneficial for me. It is important to maintain focus with light pre-exam meals, such as a bowl of oatmeal with fruit or a yogurt parfait, to provide sustained energy without feeling overly full or sluggish. Additionally, staying hydrated during the test by keeping a water bottle on hand is essential for optimal cognitive function.

Furthermore, having a fidget tool nearby can help alleviate nervous energy and keep your mind sharp. Taking a two-minute break halfway through the exam to refresh your mind can be very helpful in maintaining focus and reducing stress.

Always remember to read the questions carefully before diving into your answers. These are strategies that I have personally employed and found effective in maximizing my performance on test days.

Time Management Tips:
Excel at Scheduling

Time management skills are essential not just for succeeding in classes but also to reduce stress. A 2015 study of 120 college students observing the effects of time management on academic achievement demonstrated that there is an association between practices of time management, anxiety lessening, and higher academic success.[7]

Pharmacy school demands a different time management approach compared to undergraduate school. Unlike the flexibility of creating your own schedule, pharmacy school follows a fixed timetable. Therefore, it is crucial to prioritize your school schedule and build your time for studying, work, socializing, etc. around it.

I recommend adapting by creating a comprehensive study schedule using tools like Excel sheets, which enables you to create tables that outline time slots and days of the week to plan weeks effectively. Prioritize realistic planning, acknowledging that life might throw more at you than you can handle at times. Include dedicated slots for classes, study sessions, personal time, and even workout sessions. Recognize the importance of being flexible and build in catch-up time for those days when life gets busy. Organize tasks based on importance and urgency. These strategies have personally helped me succeed academically and manage stress effectively throughout my pharmacy school journey.

Pharmacy school presents both challenges and rewards, demanding both commitment and consistency for success. Drawing from personal experience, it's evident that a combination of mental health awareness, effective study strategies, adept test-taking techniques, and efficient time management skills are crucial for thriving in this curriculum. By incorporating these insights and strategies, students can navigate the complexities of pharmacy school with confidence and become resilient, successful professionals.

Edited by: Anastasiya Shor, PharmD, BCPS

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Regular Tech Apprenticeships vs Registered Tech Apprenticeships

Technology Career Pathways

Regular and registered tech apprenticeships serve as valuable stepping stones in a career, especially in technology, but they differ significantly in structure, purpose, and outcomes. In vocational training, apprenticeships have become a nontraditional and innovative route for gaining practical skills and experience. While both regular and registered apprenticeships provide valuable on-the-job training, the distinction between them lies in their structure and recognition.

Often less formal, regular apprenticeships provide flexibility but may need more standardized guidelines and recognition. Conversely, registered apprenticeships are regulated programs that meet stringent U.S. Department of Labor standards, leading to nationally recognized credentials. This structured approach ensures consistent training quality, high standards, and better career advancement opportunities, making registered apprenticeships a preferred choice for many aspiring professionals.

The significance of acquiring practical skills and hands-on experience cannot be overstated in today's rapidly evolving job market. Registered tech apprenticeships offer a structured pathway for individuals to gain valuable, tech industry-specific knowledge while earning a wage. Unlike traditional education routes, these programs combine classroom (virtual and in-person) instruction with on-the-job training, ensuring that apprentices are theoretically proficient and practically skilled. By meeting rigorous standards set by the U.S. Department of Labor, registered tech apprenticeships provide a nationally recognized credential upon completion, enhancing employability and career advancement opportunities.

As a result, a vital bridge between education and employment is built, fostering a skilled and competent workforce ready to meet the demands of today's competitive industries.

Regular Apprenticeship (Non-Registered)

- Formal Recognition: Not formally recognized by the U.S. Department of Labor.
- Standards: No standardized requirements for wages, training, or mentorship.
- Credential: May or may not lead to a recognized credential.
- Duration: Can vary widely in length and structure.
- Funding: Typically does not receive federal support or incentives.

Registered Tech Apprenticeship

- Formal Recognition: Nationally recognized and approved by the U.S. Department of Labor.

- Standards: Must meet specific standards for wages, training, mentorship, and on-the-job experience.

- Credential: Leads to an industry-recognized credential that employers value.

- Duration: Classroom training (3-4 months) and on-the-job training 1 year. Leading to full-time permanent employment.

- Funding: Eligible for federal support, tax credits, and other incentives.

Registered Tech Apprenticeships are a testament to commitment and structure. These formal, long-term programs, often lasting a year or more, are a unique blend of paid on-the-job training and structured education. Under the guidance of experienced mentors, apprentices delve deep into their chosen field, be it software development, cybersecurity, or cloud operations.

Unlike internships, apprenticeships are designed to ensure job readiness, often leading directly to permanent positions within the company. Registered Tech apprenticeships have been gaining traction as a valuable pathway to careers in technology. Here are some statistics that highlight their impact:

Growth in Registered Apprenticeship Programs

In FY 2021, nearly 27,000 registered tech apprenticeship programs, including many tech-focused programs, were active nationwide.

- New Registered Tech Apprentices: In FY 2021, over 241,000 new apprentices, including individuals pursuing careers in various tech fields, entered the national apprenticeship system.

- Apprenticeship Graduate: In FY 2021, 96,000 apprentices graduated from the apprenticeship system, gaining the skills needed to succeed in the tech industry.

- Economic Impact: Apprenticeships help individuals build financial security while obtaining necessary skills. Nationwide, over 593,000 apprentices obtained skills and earned wages.

These statistics demonstrate the growing importance and effectiveness of tech apprenticeships in preparing a skilled workforce for the tech industry. In essence, registered tech apprenticeships offer a more structured and standardized approach, ensuring that apprentices receive consistent training and recognition for their skills. This can lead to better job prospects and higher wages upon completion.

As the first Registered Tech Apprenticeship in Georgia, the Technology Association of Georgia (TAG) offers a robust pathway into the tech industry through its program. This program bridges skill gaps in Georgia's tech workforce and provides accessible career paths, particularly for diverse and underrepresented individuals.

Once selected by a hiring partner, apprentices in TAG's program receive structured mentorship and one year of paid on-the-job training, equipping them to tackle industry-specific challenges.

Participants also earn a portable credential, which enhances their employability across the tech sector. This initiative helps create a pipeline of talent while fostering a more inclusive tech ecosystem in Georgia.

For more information, visit:

- The Technology Association of Georgia: **https://www.tagonline.org/bridge-builders/tech-registered-apprentice**

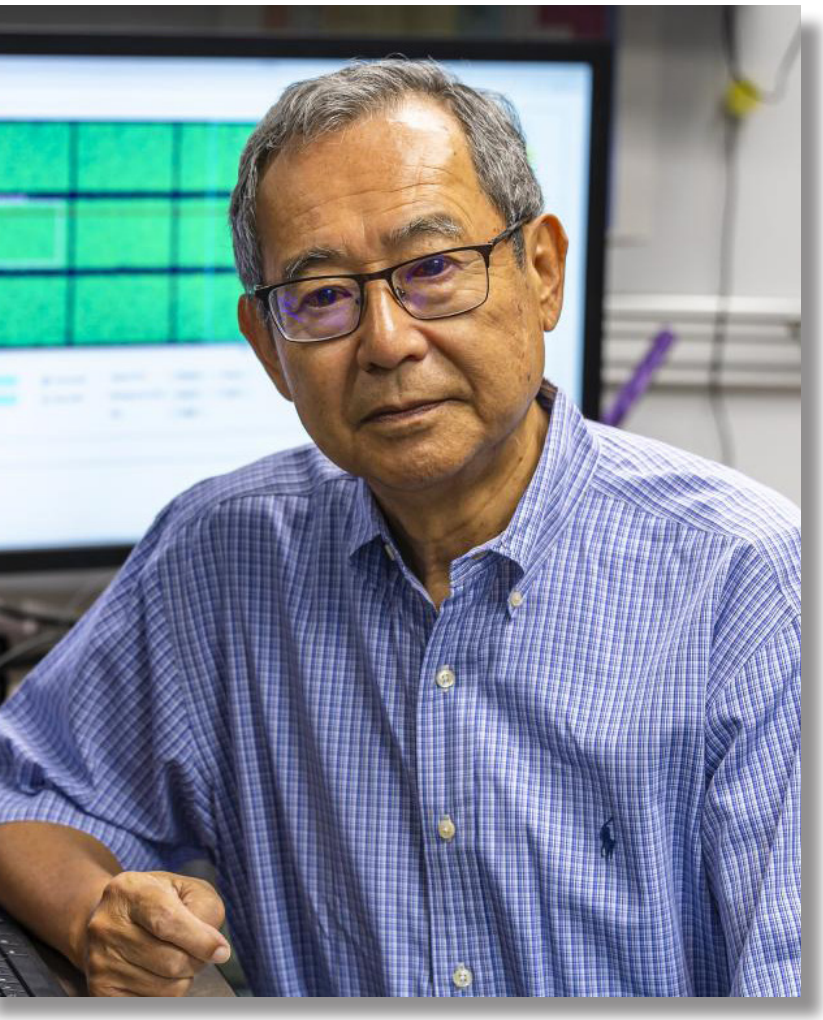
- Apprenticeship.Gov: (**https://www.apprenticeship.gov/data-and-statistics**) U.S. Department of Labor:**https://www.dol.gov/agencies/eta/apprenticeship/about/statistics/2021**)

OAK RIDGE National Laboratory

Materials scientist Egami describes new world order for glasses, liquids

By Christy White / ORNL

In 1543, Copernicus pitched the heliocentric idea that the Earth orbited the sun. His theory took 150 years to catch on and more than 400 years for the Vatican to officially accept it. Likewise, distinguished materials scientist Takeshi Egami has spent his career revealing the complex atomic structure of metallic glass and other liquids — sometimes sharing theories with initially resistant minds in the scientific community. However, he is willing to go the distance to bring his colleagues on board to his latest discoveries.



Takeshi Egami uses the Spallation Neutron Source at Oak Ridge National Laboratory to study the structure and dynamics of complex materials. Credit: Carlos Jones/ORNL, U.S. Dept. of Energy

The noncrystalline, amorphous atomic structure of liquids and glasses is, quite literally, all over the place. The landscape is chaotic: disorderly atoms are scattered about like tapioca pearls in a freshly shaken boba tea.

Egami studies these materials at the Department of Energy's Oak Ridge National Laboratory and the University of Tennessee, Knoxville, or UTK. He directed the UT-ORNL Joint Institute for Neutron Sciences from 2008 to 2015. Egami and his colleagues in ORNL's Materials Science and Technology Division use neutron scattering and

synchrotron X-ray to see, with increasing clarity, the structure, dynamics, transition and deformation of noncrystalline materials.

Takeshi Egami stands at his workstation at ORNL's Spallation Neutron Source where he used novel experimental methods to propose the density wave theory. Credit: Carlos Jones/ORNL, U.S. Dept. of Energy.

In crystalline solids, atoms bond together and are arranged in a rigid, jungle gym-like structure called a lattice. This lattice is what makes most solids — such as jewelry, refrigerators and high-rise buildings — solid.

"There's not much freedom for atoms to move around," said Egami. "A crystalline structure is like an autocracy where each atom must behave like every other atom. A liquid is like a democracy where atoms may move about more." Structural analysis is challenging since atoms are in constant disarray.

The typical method of atomic modeling is a bottom-up approach in which each atom connects with its closest neighboring atoms. This method works reliably for most solids, but bottom-up analysis of noncrystalline materials has always made Egami uneasy because of their unstable, chaotic nature. "The bottom-up approach is very self-centered, like the geocentric view of the universe where the Earth is at the center," he said. Like Copernicus, Egami has

looking for the cosmic truth about these materials his whole career.

After completing undergraduate studies in applied physics at the University of Tokyo, a doctorate in materials science from the University of Pennsylvania and postdoctoral studies at the University of Sussex and the Max Planck Institute, Egami taught at the University of Pennsylvania for 30 years. In 2003, he came to ORNL where to focus on the underdeveloped field of liquid physics.

"Water itself is a major mystery," said Egami. "The classical physics of water is well understood, but there are many things about water we don't understand. It's such basic stuff, right? Life came out of that, and we don't know why."

Egami uses enigmatic metallic glass to study the structure, function and deformation of noncrystalline materials. Metallic glass presents as solid, but its disorganized atomic structure makes it technically a frozen liquid. The opaque substance is made of metal alloys — made by mixing two or more metallic elements — that are supercooled so atoms do not have a chance to organize themselves into a lattice structure.

This lack of structure makes metallic glass highly elastic, extremely strong and easy to magnetize. Since entering the marketplace in the 1970s, metallic glass has been used in products such as sporting goods, smartphones and medical devices. Still, not much is known about the source of its mechanical properties, which has limited its commercial use.

Takeshi Egami's research at Oak Ridge National Laboratory defies current theories on the structure and function of metallic glass and other disordered materials. Credit: Carlos Jones/ORNL, U.S. Dept. of Energy

For example, for all its strength, metallic glass is extremely fragile. Give a golf ball one too many whacks with a club made of it, and the club will shatter. Current theories about metallic glass cannot describe this kind of weirdness. Egami's research has begun to suggest structural and functional behavior of noncrystalline materials that defies prevailing theory. He hopes these findings lead to changes in analysis that have wide scientific impact.

In 2017 using synchrotron X-rays at the SPring-8 facility in Japan, Egami and his group showed, for the first time, dynamic atomic correlation in water. The correlations are measures of how much the movement of one atom is influenced by the presence of others. "Everybody knows about these correlations, but no one had seen them before," said Egami. "Now, we can see how atoms relate in space and time, for the first time."

The journey to a new density wave theory began with Egami's uneasiness with bottom-up atomic modeling. With a wider look, his new approach began with the medium-range order — the correlation of a single atom and its surrounding atoms at a distance up to 10 times the atomic size.

"I always thought maybe there's a global way of looking at it, not just local," he said. "Why can't we look at the whole system at once?" A 2022 paper by Egami and UTK's Chae Woo Ryu described a density wave state, or ripple. Evidence of this ripple had been observed before but was interpreted as noise in the experimental data caused by X-ray scattering. In 2019, Egami's team used a novel experimental method of liquid levitation under vacuum that removed the noise and confirmed that the ripples are real. This finding ushered in the density wave theory and a new hypothesis on the relationship between the bottom-up and top-down methods.

"Sometimes the conflict can create something totally new," said Egami. The competition between the bottom-up and top-down observations prompted Egami and colleagues to propose a new medium-range order that may hold the key to viscosity and deformation in liquids and glasses. Egami hopes these findings will shatter the metallic glass ceiling and gain traction beyond the world of the samples they were tested on.

Scientists calculate and predict electron behaviors of complex systems using density functional theory. "Chemists use this all the time because it's easier than running an experiment," said Egami. But the calculation is not ideal for materials in which electrons are strongly

correlated, such as magnets or high-temperature superconductors. Using the same approach for electrons as he used for liquids, Egami has succeeded in seeing electron correlation. "Since we can see dynamic electron correlation, we no longer need to rely on density functional theory."

The esteemed materials scientist is taking his findings on the road and has embarked on a one-man talking tour. "I know this will take some time to catch on," he said. Although his findings have met resistance in other disciplines, he is used to it. "It's not my first rodeo," Egami said, speaking of his co-authored book that proposed — initially to great resistance — a new method of analyzing disorganized crystals.

After 10 years of persuasion, colleagues finally came around. Egami's analysis technique, detailed in Underneath the Bragg Peaks, is now standard in the field. For the proposed density wave theory and medium-range order of metallic glasses, "I'm in no hurry," Egami said. He is optimistic that his theory's acceptance will not take long as it did for Copernicus.

The DOE Office of Basic Energy Sciences funds Egami's work. His research primarily relies on the Spallation Neutron Source, a DOE Office of Science user facility at ORNL.

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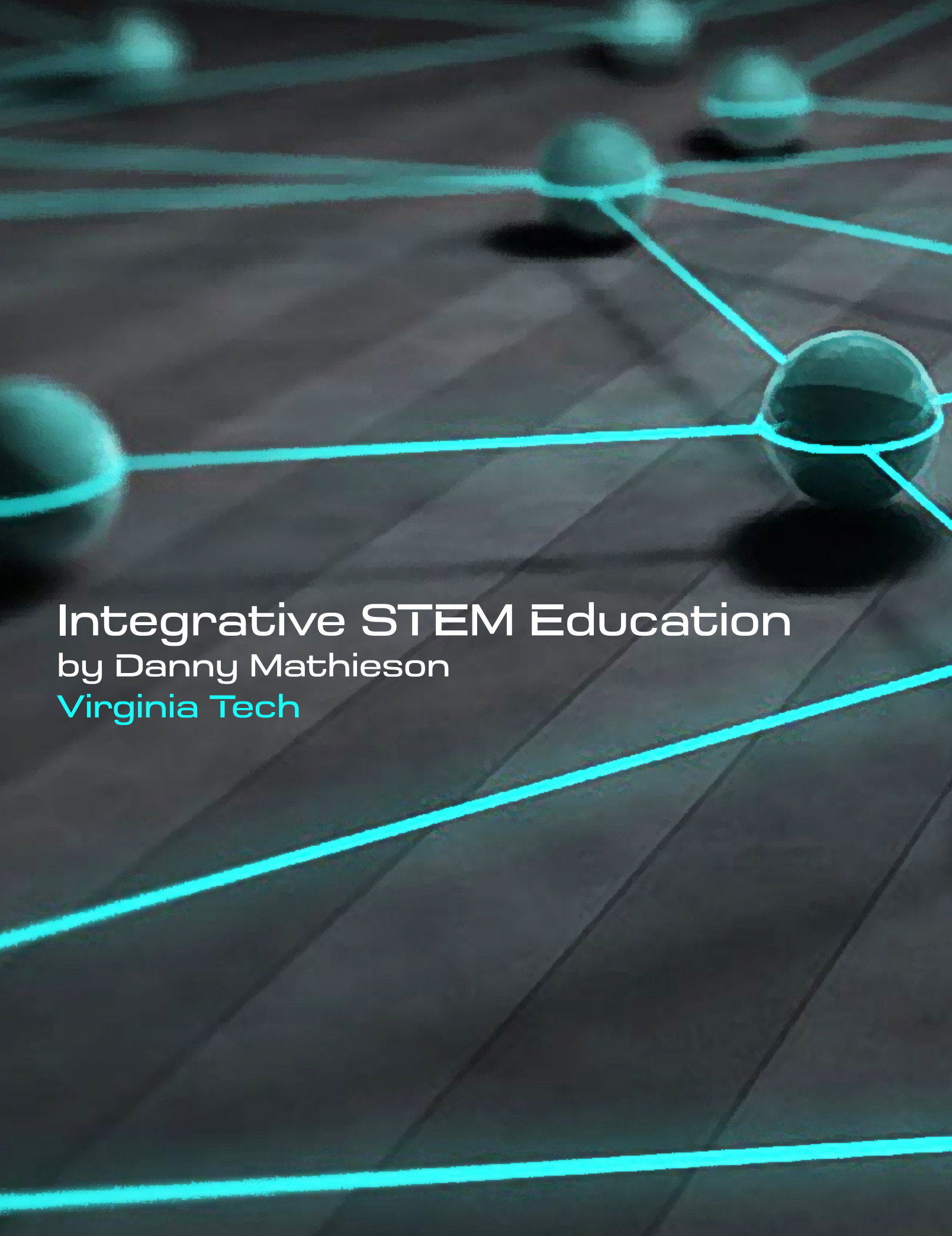
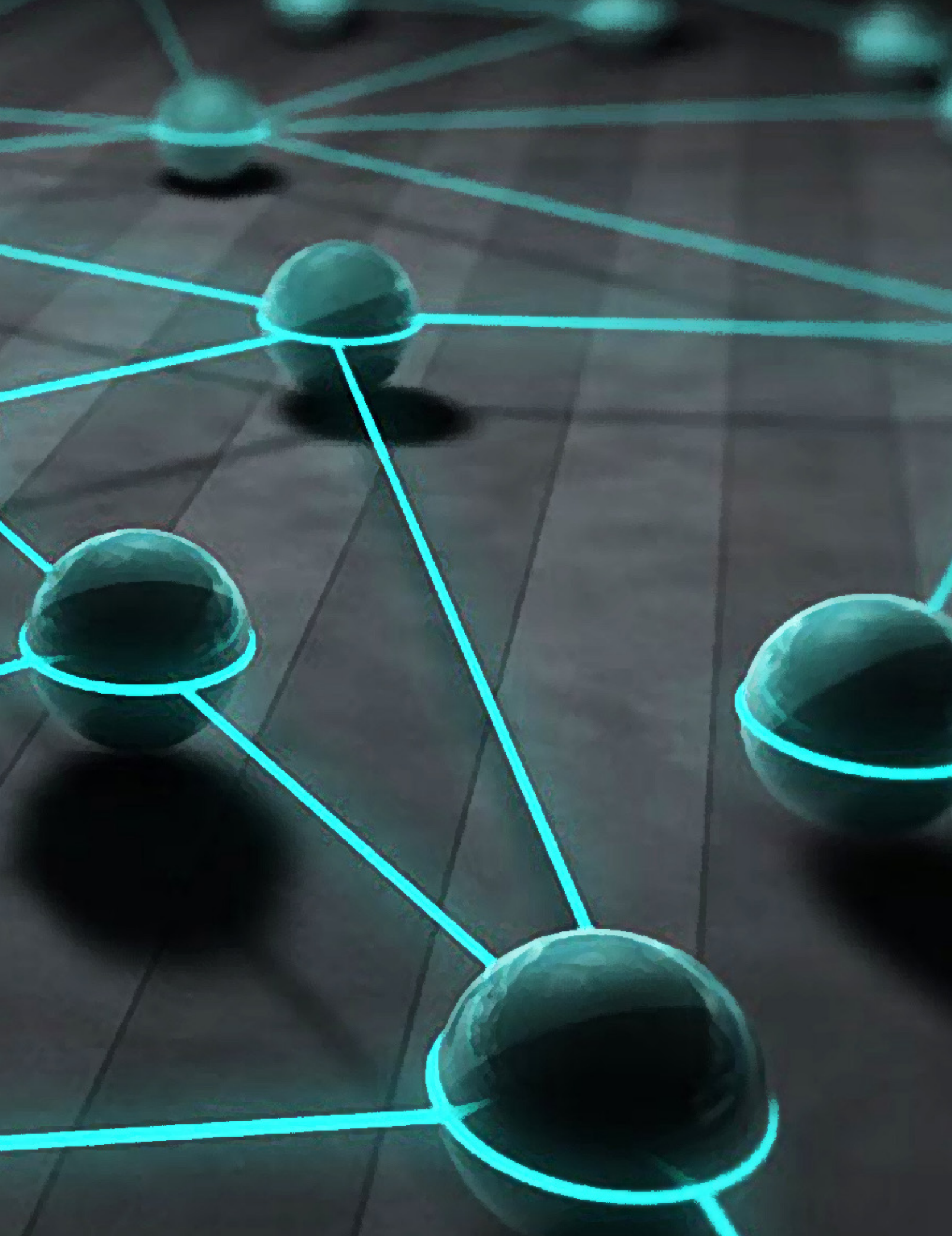


Integrative STEM Education

by Danny Mathieson
Virginia Tech



Integrative STEM Education

Integrative STEM Education (I-STEM ED) is designed as "the application of technological/engineering design based pedagogical approaches to intentionally teach content and practices of science and mathematics education through the content and practices of technology and engineering education. Integrative STEM Education is equally applicable at the natural intersections of learning within the continuum of content areas, educational environments, and academic levels" (Wells & Ernst, 2012/2015). Used as the pedagogical approach at the school level I-STEM ED creates a more effective learning environment for middle school learners.

Promoting 21st Century Literacy

Research in 2006 by Bybee et al. calls for technology and engineering education pedagogies to be at the forefront of broader educational reforms; preparing students for the desired competencies of a 21st century workforce such as "collaboration, critical thinking, complex communications skills, and the ability to solve semi-structured problems" (p. 350). I-STEM ED prepares 21st century literate students in a multitude of ways. It intentionally provides students with the opportunity to manipulate, interact with, and create technologies to meet the needs of humans. By capitalizing on the natural intersections of the four STEM disciplines, students apply skills from each field in ways to show the fields' unity and interdependence. Through a frame of technological design, students gain a clear understanding of the scope of technology and its strengths and limitations.

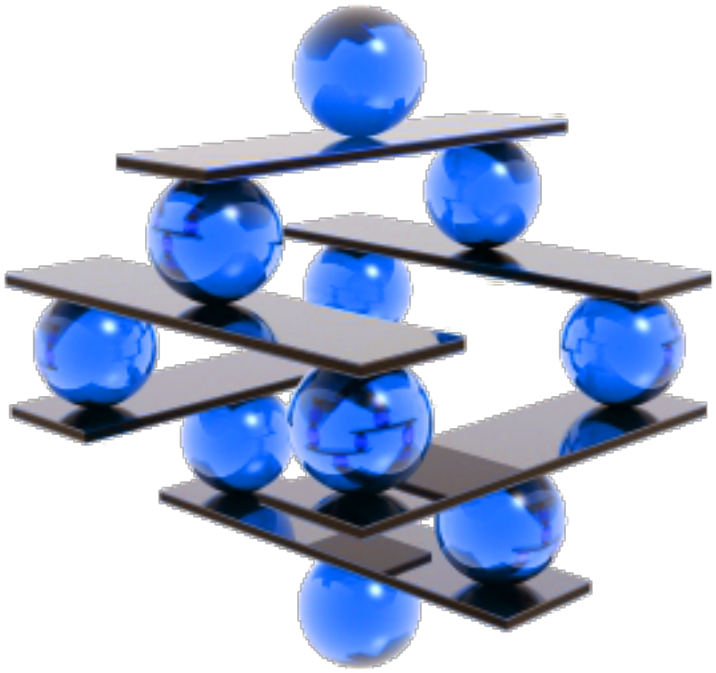
Further, **I-STEM ED** provides a framework for meaningful collaboration. The small group nature of engineering/technological design challenges provides a space for positive interaction with both peers and superiors" (Wilber and Pendered, 1967, p.30).

Promoting Engagement

Using technological/engineering design based teaching as its signature pedagogy; I-STEM ED goes a step beyond project-based learning, while still reaping some of its key benefits. Technology Education researchers have been aware the benefits of hands-on instruction for nearly a century. Key scholars in the field, Bonser and Mossman, were quick to point out technology education pedagogy allows students to take a hands-on approach to learning.

While it is clear the mechanical skills learned in this approach prepare students for the manual dexterity needed in many STEM fields, the mental benefit is less obvious. Students often manipulate objects allowing them to gain deeper interest, appreciation, and understanding of concepts (Bonser and Mossman, 1930). Kinesthetic learners, nearly 45% of the population, are most successful when totally engaged with a learning activity. They acquire information fastest when participating in a science lab, drama presentation, skit, field trip, dance, or other active activity.

The hands-on teaching techniques present in I-STEM ED are gaining recognition because they address the challenging needs of kinesthetic learners, as well as the diverse needs of auditory and visual learners" (Feldman and McPhee, 2007).



Promoting Academic Achievement

Studies show that the positive peer to peer interaction in I-STEM ED cooperative learning not only meets the needs of STEM learners, but also increases academic outcomes. As cited by Gokhale in 1995, "According to Johnson and Johnson (1986), there is persuasive evidence that cooperative teams achieve at higher levels of thought and retain information longer than students who work quietly as individuals. The shared learning gives students an opportunity to engage

in discussion, take responsibility for their own learning, and thus become critical thinkers" (Gokhale, 1995, p. 1). Additionally, research by Fortus et al showed that design based learning equally contributes to academic achievement, stating that the design based approach more closely fits the nature of sciences ill-defined problems and therefore leads to greater academic gains (Fortus, et al, 2004).

In his study, "the development of students' scientific knowledge was assessed through posters and models constructed during the curricular enactments and by identical pre- and post-instruction written tests. The post-tests showed considerable gains compared with the pre-tests, while the models and posters show application of this newly constructed knowledge in solving a design problem. These positive results support efforts being made to restructure school science around inquiry based curricula in general and design based curricula in particular" (p. 1081).

Best Practices in Integrative STEM Education

Best practices in I-STEM ED call for intentional integration of science, technology, engineering, and mathematics content and skills through the design of a solution addressing a human need. To that end, it is essential for teachers to collaborate across content areas to plan, instruct, assess, and review I-STEM ED design challenges to ensure curricular alignment and sound pedagogical practices. It is essential that the design process be student-led, shifting the role of teacher along a spectrum of instructor to facilitator as students navigate towards their optimized solution.

Key checkpoints have been identified in the I-STEM ED design process following the PIRPOSAL Model. These include: Problem Identification, Ideation, Research, Potential Solutions, Optimization, Solution Evaluation, Alterations, and Learned Outcomes. Teachers should drive students through Webb's Depth of Knowledge to appropriate checkpoints in the design process by asking both convergent and divergent questions (APS, 2009; Wells, 2016).

"Every subject is a STEM subject.....Integration"

Students participating in a design challenge should be asked to recall information from various contexts to brainstorm a solution, reaching Webb's Depth of Knowledge 1. Students should then be tasked with discerning between best solutions through comparisons and inferences, reaching Webb's Depth of Knowledge 2. Students' should then transition to Webb's Depth of Knowledge 3 through strategic thinking and design planning. Most of students' time should live in Webb's Depth of Knowledge 4, where students design a solution through application of concepts and evaluate its effectiveness. This constant waltz between knowing and doing promotes meaningful learning through the process.

About the Author

At the time of this article, Danny Mathieson is a PhD student in Curriculum and Instruction at Virginia Tech. His research focused on the intersection of Integrative STEM and place-based education pedagogies and their benefits to rural learners.

Additional Resources

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AI Skills: The New Currency in Today's Job Market

The AI revolution is here. Ever since ChatGPT arrived on the scene in late 2022, artificial intelligence has been reshaping the way we live and work. What does that mean for tech professionals looking to compete in a changing labor market?

TV pundits and talking heads love to get riled up about whether robots are coming for our jobs — but the truth is that AI will probably create more jobs than it eliminates. And one thing's for sure: understanding how AI works, and mastering AI skills, will be the key to success in tomorrow's ever-changing world of work.

New research shows that a growing number of companies are asking for AI skills in job descriptions — including non-tech roles. And a survey of HR professionals released last month shows that job candidates with AI skills ask for more money during the interview process — and tend to get it once they're hired. Simply put, AI is going to be underpinning nearly every job out there. That's why staying ahead of the latest in AI development is so important.

Building AI skills doesn't just mean learning how to engineer prompts for ChatGPT. It's everything from programming to data modeling and analysis to mastering concepts like machine learning and natural language processing. And if there's anything certain in our fast-paced economy, it's that building AI fundamentals today will translate to career opportunities tomorrow and beyond.

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It won't be long before all kinds of jobs, all across the economy, require AI skills. And starting now is the best way to accelerate your ascent up the career ladder. Build those skills today and you'll lay the foundation for opportunity for years to come — and set yourself up for success in an AI-driven future of work. Register today to get started with a career in tech.

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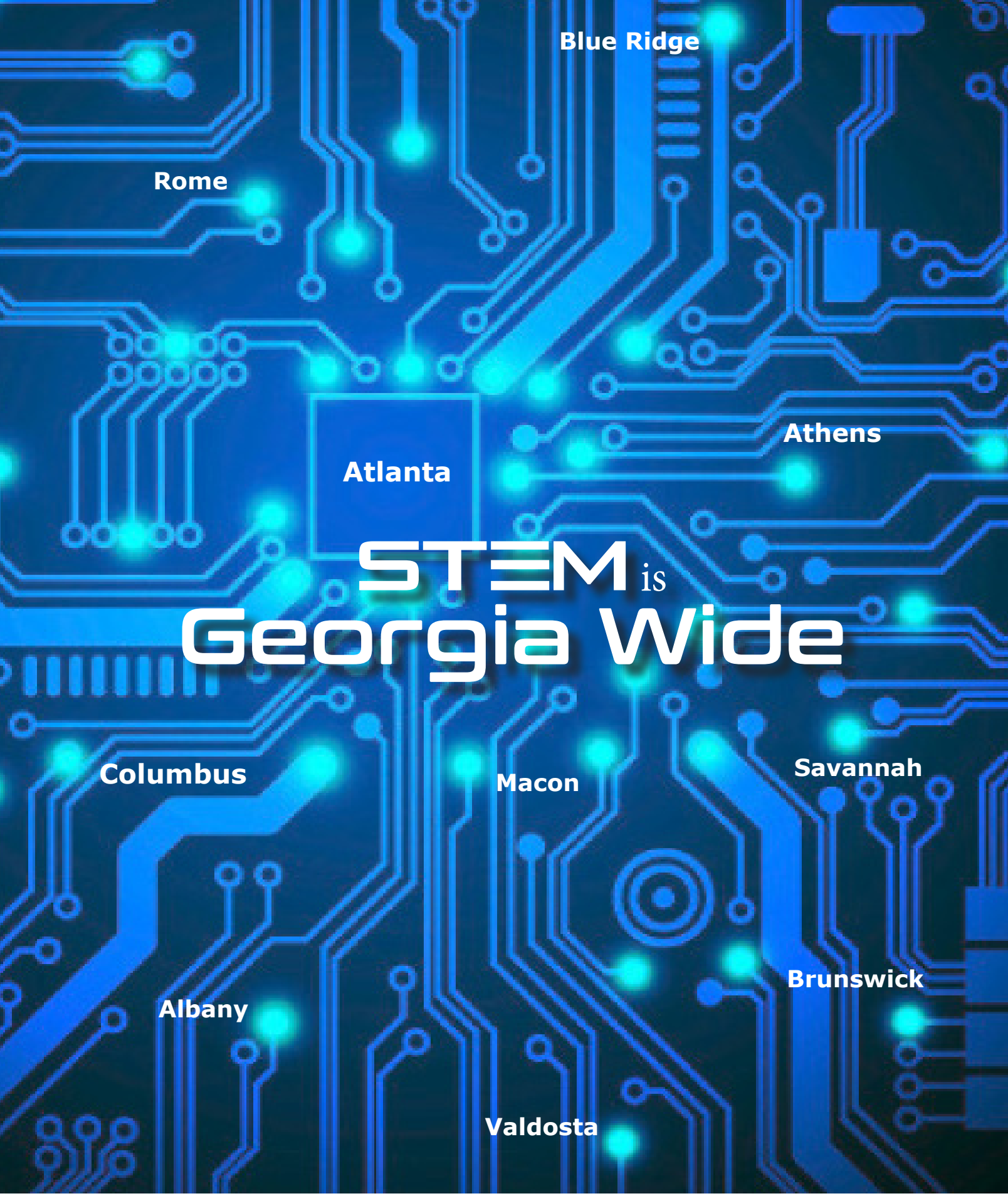

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