

STEM

M G A Z I N E

The STEM of
SOCCER

Dreaming In Technicolor?

When Innovation Becomes
a Threat

We believe that the key to success in seeing higher graduation rates, improved testing results, student inspiration, creativity, excitement and career satisfaction often rests in the hands of the educator. The example and inspiration of individual educators carries tremendous weight on a daily basis, greatly impacting the quality and effectiveness of the classroom environment.

STEM Magazine strives to encourage curiosity, investigation, inspiration, creativity, and innovation; the foundations of every career passion.

Wayne Carley
Publisher

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STEM Magazine
<http://www.stemmagazine.com>

STEM Magazine is a monthly non-profit education publication for educators, students, their parents and industry professionals.

Read monthly in 75 countries and 47 U.S. states, STEM Magazine strives to encourage the educator to better understand the importance of STEM skills, their use in every school subject, the need and ease of integration into curriculum and the urgency for students to embrace STEM through a more complete understanding of it.

We will be employing an AI assistant to help with research and content verification.

The STEM Of Soccer

Wayne Carley

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The STEM of Soccer (*Futbol*)



Soccer is a STEM sport, requiring the constant use of science (the systematic accumulation of knowledge), technology (the practical application of science), the engineering method (decision making and problem solving), and mathematics (the science of numbers, their operations, interrelations, combinations, generalizations, and abstractions).

Once again we see the human brain is already wired for the physics of soccer and other sports, therefore we don't actually have to "learn" everything. Aside from rules and guidelines of the sport, participation is a ballet of "hard-wired" science, technology, engineering and math.....lots of math.

Let's simplify and clarify our participation in soccer from the STEM perspective. This will educate you on the nuances of what your mind and body are doing naturally and intellectually.

The Science of Soccer

The systematic accumulation of knowledge (science) in soccer includes:

- Learning the rules and positions of the game.
- Learning and understanding the formations the team will use in the course of any match.
- Learning and maintaining updated knowledge about your personal physical fitness and endurance abilities. This includes dietary priorities, physical training response, rest requirements, and importantly, mental health and attitude status. Mood and emotions can vary widely from day to day and directly impact performance.
 - how long can I run "all out"?

- how much and what should I eat prior to the match?
- what is my pre-match routine?
- what physical and mental prep needs to be done?

● Learning and maintaining information about your team mates, their fitness, abilities, tendencies, preferences and communications styles.

● As well as knowing your teammates, you'll need to know all there is about each player on each team you play. Their fitness, abilities, tendencies and so on directly affect your competitiveness against them.

● Understanding the condition of the turf at each stadium on any given day, as it will directly affect your footing and play.

There is certainly much more to know and learn, but this is a general representation to consider.

The Technology of Soccer

As this is the practical application of the science we've discussed, applying all we've learned is critical to personal performance and team outcomes. Playing your best does not guarantee wins, but lack of preparedness and application certainly encourages losses.

Other tech considerations include and knowledge of your interactions with the



The Engineering of Soccer

As a decision making and problem solving process, throughout the match we are constantly choosing from a variety of choices as to where to run, kick the ball, how hard to kick it, how high, to whom and what are all of the possible outcomes of those choices....then we choose in an instant. Sometimes it's a good choice, other times it's not.

These instantaneous choices are an amazing function of our brains, but also a “learned” skill for many. Whether you are a natural or a student of soccer, you will need the engineering method.

the soccer ball. Though all regulation balls are standardized, how you kick the ball on that days turf (moisture, temperature) is a practiced application learned from months and years of experience.

Your cleats for this match will probably be chosen specifically for turf conditions and your personal preference based on those months of experience.

Reflecting back on the “science” we’ve accumulated about players and ourselves, our play choices are rooted in experience and a formation plan. The primary **problem** to be solved is simple:

“How to get the ball past defenders and into the goal. And on the opposite side, how to keep their ball out of our goal”

The catch is, there will be a hundred smaller problems to solve from start to finish, each requiring decisions by every player on the field. Every moment of the game, everyone on the field is trying to solve their problem of how to position themselves in relation to their opposition player, formation and opportunities.





Decisions -

- Where should I be at this moment?
- Where do I need to be a minute from now?
- What might my opponent do right now or in response to my play?
- Should I pass or push?
- Is the formation working?
- Should I speed up, juke, get physical?
- **DECIDE NOW**
- Then do it again, and again, and again.

One decision every 2–4 seconds.....
2,000 per match.

The Math of Soccer

Geometry and Physics dominate this sport and connect closely to your decision making. Although physics is not math, mathematics is the fundamental language of physics, serving as the bridge between abstract concepts and the natural world. It provides the exact vocabulary, grammar, and syntax needed to formulate physical laws, model complex systems, and make verifiable predictions about reality - in this case, the behavior of the soccer ball.

Physics - the study of the physical plane of matter, motion, force, and energy.

Newton's Laws of Physics

Law 1

The first law of motion is called the Law of Inertia. It states that “any object at rest, will tend to stay at rest, and any object in motion, will tend to stay in motion unless acted on by an unbalanced force.”

In soccer however, this unbalanced force is usually **the soccer player's foot**. He or she will use muscles in the body to create a force to move the leg forward and kick the ball. Once kicked, it will keep moving without stopping. The reason the ball will stop on its own is because of friction with air resistance, friction contact with the ground and Earth's gravitational pull. A player will have to intercept the flight or roll of the ball to break the first law.

Law 2

“The change in velocity (acceleration) with which an object moves is directly proportional to the magnitude of the force applied to the object and inversely proportional to the mass of the object.”

This can be explained by the equation $F=ma$. The acceleration of the ball (a) is determined by the force applied (F) divided by the mass of the object that is being moved (m). This simply means that if the ball has a lot of mass, it will require more force to accelerate. If the ball has little mass, it will require little force. Since regulation balls are the

same, this calculation remains the same from match to match.

Law 3

Newton's final law of motion states that “..for every action, there is an equal and opposite reaction.”

This literally means that when you kick the soccer ball, it will resist you just as hard. Since your leg has more mass, applied energy and acceleration, the ball has no choice to move in the opposite direction.

Geometry -a branch of mathematics that deals with the measurement, properties, and relationships of points, lines, angles, surfaces, and solids.



The mere successful interception of the ball by another player is an amazing feat of mental math and engineering, instantly calculating the ball speed, direction and what will most likely be the outcome of its flight. Using your eye and feet coordination, you must estimate the point of interception, and get there.....a geometric angle. The speed and direction of the ball are evaluated, the energy forced on the ball is estimated, the running speed and direction have to be adjusted, and then executed. Do this again, and again and again.

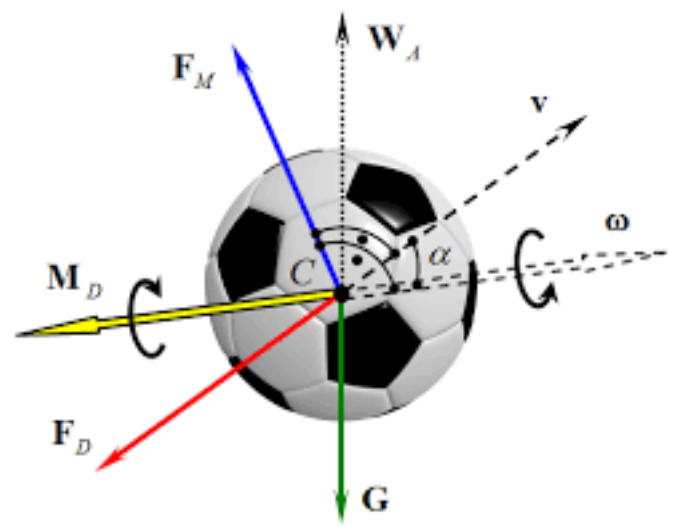
This isn't a law, but we need to mention momentum. When a player kicks a ball, they transfer their momentum to the ball. Momentum is the velocity of an object times its mass. When players pass the ball to each other, they may



use their feet to slow (control) the momentum of the ball by moving with the ball and resisting it slowly. This way, they can have more control over the ball. This is decision making and often problem solving as kicking in a specific direction, at a precise speed, at an exact moment, is at the heart of soccer. The principals of geometry, basic multiplication, trigonometry, calculusdid you have any idea? You are so much smarter than you know and much of it is hard-wired in your brain.

Say it....**"I enjoy using math"**.

We love our sports, both as participants and observers. Understanding the STEM of the sport adds interest, appreciation and awe at the ability of the human mind and body when finely tuned by devoted athletes. In spite of momentary resistance to learning a subject we don't immediately enjoy, we often embrace that subject in pursuit of another passion, such as sport. In order to become the athlete we want to be, no obstacle or necessary "subject" will stand in our way.



When Innovation Becomes a Threat: The “**Pet-to-Threat**” Tension Holding STEM Education Back

By Shelly A. Muñoz

Walk into almost any school today and you’ll hear a familiar message:

“We value innovation.”

It appears in strategic plans, conference keynote sessions, grant proposals, and professional development workshops. Teachers are encouraged to think differently, take risks, integrate emerging technologies, and prepare students for a rapidly changing future. And in many classrooms, they do exactly that. They redesign lessons. They create interdisciplinary STEM experiences. They build authentic problem-solving opportunities. They push beyond worksheets and

memorization toward curiosity, creativity, and deeper thinking.

At first, these efforts are often celebrated. Until something shifts. The innovation begins influencing others. It gains momentum. It challenges long-standing practices. It raises questions about existing systems. And suddenly, what was once praised starts to feel uncomfortable. This is what I have come to call the **Pet-to-Threat** shift.



The Innovation We Love— Until It Grows

The Pet-to-Threat concept is simple, but deeply revealing: something we celebrate, trust, or comfortably accommodate—a “pet”—can quickly become something we resist—a “threat”—the moment it begins to disrupt the system around it.

In education, innovation is often welcomed—as long as it remains inspirational but contained, encouraged but optional, and visible but not system-changing. Schools proudly showcase innovation nights, STEM expos, robotics teams, makerspaces, and creative classroom projects. Social media feeds highlight “future-ready learning” and “21st-century skills.” But real innovation rarely stays small.

The moment it begins to shift instructional expectations, expose outdated practices, require new resource allocations, challenge pacing guides or assessment systems, or influence broader school culture, it crosses an invisible threshold. What was once inspiring can suddenly become “difficult,” “hard to scale,” or “misaligned”, not because the idea lacks value—but because systems often struggle with sustained disruption.

“We are preparing students for innovation within systems designed to minimize disruption.”

The Contradiction at the Center of STEM Education

This tension is especially visible in STEM education. We tell students to ask difficult questions, experiment and iterate, embrace productive failure, solve problems that do not yet have answers, and think creatively and critically.



Yet the systems surrounding those classrooms are frequently designed for standardization, predictability, efficiency, uniform pacing, and easily measurable outcomes. This creates a profound contradiction: we are preparing students for innovation within systems designed to minimize disruption. The result is that educators often find themselves caught between two competing realities: the future demands adaptability, creativity, and innovation, while the system rewards consistency, compliance, and predictability.

The Quiet Ways Systems Resist Change

Resistance to innovation is rarely dramatic. It does not usually arrive as someone saying outright, “We don’t want innovation.” Instead, it often appears through subtle institutional responses:

- “We need everyone doing the same thing.”
- “How does this align with district expectations?”
- “That sounds great, but who will manage it?”
- “What data proves this works?”
- “We need to slow down.”

These concerns are not inherently wrong—many are rooted in legitimate responsibilities: equity, sustainability, workload management, accountability, and resource allocation. But collectively, they can create environments where innovation is admired rhetorically while being constrained operationally.



The System Isn’t Broken— It’s Doing What It Was Designed to Do

This is an important distinction. Most educational systems were not originally designed for rapid innovation cycles. They were designed for stability, scalability, operational consistency, broad access, and risk reduction. For many decades, those structures served important purposes.

But we now live in an era defined by accelerating technological change, artificial intelligence, evolving workforce demands, and information abundance. The world students are entering is fundamentally different from the one most educational systems were built to support. Yet our structures often remain largely unchanged.

So when innovative practices begin pushing beyond isolated classroom moments into broader systemic conversations, friction naturally emerges. That friction is the Pet-to-Threat moment.

Beyond Schools: A Broader Pattern Across STEM

This phenomenon is not limited to K–12 education. Across the broader STEM landscape, similar tensions are emerging within some of our largest scientific and research institutions—

including the National Science Foundation and other organizations historically created to fuel discovery and innovation.

These institutions have long championed high-risk research, emerging scientific fields, interdisciplinary collaboration, and transformational breakthroughs. Yet during periods of economic, political, or structural pressure, even innovation-centered institutions can begin shifting toward predictability over exploration, safer investments over bold experimentation, and short-term outcomes over long-term discovery.

“Under pressure, systems protect what is known before investing in what is uncertain.”

This is not necessarily evidence of failure. It reflects a broader systems reality: under pressure, institutions protect what is known before investing in what is uncertain. But therein lies the challenge. Innovation requires uncertainty. Discovery requires risk. Breakthroughs rarely emerge from environments optimized solely for stability.

What Gets Lost When Innovation Is Contained

When educators repeatedly experience the Pet-to-Threat cycle, something subtle but significant begins to happen: they start adjusting—not just their

practices, but their aspirations. Teachers begin scaling back bold ideas, waiting for permission, self-censoring creativity, avoiding initiatives that may create friction, and choosing alignment over experimentation.

Over time, schools can unintentionally build cultures where innovation exists performatively but rarely transforms systems in meaningful ways. And perhaps most importantly: students notice. They quickly learn whether creativity is genuinely valued or merely tolerated when convenient.



AI Has Intensified the Conversation

The emergence of artificial intelligence has only amplified these tensions. AI is forcing education systems to confront difficult questions: What counts as authentic learning? How do we measure understanding? What skills remain uniquely human? What happens when performance no longer guarantees comprehension?

For decades, education operated under an unspoken assumption: performance was evidence of learning. AI has disrupted that assumption. Students can now generate polished essays, answers, and even code with remarkable ease—which means schools can no longer rely solely on traditional outputs as indicators of understanding.

And once again, systems face a choice: adapt and rethink learning models, or protect familiar structures longer than they remain effective. This, too, is a Pet-to-Threat moment.

From Protecting Systems to Building Resilient Ones

Perhaps the goal is not to eliminate stability from education. Schools need structure. Students need consistency. Communities need trust. But systems must also become resilient enough to evolve.

Resilient systems allow for experimentation, support pilot programs, create space for iteration, protect thoughtful risk-taking, redefine evidence of learning, and encourage professional curiosity rather than quiet compliance. Most importantly, they recognize that discomfort is not always dysfunction—sometimes discomfort is simply the feeling of growth.

A Different Question

When an innovative idea begins creating tension in a school or organization, perhaps the first question should not be: “How do we control this?” Maybe the better question is: “What is this revealing about the limits of our current system?”



Because innovation itself is rarely the true threat. The greater threat may be systems that become so protective of stability that they lose the capacity to evolve.

Final Reflection

The next time an idea feels disruptive, difficult to scale, or slightly uncomfortable, pause before dismissing it. You may be witnessing the Pet-to-Threat shift in real time.

The question is not whether the innovation is creating pressure. The question is whether the system is resilient enough to grow with it.

“The greater threat may not be innovation itself, but systems that lose the ability to evolve.”

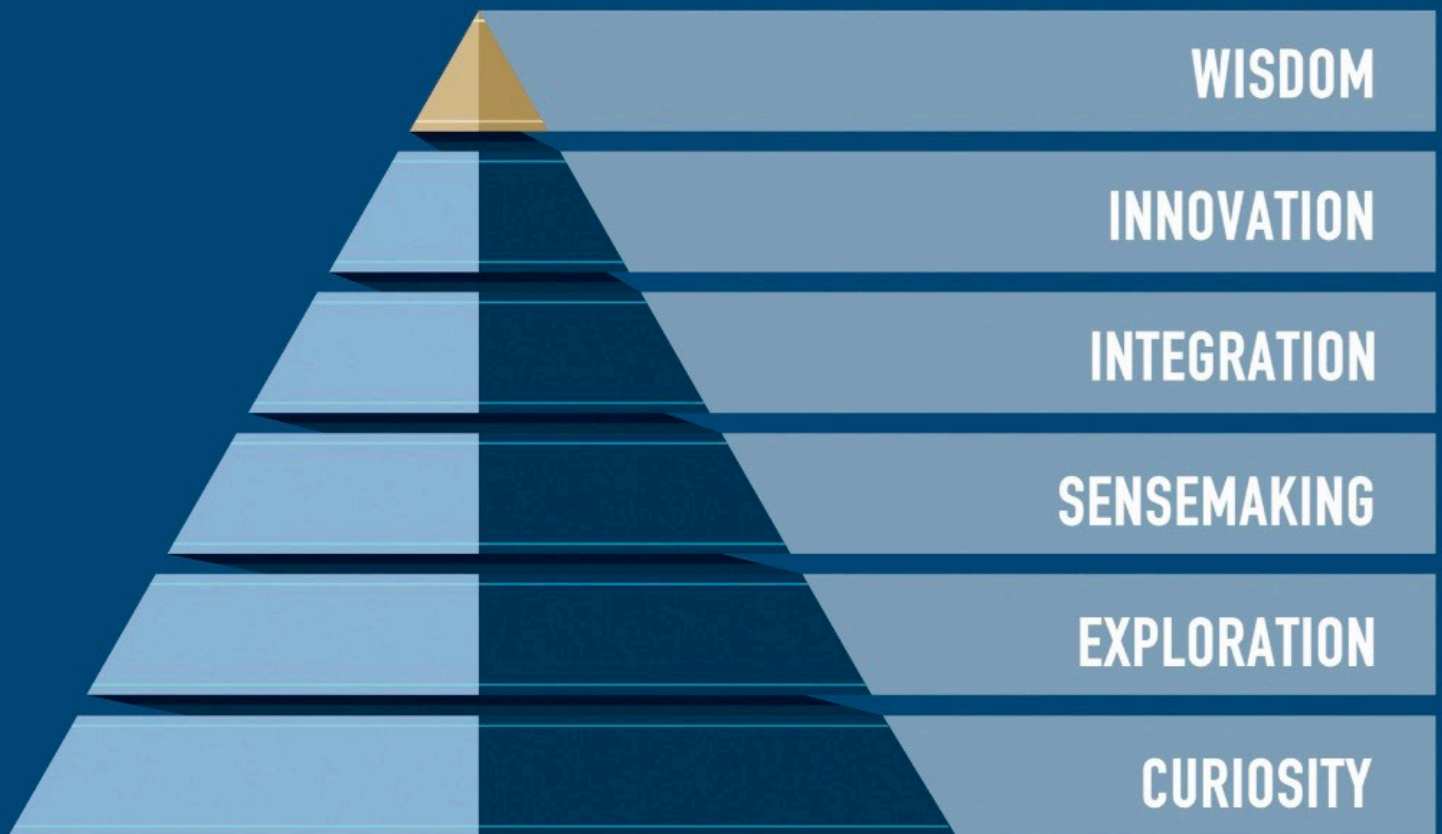


Shelly A. Muñoz is a STEM Curriculum Coordinator, national presenter, and author of *Architects of Cognitive Resilience: Reimagining Learning in the Age of Artificial Intelligence*. Her work focuses on designing human-centered learning systems that prioritize curiosity, adaptability, innovation, and deep thinking in a rapidly changing world.



Architects *of* COGNITIVE RESILIENCE

*Reimagining Learning
in the Age of Artificial Intelligence*



Shelly A. Muñoz

ARCHITECTS OF COGNITIVE RESILIENCE

Reimagining Learning in the Age of Artificial Intelligence

A student sits at her desk. She types a prompt. Within seconds, the page is no longer blank.

It does not sound like her. It does not feel like thinking.

For the first time in history, students are not just outsourcing answers. They are outsourcing thinking itself.

Artificial intelligence can now do what classrooms have always measured — recall facts, summarize texts, write essays, solve problems, and generate polished work on demand. This is not a trend. It is a permanent shift. And it has broken the most fundamental assumption in education: that performance is evidence of learning.

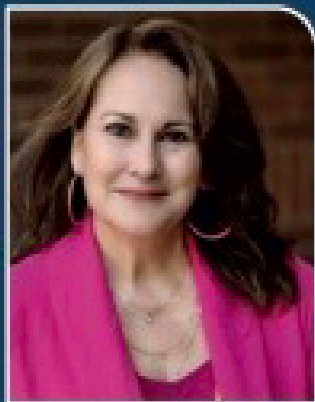
Architects of Cognitive Resilience argues that education's most urgent task is not to detect AI use, restrict AI access, or compete with AI capability. It is to build the six capacities that no machine can replicate — the internal architecture of human thought that makes a person genuinely capable, not merely credentialed.

01 — Curiosity: Why? What if? How do we know? 02 — Exploration: What do I find when I go look? 03 — Sensemaking: What does this mean, and how do I know? 04 — Integration: How does this connect to everything else? 05 — Innovation: What can I create that did not exist before? 06 — Wisdom: What is the right thing to do, and why?

Drawing on cognitive science, neuroscience, Hattie's Visible Learning, Bloom's Taxonomy, Self-Determination Theory, and Webb's Depth of Knowledge — and grounded in two decades of classroom practice and instructional leadership — this book gives teachers, administrators, and school leaders a complete, research-grounded framework for what must be built now, and how to build it.

"AI has made performance easier to generate. It has made understanding no easier to build. That gap is where this book lives."

For every educator who has looked at a classroom and quietly asked: What are we actually preparing them for?



Shelly A. Muñoz

Shelly Muñoz is a STEM Curriculum Coordinator with more than 25 years of experience at the intersection of science, mathematics, and instructional leadership. A national presenter and contributor to *STEM Magazine*, she is the creator of the Cognitive Resilience Framework, advancing a new vision for learning in the age of artificial intelligence. Through her work, she champions equitable, real-world STEM opportunities, preparing learners to think, adapt, and lead in an ever-changing world.

The Science of *Storytelling*

by Ruth Spiro

In 2010, The New York Times ran the article “Picture Books No Longer a Staple for Children” which I read with interest. The article reported a noticeable drop in picture book sales, as some parents were reading fewer picture books to their very young children. Instead, they were choosing books intended for older readers, such as chapter books and even novels.

The news was concerning, both for the children missing out on the pleasure of picture books and for those of us who create them. Research shows that picture books are important, serving as an introduction to the rhythm of language and providing practice with both literal and visual storytelling.



While discussing the article with writer friends I wondered aloud, “What do parents want, quantum physics for babies?” As I continued to think about it, I realized that parents sought books with elevated content. Could I bridge this gap by writing about STEM topics, but for a young audience?

It seemed like a good idea, but I knew that to earn a spot on home and library shelves the books would need to be accurate, age-appropriate, and engaging. I spent nearly a year researching early childhood development and reading hundreds of popular board books.

I discovered that beyond helping to verbally put a name to an object, alphabet books aren’t as beneficial to babies and toddlers as one might assume. “A is for apple” only makes sense if you know how to read, because “A” is the first letter in the word “apple.” This understanding that speech sounds can be represented by letters is called phonemic awareness. To a pre-reader, there’s no meaningful connection between the letter “A” and a picture of an apple. While concept books have their place in a child’s first library, I’d need to take a different approach.

One effective way to make abstract ideas accessible is by scaffolding, or connecting new information to prior knowledge. Another way is to present

the material within the context of a story, rather than simply stating the facts. Taking it a step further, when the story is told from the point of view of a character the child can relate to, areas of the brain respond as if they are experiencing events right along with the character.

Applying what I learned, I decided to structure my books in the form of a simple story featuring a child engaged in a familiar real-world experience or observation. I was happy to discover that this scientifically supported structure just happened to align with my years of experience writing picture books.

Each new Baby Loves Science book starts with a question:

“How does a bird fly?”
(Baby Loves Aerospace Engineering)

“Why does it rain?”
(Baby Loves Meteorology)

“What makes sound, and why can’t I see it?” (Baby Loves the Five Senses: Hearing)

I begin my research with a deep dive into books and articles on the science related to the question. I also speak with professionals in the field until I understand the material well enough

to simplify it for my readers. Often, I discover more fascinating information than space permits, requiring difficult choices about what to include and what to cut. Once my text is finished, the illustrator takes over. At each stage of the book's progress, both the text and illustrations are reviewed for accuracy by subject matter experts.



To be clear, my goal in writing these books isn't to "teach" science to very small children. Rather, I'm guiding them in making the connection between familiar observations and the science behind them, in addition to introducing new vocabulary. These are the books I wish I'd had when my two daughters were small, as I would have enjoyed learning right along with them!

When the first two titles were published in 2016, I never imagined that ten years later there would be twenty-six in the series. I've tackled topics including gravity, structural engineering, photosynthesis, and paleontology. Within a few years, parents and educators began requesting a "next step" series for children who had outgrown the board books. My editor at Charlesbridge agreed, but it took me a while to land on a concept that felt fresh and exciting for the early elementary reader.

The result is *How to Explain Science to a Grown-Up*. These books include expanded content and backmatter, while empowering young readers to proudly share their passions with others. Titles include *How to Explain Climate Science to a Grown-Up* and *How to Explain Aerospace Engineering to a Grown-Up*.

None of my books would be effective without the talented artists who create the illustrations. The *Baby Loves Science* books are illustrated by Irene Chan and Kat Uno. *How to Explain Science to a Grown-Up* is illustrated by Teresa Martinez. Their work is a magical combination of scientific detail, humor and charm.

I often speak at educational conferences and have been pleased to share that the Baby Loves Science books align with early childhood standards and curriculum. It's never too soon to encourage a child's curiosity. A report issued by the Joan Ganz Cooney Center at Sesame Workshop confirms that introducing children to science activities and vocabulary from an early age helps them develop positive attitudes toward science and improves their problem-solving skills in all areas of learning.

About the author:



Ruth Spiro is the author of more than 30 children's books, with over one million copies sold worldwide. Her best-selling Baby Loves Science board books are the groundbreaking originals that introduce big ideas to the littlest listeners in an age-appropriate and engaging style.

In addition to these board books, Ruth is the author of picture books including

Made by Maxine, Maxine and the Greatest Garden Ever, Growing Together, and Love Grows. The enthusiastic response to the Baby Loves Science books inspired a new picture book series perfect for early elementary readers, How to Explain Science to a Grown-Up.

A frequent speaker at schools and conferences, Ruth's previous appearances include Windy City Live, The Weather Channel, Los Angeles Times Festival of Books, World Science Festival, Chicago Tribune Printer's Row LitFest, and the National Association for the Education of Young Children.

www.RuthSpiro.com

Activity Guides for all Ruth's books, including Baby Loves Science and How to Explain Science to a Grown-Up, are available as free downloads at the Educator Resources tab at www.ruthspiro.com. Four Baby Loves Science titles are available in Spanish bilingual editions. The How to Explain Science to a Grown-Up books have been recognized by the National Science Teaching Association, Junior Library Guild and several state reading associations.

Advancing STEM Innovation in Protective Textile Science

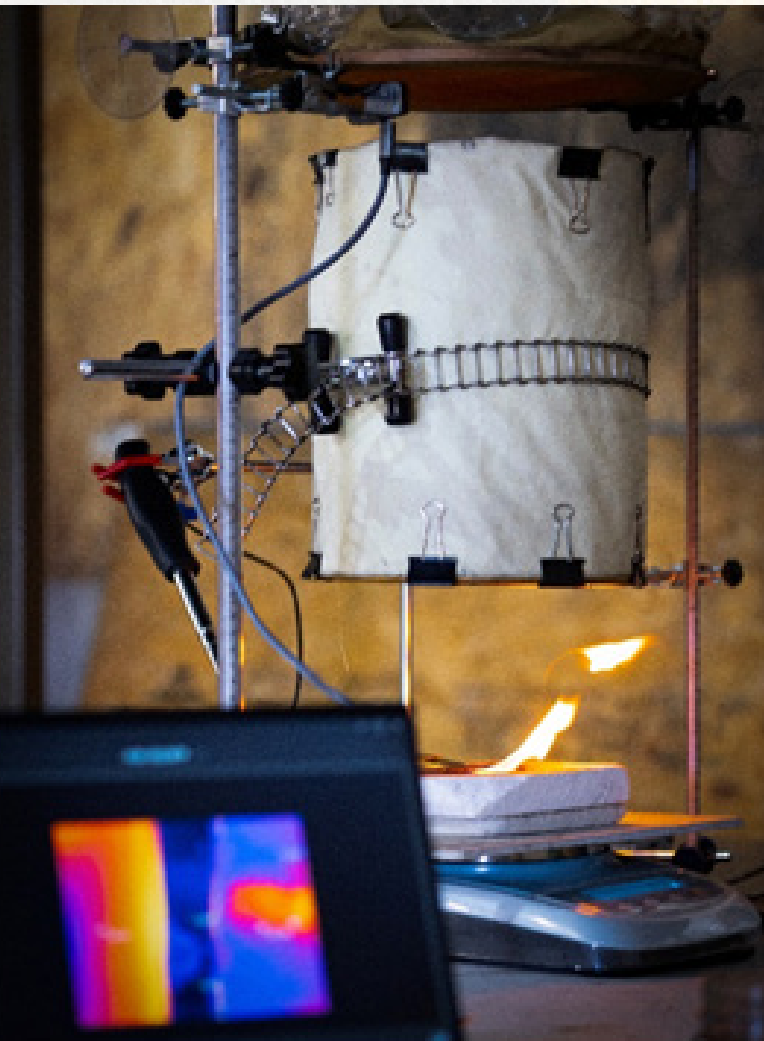
Dr. Sumit Mandal
Oklahoma State University

At the intersection of science, technology, engineering, and mathematics (STEM), the Textile and Apparel Science Laboratory (TASL) in the Department of Design and Merchandising (DM) at Oklahoma State University (OSU) is redefining how protective clothing performs in some of the world's most hazardous environments.

The lab, led by Dr. Sumit Mandal, focuses on flame-resistant clothing (FRC) used by oil and gas workers and firefighters, individuals exposed to flash fires, radiant heat, and toxic environments. By integrating experimental science, engineering principles, and data-driven modeling, TASL establishes a comprehensive STEM-driven approach to improving protective textile performance.

Materials Science Innovation

The STEM contributions of TASL begin at the most fundamental level: materials science. The lab investigates how fibers, yarns, and fabric constructions interact across multiple scales of FRC to influence thermal protective performance (TPP). Through systematic experimentation and engineering analysis, TASL demonstrates that protection depends on a complex interplay of variables such as fabric weight, thickness, air permeability, and weave structure. This STEM-based framework enables predictive modeling and optimization of protective clothing systems, moving beyond traditional trial-and-error methods.

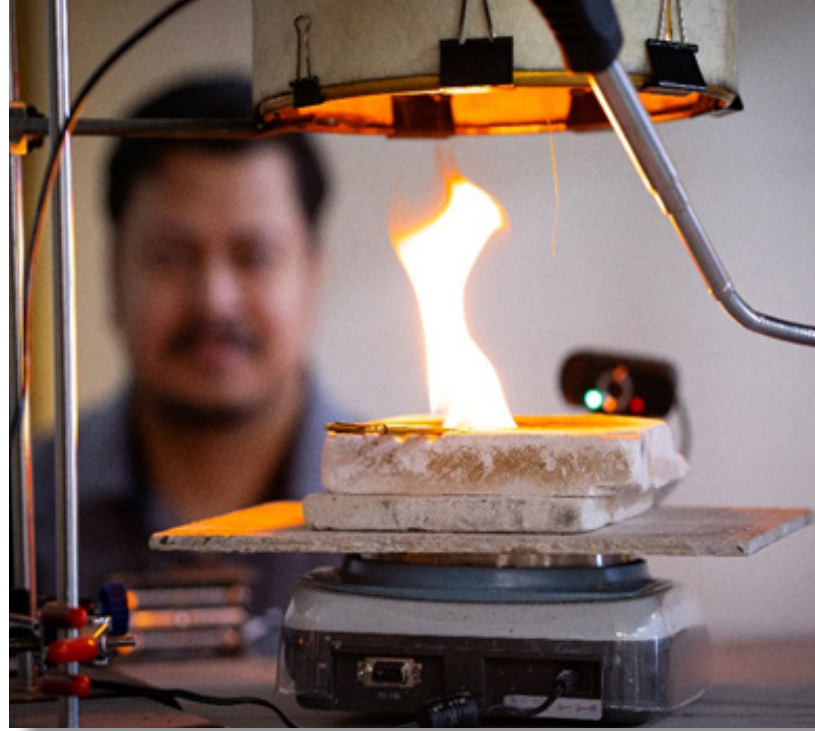


Real-World Challenges, Contamination Science, and Experimental STEM Discoveries

A defining STEM advancement of TASL is bridging laboratory research with real-world conditions. While conventional testing standards often evaluate unused garments, TASL examines how clothing performs during actual use. In oil and gas environments, garments are frequently exposed to contaminants such as crude oil and drilling mud. TASL's research systematically evaluates how these substances alter heat transfer and increase or decrease burn injury risks, providing critical STEM insights into occupational safety.

Experimental findings from TASL reveal that contamination effects are highly complex. Crude oil contamination can increase flammability and accelerate heat transfer, elevating burn risks.

In contrast, drilling mud, due to its higher heat capacity and lower flammability, can enhance thermal protection under certain conditions. By developing statistical and predictive models, TASL establishes quantitative relationships among contamination levels, fabric properties, and thermal outcomes, offering actionable STEM solutions for industry and safety standards.



Engineering Heat Transfer Modeling

Beyond material behavior, TASL contributes to STEM knowledge through advanced modeling of heat transfer processes. Fire exposure involves simultaneous conduction, convection, and radiation. TASL applies engineering and mathematical modeling to describe how heat moves from the external environment, through fabric layers, and ultimately to human skin. These STEM-based models incorporate variables such as air gaps, fabric layering, and exposure intensity, enabling accurate prediction of protective performance.

Design Insights: Air Gaps and Garment Engineering

One of TASL's notable STEM findings is the role of air gaps in thermal protection. Small air gaps act as insulating

layers, significantly enhancing TPP by reducing conductive heat transfer. However, larger air gaps can introduce convective heat flow, reducing protection. This insight highlights the importance of garment fit, structure, and ergonomics in protective clothing design, emphasizing that optimal protection depends on both materials and configuration.

Beyond Burns: Health and Toxic Exposure

TASL's STEM impact extends beyond thermal protection to include long-term health risks. The lab investigates how wildfire smoke and toxic particles interact with protective clothing. Harmful compounds such as polycyclic aromatic hydrocarbons (PAHs) can accumulate on fabrics and penetrate clothing layers, leading to dermal exposure and increased cancer risk. By linking fabric properties, such as porosity and surface texture to contaminant behavior, TASL expands the understanding of protective performance beyond burn prevention.

Interdisciplinary STEM Integration

A hallmark of the TASL is its interdisciplinary STEM integration. The lab combines textile science, thermal engineering, chemistry, and data analytics to address complex safety challenges.

Its experimental systems simulate real-world fire conditions using combined radiant and convective heat flux, while computational models enable performance prediction across diverse scenarios. Under the leadership of Dr. Sumit Mandal, TASL continues to advance innovation through integrated STEM research.

Innovation, Future Technologies, Industry Impact and Translation

This integrated STEM approach allows TASL to identify research gaps and propose forward-looking solutions. The lab's work highlights the need for next-generation protective textiles with enhanced resistance to contamination, improved thermal stability, and self-cleaning or decontaminating capabilities. These emerging technologies represent transformative STEM innovations with the potential to significantly improve worker safety.

TASL ensures that its STEM research translates into real-world applications. Through collaborations with industry partners, standards organizations, and safety professionals, the lab contributes to improved testing methods, better protective garment design, and evidence-based safety practices. This translational approach strengthens the connection between academic research and industrial implementation.

STEM Impact and Societal Benefit

In an era of increasing industrial hazards and wildfire risks, the TASL addresses critical safety challenges through STEM innovation. By advancing scientific understanding and engineering solutions, TASL delivers transformative contributions that redefine protective clothing systems. Ultimately, the lab's mission is to leverage STEM knowledge to enhance human safety, reduce injuries, and improve the quality of life for workers operating in high-risk environments.

Beyond immediate occupational safety, TASL's STEM contributions generate far-reaching societal benefits that extend across industries and communities. By improving the thermal and contamination resistance of protective clothing, the lab directly contributes to reducing workplace injuries, fatalities, and long-term health complications. This not only safeguards workers but also alleviates the economic burden associated with medical treatment, lost productivity, and compensation costs.

Enhanced protective systems developed through TASL's research can lead to more resilient workforces in critical sectors such as energy, emergency response, and disaster management. TASL's work also plays a vital role in advancing public health awareness.

By identifying risks associated with toxic exposure - such as carcinogenic particles in wildfire smoke - the lab highlights the importance of protective strategies that go beyond traditional burn prevention. These insights influence not only occupational safety policies but also broader discussions on environmental health and community resilience, particularly in regions increasingly affected by wildfires and industrial activities.

In addition, TASL contributes to workforce development and STEM education by training students and researchers in interdisciplinary problem-solving. The lab equips future scientists, engineers, and industry professionals with the skills needed to address complex safety challenges using data-driven and experimental approaches. This educational impact strengthens the STEM pipeline and fosters innovation across multiple sectors.

Through its commitment to applied research and collaboration, TASL ensures that scientific advancements translate into tangible societal improvements. By protecting those who protect others, workers, firefighters, and first responders, the lab's STEM innovations ultimately contribute to safer communities, stronger industries, and a more sustainable future.

Engineering Students' Futures:

Colegio CIEDI's Integrated Approach to STEM

by David Jácome

COLOMBIA

Colombia has established itself as one of Latin America's premier tech hubs, and the country's demand for STEM talent has never been greater. At Colegio CIEDI, an International Baccalaureate (IB) Continuum school in Bogotá, we are preparing our 450 pre-K-12 students for this new world of work with an innovative integrated STEM (i-STEM) learning model.

CIEDI's STEM journey started around 2019 with a pioneering group of educators from diverse disciplines who came together to lead experiments and research on this educational approach. These educators — David de la Torre, Veder Garzón, Andrés Cañón, and Julian Pérez from CIEDI's Information and Communication Technology + Design department, alongside Diana Villa, Primary Science Leader, and Andrea Barrera, Middle Years Programme Coordinator and math expert — became the prime members of the school's STEM leadership team, which still exists today.

Felipe Palacios, our Head of School, later instituted i-STEM in 2021 after

encountering it during his doctoral studies at the University of Melbourne, Australia. When he realized the model's potential, he focused his doctoral research on innovative ways to make it part of primary and secondary school education.

Once Palacios returned to CIEDI, his i-STEM model fit seamlessly within our school's existing culture. This was not only because we were already implementing extensive inquiry-based learning and project-based learning, but also due to the foundations laid by the STEM leadership team.

Engineering: The Missing Piece

Our i-STEM program has a deep focus on the engineering component of STEM education. In fact, it's the centerpiece of our approach. Engineering is the only STEM component that is not a specific subject in K-12 education. As a result, educators everywhere have found engineering to be the hardest to integrate into instruction. But engineering is supposed to be the thing that brings everything else together.

One of the ways that Palacios resolved this challenge was by incorporating the engineering design process into our program. That process, which I often liken to melding the scientific method with design technology, consists of five key steps:

1. Researching and identifying the problem
2. Brainstorming
3. Selecting a design or solution
4. Building a model or prototype
5. Testing, evaluating, and refining the design or solution

Our program helps students integrate and apply knowledge and concepts across STEM subjects and develop problem-solving skills. They identify (or are given) a problem to solve, and they need to find different solutions. Plus, they need to work as engineers to efficiently create their solutions. That's the backbone of our i-STEM units.

Earning STEM Certification

While students, parents, and teachers responded well to the i-STEM model, our leadership team wanted an objective, third-party assessment of the new program's quality. Therefore, we decided to have CIEDI work toward earning the STEM certification from Cognia®, an international nonprofit, nongovernmental organization that's well known

for the rigor of its evaluations.

Pursuing the non-profit's STEM certification was a long-held ambition of mine. Before joining CIEDI in 2023, I visited Colegio Panamericano in Bucaramanga, the first school in Latin America to achieve Cognia STEM certification, to learn about the process firsthand. When I came to CIEDI in 2023, I saw that their very robust STEM program could easily align with a process that I knew would provide feedback on how to continuously improve.

The certification review visit was not just a simple stamp of approval. It was a comprehensive process during which we were assessed from a variety of angles. Evaluators observed classes, attended summative events of an i-STEM unit, reviewed documentation, and conducted interviews with different stakeholder groups, including CIEDI's STEM leadership team.

In 2024, CIEDI earned Cognia STEM certification. The evaluators had special praise for two components of our i-STEM program. The first component was the university partnerships our school had formed for the purpose of enriching i-STEM units, particularly students' engineering activities. The second was our school's practice of incorporating i-STEM activities or units into traditionally non-STEM-related courses.

Driving the Program via University Partnerships

CIEDI formed strategic partnerships with Escuela Colombiana de Ingeniería Julio Garavito in 2022 and with Universidad del Rosario in 2023. As a result of these collaborations, CIEDI students have been able to use each university's state-of-the-art laboratories, such as the wind tunnel at Escuela Colombiana de Ingeniería, to test several engineering projects.

In return, CIEDI teachers share their pedagogical techniques with the university professors. That's the selling point for the universities. They benefit from more dynamic teachers, and we benefit from their facilities and their content-specific knowledge.

Palacios created the partnership process as part of his doctoral studies. To begin the partnership, both sides sign a Memorandum of Understanding. Then, a school delegation tours university laboratories that could potentially be used for STEM units. Afterward, the school and university partners create an interdisciplinary community of practice that identifies which units would be best for collaboration. Faculty members from both institutions are then selected for inter-institutional teams. Each team meets to clarify the learning outcomes and expectations of their i-STEM unit. They also establish a

timeline of follow-up meetings, checkpoints, and work sessions on both campuses.

The majority (80%) of the CIEDI-university collaborative units take place at our school, with university professors even visiting to give lectures. The remaining 20% occurs in the university facilities. There, the students test their project models in contemporary science practice learning spaces.

Each i-STEM unit consists of CIEDI students making three visits to the university campus. The first visit is for the initial testing of students' prototypes. The second visit is to evaluate the upgrades students have made to their models. During those first two visits, students receive feedback and guidance from university professors involved in the unit. In the third and last visit, university deans and other professors participate in a summative evaluation of the prototypes.

CIEDI leaders are now looking into partnering with universities in other countries. Getting the attention of international universities requires a larger number of students. So, we've been talking to schools in India, Japan, and Costa Rica about forming an alliance to create that number.

Integrating STEM in Non-STEM-Related Curricula

School departments not typically involved in STEM education have found ways to incorporate STEM activities into students' learning. One example is our social studies department. Social studies teachers conduct research in the local community and find issues that align with a topic that will be covered in the curriculum. From there, they devise an i-STEM activity.

My favorite social studies i-STEM activity occurs in a first-grade unit about shelters. For that unit, students investigate all the shelters created by humans living in various places. They also compare human shelters with the shelters that different types of animals create.

The i-STEM activity involves the creation of a shelter using the elements of an environment that the students have selected. For example, if students choose the desert, they work with the materials they'd be able to find and use in the desert. If they opt to create shelters they'd find in Bogotá, they use materials found within the country's mountain region.

The student-created shelters must be able to withstand challenges such as earthquakes or storms. The Cognia evaluation team was present for that unit's summative evaluation, and they

were able to observe six- and seven-year-old students using a university's wind tunnel to gauge their models' flood resistance. Those students also tested their models' earthquake resistance via the university's earthquake simulator.

CIEDI's French department has created another interesting STEM integration activity. To celebrate Francophonie Day (March 20), French teachers collaborated with the school's STEM leadership team to create a unit centered on the story *The Little Prince*. Students designed and built elements of the story's scenery, blending language immersion with engineering and design thinking. That particular activity demonstrated that the i-STEM model can find a home in any classroom.

Building Teachers' STEM Proficiency

As CIEDI continues to train its teachers on the IB curriculum and methodology, our school leaders are also working on ways to further incorporate STEM into course units. To that end, we give new teachers access to an introductory course created by the Colectivo Nacional de Educación STEM (<https://www.conastem.org>), a Colombian organization dedicated to supporting STEM education throughout Latin America. This introductory course has proven to be very effective during the induction and onboarding to get new staff up to

speed in the STEM mind frame. CON-ASTEM has become a powerful ally in our growing STEM program, partnering for events, updating assessment practices, and introducing new potential partners.

In addition, a group of CIEDI educators serves as STEM leaders within the school. The STEM leadership team canvasses school stakeholders to determine the best direction for the STEM program, devises best practices for teacher training, and regularly collaborates with teachers on ideas for integrating STEM into lessons.

Although CIEDI provides STEM professional development workshops, formalized training in STEM instruction is still a work in progress for many classroom teachers. The Cognia evaluation team recommended that we implement one-on-one teacher coaching sessions. We plan to base those new sessions on the one-on-one collaborative sessions already happening with local university professors.

The Right Partnership Mindset

The advice I have for other educators who are trying to put together partnerships for STEM education is that they need to understand that they're not asking for a favor from universities or industry partners. It's not charity. Both sides win.

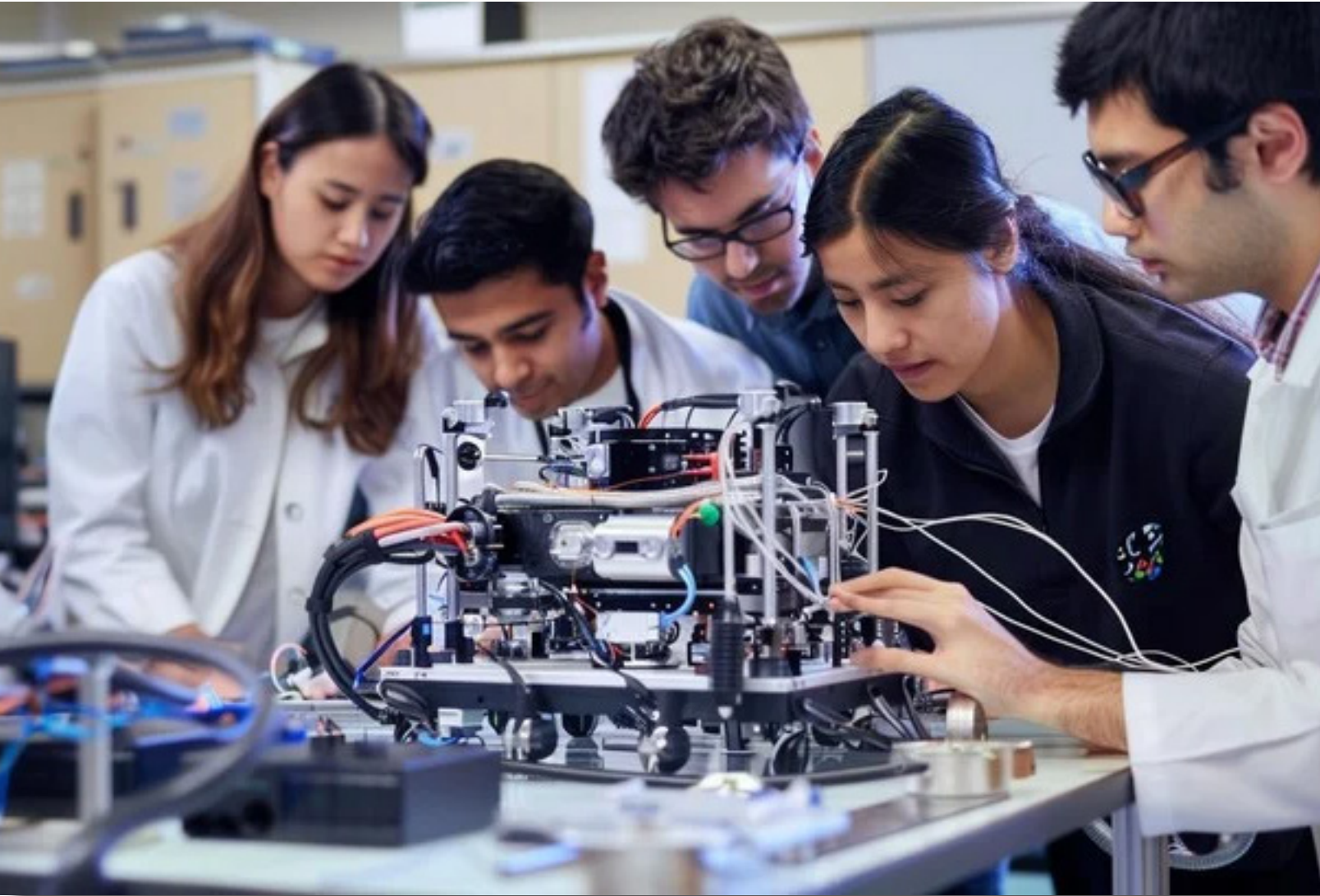
CIEDI's partnerships result in industries gaining new workers who have been honing STEM skills for almost their entire lives. Universities benefit from admitting well-trained students who can engage in postsecondary work right away rather than requiring remedial courses. Palacios developed and has adhered to this "win-win" approach throughout all his discussions with potential partners. And I think that's what has allowed us to create successful relationships with the partners we have right now. What we're doing is something that is mutually beneficial for all.

David Jácome is the deputy head of Colegio CIEDI and serves as Lead Evaluator in Cognia International Accreditation Review Teams. He's a former elementary and middle school principal at Colegio Bilingüe Richmond in Colombia, a Primary Coordinator at Gimnasio Colombo Británico, and Community and Wellbeing Director at The English School. As deputy head, Jácome serves as a facilitator of growth, working alongside educators and the wider community to create an environment where students can flourish and make a positive impact on the world. He holds two master's degrees, one in Biological Sciences from Universidad de los Andes (COL), and another one in educational leadership from the Universidad Internacional de La Rioja (ESP).

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Why Do Some Medications Make You Dream In **Technicolor**?

By: Aniq Niha, BS, PharmD Candidate,
Class of 2026

Edited by: Anastasiya Shor, PharmD, BCPS

When Medications Take the Director's Chair

While often overshadowed by more clinically significant and debilitating side effects, outlandish, vivid, and emotionally intense dreams are frequently reported by patients taking certain medications. Although relatively harmless, these dream experiences can be distressing, negatively impacting sleep quality and potentially influencing medication adherence. By understanding how certain drugs may write and direct an entire screenplay inside a patient's head, pharmacists and other healthcare professionals can provide anticipatory counseling and suggest appropriate adaptive strategies.

The Brain’s Night Shift

Sleep is an active, strictly controlled biological process vital for strengthening memory, regulating emotions, supporting metabolic recovery, and recalibrating neuroplasticity.^{1,2,3} Sleep allows the brain to restructure learned information, removes metabolic waste products that accumulate throughout the day, and resets stress-response systems.^{1,4,5} Simultaneously, sleep is necessary to restore immune and endocrine function, as well as to preserve cardiovascular stability.⁵

One night’s sleep consists of approximately 4 to 5 cycles of non-rapid eye movement (NREM, including stages N1, N2, N3, and a return to N2) and rapid eye movement (REM), as outlined in Table 1 below.

The NREM stages are responsible for “deeper sleep”, during which muscle tone declines and brain activity slows, allowing the body to restore energy and repair tissue. Conversely, REM sleep is associated with low-amplitude, desynchronized electroencephalographic activity that resembles waking brain activity, dreaming, and postural muscle atonia (temporary paralysis).

Sleep-wake transitions are mediated by a balance between neurotransmitters that promote wakefulness and those that promote sleep. During REM sleep, cortical acetylcholine (Ach) release increases, while serotonin (5-HT) and norepinephrine (NE) release are relatively suppressed, creating an environment that supports the sensory and emotional experiences of dreams.⁶

STAGE	DESCRIPTION	TYPICAL DURATION
N1 (Stage 1)	Light transitional sleep between wakefulness and sleep; slow eye movements; easily awakened.	~1–7 minutes at sleep onset; ~5% of total sleep time
N2 (Stage 2)	Light sleep; by decreased heart rate and body temperature.	~45–55% of total sleep time
N3 (Stage 3, Slow-Wave Sleep)	Deep restorative sleep; important for physical recovery and immune function.	~15–25% of total sleep time
REM (Rapid Eye Movement)	Dreaming stage; skeletal muscle atonia; emotional memory processing.	First REM period ~70–100 minutes after sleep onset; REM periods lengthen toward morning; ~20–25% of total sleep time

The architecture of dreams is regulated by a balance between brain processes that promote REM sleep and those that inhibit it.⁷ Medications such as antidepressants and varenicline can shift this homeostasis by altering neurotransmitter activity, which in turn, may change how and when REM sleep occurs.^{8,9} Contrastingly, melatonin influences the timing of the circadian rhythm and the overall structure of sleep, as opposed to directly acting on REM pathways.¹⁰

Antidepressants and After-Hours Adventures

Changes in REM sleep, whether suppression, enhancement, or rebound, can alter dream frequency and the degree of vividness. Antidepressants such as tricyclics (TCAs), selective serotonin reuptake inhibitors (SSRIs), serotonin–norepinephrine reuptake inhibitors (SNRIs), and monoamine oxidase inhibitors (MAOIs) prolong REM sleep latency, i.e., the time from sleep onset to the first stage of REM.

Because REM sleep is most strongly associated with vivid dreaming, suppression is expected to reduce dream activity. While treatment may suppress REM sleep and reduce dream recall, abrupt discontinuation of the antidepressant may trigger REM rebound. REM rebound is characterized by increased REM duration and density, leading to vivid, emotionally intense,

Table 2: Monoaminergic Mechanisms

CLASS
SSRIs
SNRIs
TCAs
MAOIs

Abbreviations: MAOIs, monoamine oxidase inhibitors; SSRIs, selective serotonin reuptake inhibitors; SNRIs, serotonin–norepinephrine reuptake inhibitors; TCAs, tricyclic antidepressants.

and occasionally frightening dreams.¹¹

As summarized in Table 2, major antidepressant classes increase monoaminergic signaling by increasing 5-HT and/or NE in the synapses.¹² In theory, increased serotonergic and noradrenergic signaling should inhibit REM sleep and, as a result, reduce dream vividness. In practice, patients report unusually memorable and intense dreams during dose adjustment or discontinuation.⁸

isms of Antidepressants and Their Impact on REM Sleep¹²

REM EFFECT	DREAM IMPACT
↑ REM latency	↑ Emotional intensity
↓ REM duration	Vivid dreams during dose change
↓ REM atonia (RBD-like)	REM rebound if discontinued
↑ REM latency	Intense, realistic dreams
↓ REM duration	Possible dream enactment
↓ REM atonia	REM rebound
REM suppression	Fewer dreams while on therapy
↑ REM latency	Vivid rebound dreams if discontinued
REM suppression	High rebound potential
	Emotionally intense dreams on withdrawal

ne oxidase inhibitors; SNRIs, serotonin–norepinephrine reuptake inhibitors; SSRIs, itors; TCAs, tricyclic antidepressants

Antidepressant-mediated vivid dreaming is likely a combination of REM modulation, neurotransmitter imbalance, and neurochemical instability caused by withdrawals/dose changes rather than a single mechanism. In the reciprocal interaction model, cholinergic neurons function as “REM-on” cells, while serotonergic and noradrenergic neurons act as “REM-off” cells.

Therefore, when monoamine levels increase due to antidepressants, REM

sleep is further suppressed. This results in reduced REM duration and prolonged REM latency.⁷ Chronic suppression of the REM stage, consequently, may lead to REM rebound, and despite fewer overall REM episodes, the REM periods that do occur may be delayed, fragmented, or altered by changes in neurotransmitter activity, leading to heightened emotional significance.¹³

Table 3: Evidence-Based Management Strategies for Medication-Induced Vi

MEDICATION	MANAGEMENT	CLINICAL APPLICATION
SSRIs, SNRIs, TCAs, MAOIs	Adjust the dose or advise to take it in the morning	Switch to an agent with favorable sleep profile
	Switch agents if poorly tolerated ¹⁷	• Mirtazapine: more effective at lower doses²¹ • Trazodone: Often effective at low doses (25–100 mg) for insomnia and is less anticholinergic than TCAs
	Consider alternative antidepressant ¹⁸	
Varenicline (Chantix)	Counsel on common adverse effects including abnormal dreams ¹⁹	Reduce dose (1 mg BID) ¹⁹
	Recommend as first line and monitor adverse effects ²⁰	Dose modification
Melatonin	• Recommends against routine melatonin for chronic insomnia in adults due to limited efficacy evidence • May consider melatonin for circadian rhythm disorders²¹	Dose modification Emotionally intense drug withdrawal ²¹

* The “Clinical Application” column is not directly taken from the guidelines. Guideline recommendations for the general management of “adverse effects” or “sleep disturbances” provided in the guidelines.

Vivid Dreams

RECOMMENDATION*	GUIDELINE SOURCE
with a more e re sedating n used at (0.0 mg) for less than TCAs ²²	American Psychiatric Association MDD Guideline (2020)
D to 0.5 mg	U.S. Public Health Service Tobacco Treatment Guideline (2008, updated evidence reviews)
	U.S. Preventive Services Task Force (2021)
reams on	American Academy of Sleep Medicine Insomnia Guideline (2017)

Recommendations have been extrapolated from th

Increased stimulation of 5-HT₂ receptors has been associated with changes in dream intensity and emotional processing, and REM sleep behavior disorder–like symptoms have been associated with SSRIs and SNRIs. During REM sleep, the body temporarily hits the “pause” button on the muscles, preventing you from leaping out of bed to run the marathon you are winning in your dream. This temporary muscle paralysis, reduced by SSRIs and SNRIs, leads to increased movement during REM sleep. Consequently, dreams may feel more intense, realistic, or even physically acted out, making them seem dramatic or vivid.⁸

Stop Smoking Start Dreaming

Varenicline is a partial agonist at the $\alpha 4\beta 2$ nicotinic acetylcholine receptor used as a first-line treatment for smoking cessation. Difficult enough as it is already, adherence can be complicated by vivid or unusual dreams.¹⁴

Varenicline partially stimulates nicotinic receptors in the mesolimbic dopamine pathway to reduce cravings while it concurrently blocks the reinforcing effects of nicotine.⁹ By partially activating nicotinic receptors, varenicline may enhance cholinergic signaling during REM. Because cholinergic activity is associated with increased dream vividness and recall, varenicline may intensify

dreams and emotional salience.⁷ Additionally, withdrawing from nicotine itself changes sleep architecture and can lead to REM rebound, further potentiating dream intensity during initial cessation.¹⁵

Melatonin: Small Pill, Big Dreams

Melatonin is an easily accessible over-the-counter sleep aid used to regulate the circadian rhythm. The widely available supplement acts on the Melatonin 1 and 2 (MT1 and MT2) receptors to synchronize circadian rhythms and promote sleep onset.¹⁰ While melatonin does not directly trigger REM sleep, it can change how sleep is structured throughout the night, helping you stay asleep longer and increasing REM propensity later in the night.¹⁶ As REM sleep periods naturally lengthen in the early morning, when endogenous melatonin levels are still elevated, taking melatonin may strengthen or prolong these REM phases, leading to increased dream recall.⁷

Moreover, as awakenings earlier in the night are reduced and REM density is

moved towards later cycles, melatonin may increase the probability of awakening directly from REM sleep, which correlates with vivid dream recall.^{7,16}

Blockbuster Nights: What to Do When Your Dreams Go 4K

No major guidelines specifically address medication-induced vivid dreams. However, the principles of “sleep disturbance” can be applied. The American Psychiatric Association and National Institute for Health and Care Excellence recommend dose adjustment, timing changes, or switching antidepressants if sleep disturbance is intolerable. Tobacco guidelines recommend counseling and dose reduction for varenicline-related abnormal dreams.

The American Academy of Sleep Medicine proposes reassessing or discontinuing melatonin if sleep disturbances are affecting a patient’s quality of life. Table 3 summarizes guideline-based recommendations for sleep disturbances.



Table 3: Evidence-Based Management Strategies for Medication-Induced Vivid Dreams

MEDICATION	MANAGEMENT	CLINICAL APPLICATION*	GUIDELINE SOURCE
SSRIs, SNRIs, TCAs, MAOIs	Adjust the dose or advise to take it in the morning	Switch to an agent with a more favorable sleep profile	American Psychiatric Association MDD Guideline (2020)
	Switch agents if poorly tolerated ¹⁷	• Mirtazapine: more sedating at lower doses²¹ • Trazodone: Often used at low doses (25–100 mg) for insomnia and is less anticholinergic than TCAs²²	
	Consider alternative antidepressant ¹⁸		
Varenicline (Chantix)	Counsel on common adverse effects including abnormal dreams ¹⁹	Reduce dose (1 mg BID to 0.5 mg BID) ¹⁹	U.S. Public Health Service Tobacco Treatment Guideline (2008, updated evidence reviews)
	Recommend as first line and monitor adverse effects ²⁰	Dose modification	U.S. Preventive Services Task Force (2021)
Melatonin	• Recommends against routine melatonin for chronic insomnia in adults due to limited efficacy evidence • May consider melatonin for circadian rhythm disorders²¹	Dose modification Emotionally intense dreams on withdrawal²¹	American Academy of Sleep Medicine Insomnia Guideline (2017)

* The “Clinical Application” column is not directly taken from the guidelines. Guideline recommendations have been extrapolated from the general management of “adverse effects” or “sleep disturbances” provided in the guidelines.

Rolling the Credits

Medications may treat disease by day, but at night they often stay for the after-hours production of your dreams by reshaping REM activity, altering neurotransmitter activity, and causing a rebound during withdrawal or dose adjustments that can affect sleep quality and medication adherence. Although vivid dreams are not a high-alert adverse effect, it is imperative to

understand these causative mechanisms, as it will allow pharmacists to help patients navigate not only their health while conscious but also their after-hours adventures.

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To understand STEM...

...you must DEFINE STEM. You cannot define an acronym without defining each of the words the letters stand for.

Universities and organizations around the world continue to debate what a STEM career is, but there is no doubt that “every career” uses STEM skills and this observation remains the focus of STEM Magazine.

Science: “The systematic accumulation of knowledge” (all subjects and careers fields)

Technology: “The practical application of science” (all subjects and careers)

Engineering: “The engineering method: a step by step process of solving problems and making decisions” (every subject and career)

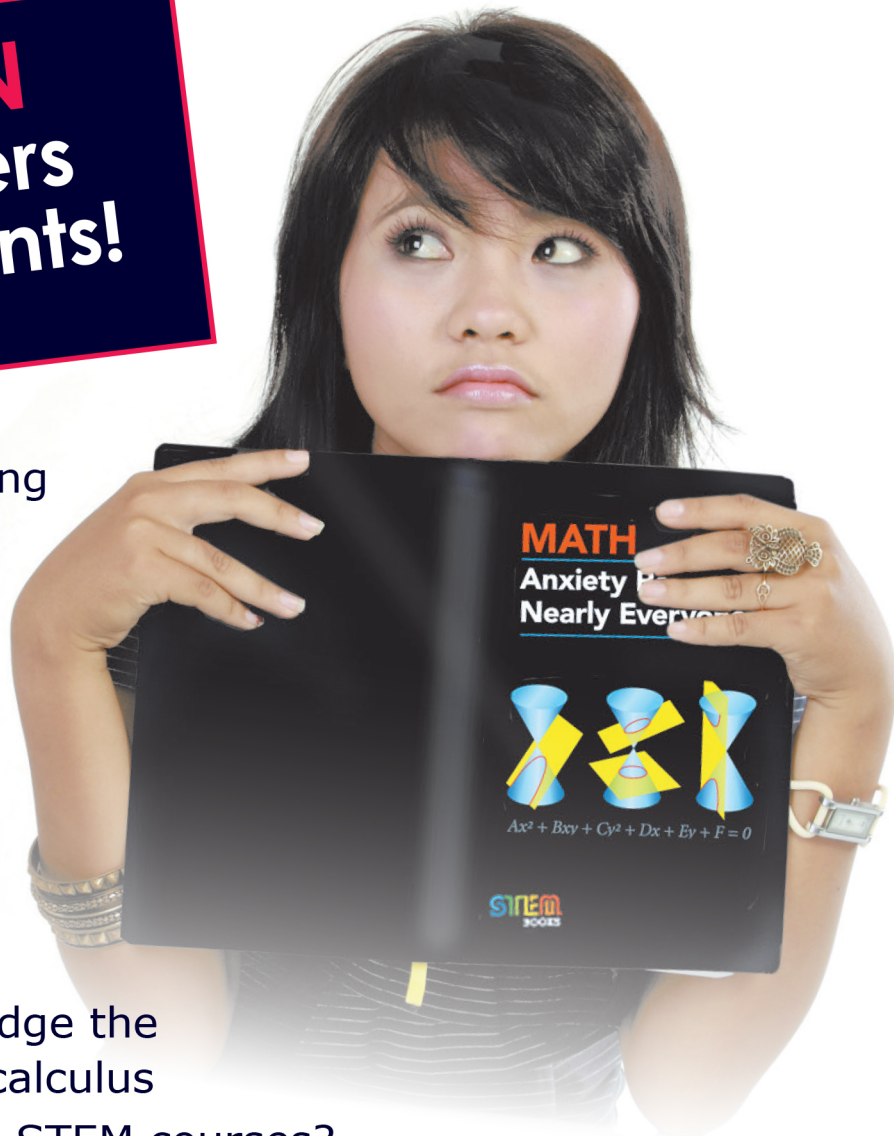
Math: “The science of numbers and their operations, interrelations, combinations, generalizations, and abstractions” (every career will use some form[s])

For a moment, set aside any preconceived notions of what you think a STEM career is and use the above dictionary definitions to determine the skills used in any career field you choose.

These definitions are the “real” meaning of STEM and STEM careers.

ATTENTION K-12 Teachers & STEM Students!

- Are you experiencing difficulties when it comes to math?
- Do you need a quick introduction to calculus?
- Are you currently taking non-credit developmental math courses?
- Do you need to bridge the gap between non-calculus and calculus based STEM courses?

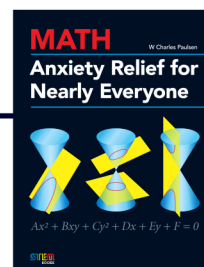


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