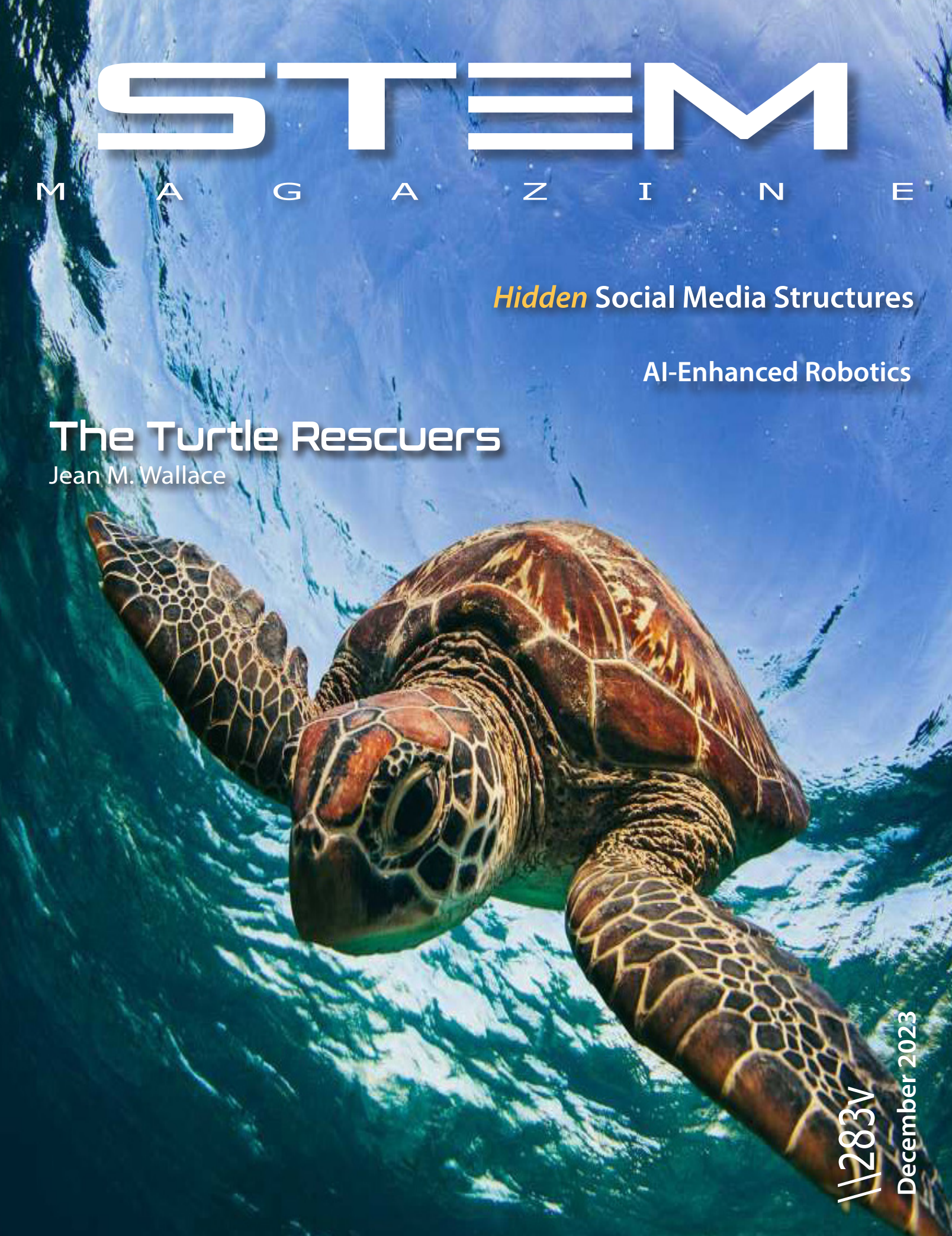
STEM MAGAZINE

Hidden Social Media Structures

AI-Enhanced Robotics

The Turtle Rescuers

Jean M. Wallace



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December 2023

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.

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

Read monthly in 74 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.

STEM
FUNDERS NETWORK

Share this issue with your students, peers, parents and industry professionals you know. Make this a new monthly connection for curiosity, interaction, college prep and career development.

Many parents really enjoy this content as they too pursue their personal life-long learning goals.

International industry and government leaders need to know about this resource as their future employees decide and prepare how to spend their careers.

The Turtle Rescuers of Flagler County

By Jean M. Wallace

Experiential learning is STEM in action. This type of learning not only allows for integrating across subject areas but ensures that students are actively engaged in tasks that connect in-class learning to real-world problems and solutions. It may seem simple, but when students are able to relate school learning to real-life issues, both academics and classroom dynamics improve. Students remain focused and motivated when they clearly see a purpose to their learning.

After spending decades in various aspects of experiential environmental education, what I miss most is witnessing those "aha" moments when students transform from passive learners to active participants wanting to do all they can to make a difference. As someone who loves being in nature, I never stop learning about the world around me.

When I travel to a new place, I make it a point to explore the local wildlife, learn about the environmental challenges they face, and reach out to meet the good people who rescue, rehabilitate and return wildlife to their natural habitat. As a former wildlife rehab volunteer, I value the work of rehab experts.

As an educator, I am always interested in how organizations partner with local schools and engage students.

Manatees and Marine Science

As one example, on a recent visit to New Smyrna Beach, Florida, a friend and I kayaked the Indian River with expert guides from the Marine Discovery Center. We discovered the local flora and fauna and learned of the alarming number of manatees dying of starvation caused, in part, by the over-fertilization of lawns. It was alarming to hear how fertilizer runoff enters the river causing a chain of events leading to a decline in a vital food source for manatees.

After kayaking, we were fortunate to be given a behind-the-scenes tour of The Marine Science Center (MSC) in Volusia County.

While here we heard about the Center's efforts to add additional space for educational programs and saw, firsthand, the critical work the Center does rehabilitating wildlife. When asked about school projects, we learned of a wonderful collaboration MSC had with one very special teacher and her, then, first grade class at R.J. Longstreet School in Daytona Beach, Florida.

The Turtle Rescuer Project

Ms. Carly Stasa has been a teacher for 18 years. She currently teaches first grade at Old Kings Elementary School in Flagler County, Florida. Prior to teaching at Old Kings, she worked at Longstreet Elementary in the Daytona Beach area.

While there, she partnered with MSC on a very special project. Her students were known as "The Turtle Rescuers." Through this project, Ms. Stasa's integrated approach to academics provided her students a purpose for learning and created opportunities for them to show empathy for local wildlife; even raising money for medical equipment for injured turtles. Students were engaged, test scores improved, and classroom dynamics enhanced as students transferred this empathy for wildlife to their fellow classmates. Whether in the classroom or on the playground, the act of caring grew exponentially as the turtle project played out.

A Move to Flagler County

When a personal situation meant a move to a new school and classroom, Ms Stasa was thrilled at being able to bring The Turtle Rescuers project to Old Kings Elementary School. Flagler County Schools and their science department has always had a strong passion for sea turtles. They have traveling turtle trunks from Inwater Research Group and these trunks offer the students a hands-on experience where they can sample a population and collect data from their very own life like sea turtle, including measuring and weighing.

Each turtle is equipped with a tag that matches a QR code which tells the story of the turtle's journey. From in-class learning to the real-world, the students were able to witness nature in action when they visited a turtle's nest adopted by their school. While at the beach, they helped count the eggs and even saw 5 hatchlings make their way to the ocean! According to Ms Stasa, "This was a great opener to start our

program. I am already seeing their love for the world around them, and they already have such a tight bond."

As an enrichment program, Old Kings Elementary school also has a marine science club, that Ms Stasa will facilitate.

This club offers third through fifth grade students the opportunity to engage in additional experiential learning projects where they will educate others about local wildlife and marine science.

Experiential Learning and STEM

In these days of high-stakes testing, with Math and Reading taking up a good deal of class time, how does Ms Stasa fit this project into her school year? While she has the flexibility to bring in outside resources, she is required to follow the school's academic standards in science. Partnering with local science organizations is key. After doing their own, in-class research, the students get to meet with marine

experts and get an up-close look at sea turtles. They also learn about the issues impacting turtles and other wildlife, what they can do to help, and how certain issues could easily be prevented if humans simply threw their trash in a receptacle and not on the beach.

Decades of research prove time and again how authentic, real-world learning can transform teaching and learning. Experiential learning and STEM go hand-in-hand. Yet, few teachers and schools take full advantage of the ways in which expert partnerships make these projects come to life for students. Whether a zoo, museum, nature center or wildlife rehabilitation center, there are so many organizations just waiting to build real partnerships with schools.

Academic and Social / Emotional Benefits

Rather than the one-off field trip that has little impact on quality learning, developing expert partnerships results in deeper learning when students have ongoing access to scientists, see how their learning is connected to their world and given a purpose – an opportunity to make a difference in the lives of local wildlife. As Ms. Stasa has witnessed, not only do academics improve, but the social-emotional benefits of environment-based experiential learning allow young children to spend time outdoors with nature. Something the experts agree is diminishing with each new generation.

On a personal note, as the former CEO of a successful public charter school in Philadelphia, I worked with an incredible team of educators to design and implement an award-winning experiential learning program. Our K-8 curriculum, based on integrated action-oriented learning, was recognized locally, statewide, nationally and even internationally for excellence. I firmly believe in this way of learning and of parents to have the option to choose a child's learning environment. Not because the choice is one of traditional public vs private or charter, but because the choice is one of how and what a school is teaching, and how parents can engage their child in opportunities like The Turtle Rescuers of Flagler County.

All children should have access to real-world learning. The benefits are clear. Should schools present excuses for why experiential learning just isn't possible, remind them about Ms. Stasa and her elementary students. Not only is it possible, but it is also necessary. Ms Stasa summed it up nicely by telling me, "The impact I have seen over the years in my classrooms is huge.

After teaching all these years I have never seen classes bond together like

I have seen since doing this project. I will continue to teach this way as long as I am able to!"

To Ms. Stasa and her Turtle Rescuers – the environment and the turtles thank you.

Author: Jean M. Wallace

Jean has over two decades working in experiential education. During her tenure as the CEO of Green Woods Charter School in Philadelphia, the school received numerous awards and was recognized locally, regionally, nationally, and internationally for its innovative approach to learning and its academic achievement.

Prior to her work at Green Woods, Jean served as the regional Director of Education for Earth Force, Inc. (www.earthforce.org). As the Director of Education for Earth Force, Jean supported hundreds of teachers and thousands of students in student-directed, service learning and civic action projects focusing on local and regional environmental issues.

Jean is always learning and enjoys writing about schools and education. Jean blogs at jeanwallace.org

To understand STEM...

...you must DEFINE STEM, but you cannot define an acronym using the words it stands for; you must define the words the acronym represents.

Universities and organizations around the world continue to debate what a STEM career is. 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.

Representation MATTERS

from CRADLE TO CAREER

Representation Matters is a centralized preK-workforce collaborative that focuses on diversity, equity, inclusion, access, and belonging within the STEM continuum for students, teachers, faculty, higher education administrators, and corporate leaders throughout the continuum.

STEM FUNDERS NETWORK

UNIVERSITY OF WATERLOO

New *programmable* smart fabric responds to temperature and electricity

A new smart material developed by researchers at the University of Waterloo is activated by both heat and electricity, making it the first ever to respond to two different stimuli.

The unique design paves the way for a wide variety of potential applications, including clothing that warms up while you walk from the car to the office in winter and vehicle bumpers that return to their original shape after a collision. Inexpensively made with polymer nano-composite fibers from recycled plastic, the programmable fabric can change its colour and shape when stimuli are applied.

"As a wearable material alone, it has almost infinite potential in AI, robotics and virtual reality games and experiences," said Dr. Milad Kamkar, a chemical engineering professor at Waterloo. "Imagine feeling warmth or a physical trigger eliciting a more in-depth adventure in the virtual world."

The novel fabric design is a product of the happy union of soft and hard materials, featuring a combination of highly engineered polymer composites and stainless steel in a woven structure. Researchers created a device similar to a traditional loom to weave the smart fabric. The resulting process is extremely versatile, enabling design freedom and macro-scale control of the fabric's properties.

The fabric can also be activated by a lower voltage of electricity than previous systems, making it more energy-efficient and cost-effective. In addition, lower voltage allows integration into smaller, more portable devices, making it suitable for use in biomedical devices and environment sensors.

"The idea of these intelligent materials was first bred and born from biomimicry science," said Kamkar, director of the Multi-scale Materials Design (MMD) Centre at Waterloo.

"Through the ability to sense and react to environmental stimuli such as temperature, this is proof of concept that our new material can interact with the environment to monitor ecosystems without damaging them."

The next step for researchers is to improve the fabric's shape-memory performance for applications in the field of robotics. The aim is to construct a robot that can effectively carry and transfer weight to complete tasks.

A paper on the research, Multi-Stimuli Dually-Responsive Intelligent Woven Structures with Local Programmability for Biomimetic Applications, appears in the journal Nano-Micro Small.

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Sydney researchers discover hidden structure in networks like "X"

"New findings could help explain how social media content appears in our feeds / December 2023"

Research published in the latest issue of the journal PNAS Nexus introduces a new method capable of identifying and classifying relationships in networks. They found unexplored types of relationships in almost all of the 53 networks they analyzed.

The study represents a significant advance in understanding complex networks and their scaffolding, while the methodology has the potential to change the way networks are analyzed and interpreted.

The research was led by PhD student Cathy Liu and co-authored by Professor Eduardo Goldani Altmann, both from the School of Mathematics and Statistics, and Associate Professor Tristram Alexander from the School of Physics. All three are members of the Centre for Complex Systems.

One new relationship that the researchers call a "source-basin" structure plays an important role in two online networks the team closely examined – a new network of Twitter users and a well-studied network of political blogs.

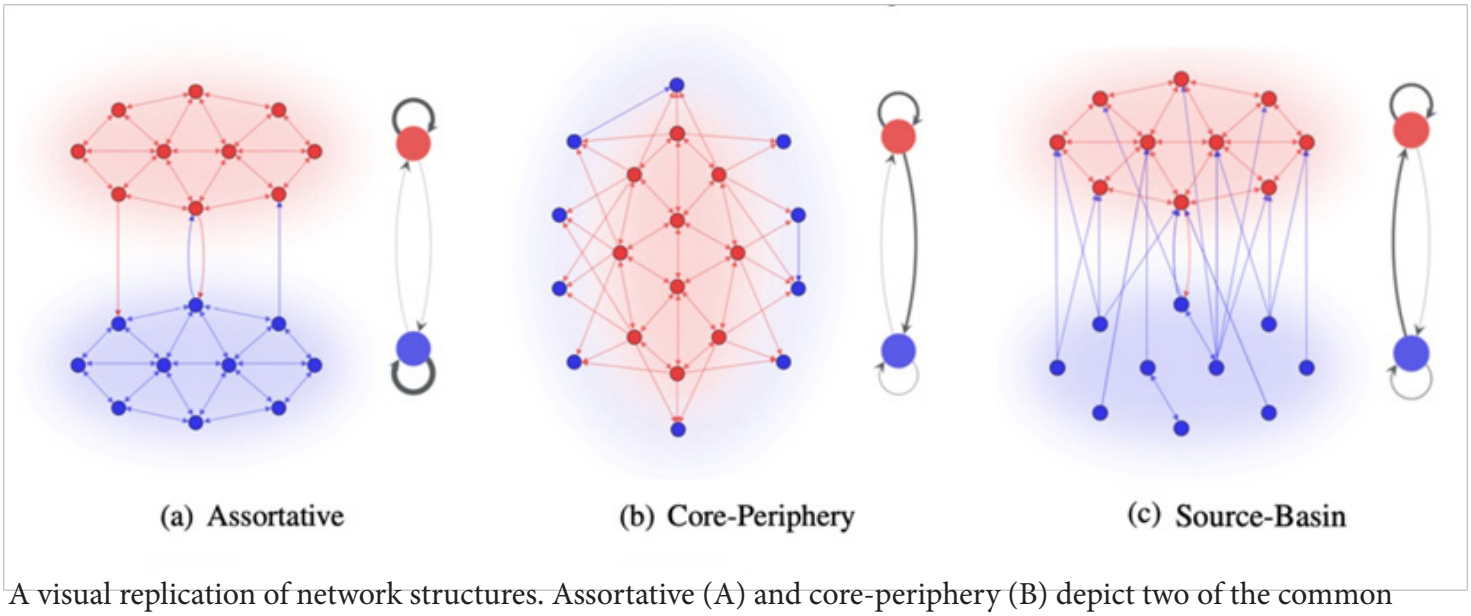
"This structure organizes the flow of information in online social networks, which happens from a community of sparsely connected influential nodes – the source – to a community of densely inter-connected active nodes – the basin," Professor Altmann said.

"An example of source-basin organisation would be 'influencers', such as news agencies, acting as the source with regular users performing the role of the basin.

Cathy Liu

Tristram Alexander

Eduardo Goldani Altmann



A visual replication of network structures. Assortative (A) and core-periphery (B) depict two of the common relationship structures found in networks, while source-basin (C) portrays the newly found flow of information from less-connected influencers to highly connected users. [Credit: Liu et al.]

"The influencers compete with each other and therefore don't engage one another, while regular users are engaged by the influencers and also connected to each other, such as through retweeting."

Associate Professor Alexander said it is helpful to think of a network like a city with different neighborhoods, each with its own distinct character and social dynamics. The researchers' method allowed them to identify and classify all possible relationships between these neighborhoods, from close-knit communities to more diffuse and diverse networks.

A social media platform like Twitter or a network of blogs are considered complex networks because they involve many interconnected nodes (such as users or accounts) and relationships (like connections, interactions or links) between these nodes.

"Networks are a powerful mathematical representation of various datasets and systems. An important computational tool to study and extract information from large complex networks is to partition it into groups of nodes with similar connectivity," lead author Ms Liu said.

"The surprising finding for the blog network suggests that the source blogs, being heavily referenced, are not tightly connected with each other while receiver blogs are less referenced but highly active in referencing others and strongly connected with each other.

"Our research presents a new way of studying network organisation and, at this stage, we can only speculate on the why and what their effects are on social media, but our plan for the future is to go deeper into this question."

To read the complete study, **click here.**

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The University of Texas at Austin
WHAT STARTS HERE CHANGES THE WORLD

New Technique Could Improve GPS

Graduate research assistant Joe Skeens stands in front of a GPS antenna deployed at the Very Long Baseline Array facility in Fort Davis, Texas.

A new scientific technique could significantly improve the reference frames that millions of people rely upon each day when using GPS navigation services, according to a recently published article in Radio Science.

For the first time, researchers at The University of Texas at Austin's Applied Research Laboratories and NASA's Goddard Space Flight Center have formed a radio interferometer between a GPS antenna and receiver and a large radio telescope. The new technique leverages a type of radio interferometer, a device that measures the difference in arrival time of radio waves emitted by distant astronomical sources, with antennas that detect and record the emission.

The team used an approach called Very Long Baseline Interferometry to use the sensitivity of the radio telescope to increase the GPS receiver's sensitivity. This additional sensitivity enabled them to extend the reach of the receivers to observe powerful jets of radia-

tion and particles generated by supermassive black holes up to 5 billion light-years away. The discovery will improve a variety of critical scientific measurements, from tracking small movements of land in earthquake-prone areas to understanding sea level change.

"The ability to reference new sources directly to GPS antennas paves the way for improvements in geodetic reference frames, which underpin modern navigation in applications from smartphones to national security," said Johnathan York, a research scientist at Applied Research Laboratories. "Improving reference frames to meet the millimeter-level consistencies demanded by a variety of important Earth science applications is critical for taking the next steps in robust precision positioning."

Using data collected at the Very Long Baseline Array facility in Fort Davis, Texas, and the nearby McDonald Geodetic Observatory, the researchers were able to demonstrate multiple detections of these powerful extragalactic jets. The detections extend the distance of signals referenced to a GPS antenna from satellites found about 20,000 kilometers away to astronomical objects 5 billion light-years from Earth. This distance is equivalent to flying to a GPS satellite and back about 1 quintillion (a 1 followed by 18 zeros) times, or an increase of 18 orders of magnitude.

"Expanding the reach of a scientific instrument is common — scientists are always trying to push their instruments to the limit — but a leap at 18 orders of magnitude is certainly extraordinary," said Leonid Petrov, lead scientist for the Space Geodesy Project at NASA Goddard Space Flight Center.

Observations using this novel combination of antennas and receivers will improve the accuracy of geodetic reference frames, which use a large set of locations measured by positioning techniques such as GPS to establish a common coordinate framework.

Future research will explore the connections between GPS positioning and the positioning based on observations of distant astronomical sources carried out by radio telescopes. Unifying these techniques will further help researchers to improve the geodetic reference frames that define how positions are measured in reference to Earth.

For more information, contact: Karen Adler, karen.adler@austin.utexas.edu Office of the Vice President for Research, Scholarship and Creative Endeavors, or Carly Knowles, caroline.knowles@arlut.utexas.edu Applied Research Laboratories.

Innovative AI-Enhanced Robotics Brings New Opportunities to Veterans at CGTC, VECTR Center

Central Georgia Technical College (CGTC) recently made headlines by surpassing 10,000 students enrolled for the fall term, in part because of innovative programs and partnerships, and opportunities for veteran students, among other populations to explore new career opportunities.

Enrollment growth comes as the College and its leadership have partnered with key local and regional organizations to improve outcomes for all its students. In particular, active duty, veterans and their families are benefitting from innovative career training and education. CGTC is the operational arm of the Georgia Veterans Education Career Transition Resource (VECTR) Center and the development of AI-Manufacturing coursework under the GA-AIM Grant, is spring-boarding new and modern career opportunities.

The GA-AIM Grant, or Georgia AI Manufacturing Grant, is led by the Georgia Tech Research Corporation with the goal of serving as a national model for how to accelerate the transition to automation in manufacturing while diversifying the next generation of AI leadership.

Andrea Griner, the CGTC vice president for Economic Development oversees the implementation of the grant awarded in 2022, and says "local industries, particularly those at Robins Air Force Base have shown increasing interest in a workforce prepared with AI-enhanced skills."

To meet high-demand manufacturing needs, the College developed a Technical Certificate of Credit (TCC) for AI Enhanced Robotic Manufacturing Specialist, partnering as a GA-AIM coalition member through the 21st Century Partnership. CGTC and VECTR launched the new lab for the AI program housed at the VECTR center in October.

Courses leading up to the lab compo-

nents of the TCC have begun this Fall and students are on their way to obtaining their credits. In addition to the TCC, they will also earn two Robotic Industry Certificates from Fuji Automatic Numerical Control (FANUC). Upon successful completion, students can apply for jobs immediately.

According to Deryk Stoops, CGTC Industrial Systems Technology and Aerospace, Trade & Industry instructor, the AI Enhanced Robotic classroom-lab is attracting students and conversation.

Situated in the center of the Georgia VECTR Center the lab, with open windows designed to draw attention to state-of-the-art robotic lab equipment, people are taking notice of what the innovative career path can mean for Central Georgia.

"AI is basically the next generation of manufacturing," said Deryk Stoops. "We are at a time where we have all these devices communicating making decisions autonomously. As technology continues to roll out in manufacturing we are seeing a lot of companies coming back to the United States because automation is making them more competitive." As students enter the room they are greeted by an autonomous robot that circles the laboratory as if it was another student.

Student Andrew Gray explained that the autonomous robot was made by MiR (Mobile Industrial Robot), this company specializes in creating autonomous robots that help in different sectors of the industry. Stoops shared how the programming works for the MiR 100 as the robot continues to circle around. He said this particular model is employed by hospitals to perform many tasks, one of them is the transportation of sterilized medical equipment and this specific model can handle up to 200 pounds.

Matthieu Snow, Air Force veteran and student, explains why he decided to enroll in the AI- Enhanced Robotic Manufacturing Specialist program. "As a 20+ year Air Force veteran my body has endured so many stress over the years and my bones and joints can not handle a lot of weight anymore, so I decided to get a career where I can maximize the use of my mind by programming AI Robotics and making industries more efficient while making it easier on my body as well."

Georgia VECTR Center serves as a gateway for veterans' re-entry into Georgia's public postsecondary educational systems and workforce. The center was established by the state and is designed to serve veterans and their families through career counseling, educational coaching, workforce training, and more.

The VECTR Center provides unique, accelerated programs in high demand and strategic industries tailored to abbreviate the process of receiving post-secondary certificates and degrees by recognizing the extensive training veterans receive during their military service.

It is a one-stop model for veterans seeking benefits, educational opportunities, employment services, entrepreneurship, and links to community resources.

AI-Enhanced Robotics is just one more innovative approach to that mission. “Across all the programs we offer, we want to fill seats with anyone who is serious about earning a great wage in a high-demand career field,” said U.S. Air Force Col. Don Layne, chief operating officer for the Georgia VECTR Center.

Learn more about the Georgia VECTR Center at, **www.gavectr.org**

"How my academic training helped me become a better Scientist in industry."

by **Minal Mehta**
Research Scientist, AstraZeneca, Gaithersburg, Maryland

I was ecstatic when I first found out that I got an industry job offer in a major pharmaceutical company, a few months before I was defending my PhD dissertation.

The role was a great fit-- it was a lab-based scientist position, and the work I was doing was very similar to what I had pursued during my PhD and what I honestly enjoyed.

It all felt like a dream come true, as my career goal at the time was to get an industry research position, with a meaningful opportunity to have a wider impact through my work by helping to deliver medicines to patients faster through evidence-based scientific research. It was certainly not an easy journey landing this role-- I had heard from colleagues and friends how difficult it is to break out of the ivory tower without industry experience.

Towards the last six to nine months of my PhD career, I was frantically preparing to finish my dissertation, manuscript, complete the last big experiments, and on top of it to find a position relevant to my knowledge base, interests and skill set. I applied to over 80 job positions, only to be fraught by the emails I would get saying,

"Thank you for applying, but we will not be moving forward with your candidacy."

I did countless phone interviews, long in-person interviews for many jobs, and fortunately towards the last two months of PhD, I found a role that was a good fit, and received a job offer within one week of my interview. It was certainly a very stressful time but nonetheless the hard-work certainly paid off.

One of my primary concerns was whether I had the skills that allowed me to function and thrive outside of academia. I felt like I was pigeon-holed into a very specialized niche within my field that breaking out of it would seem difficult.

Through personal reflection and preparation, I discovered that I did have the knowledge, experience and skills that are useful for the industry roles I wanted.

One of the key skills we learn as PhD scientists is how to communicate our science well to others. This is paramount to success in every function across industries. Knowing how to organize your thoughts well, present them in a clear and concise manner, and telling a compelling story of your data and results is crucial for success.

In graduate school, we have to convince our advisors and thesis committees that our research and ideas are sound and promising, and are worth pursuing. This task is no different than when sales representatives have to convince their customers that their company's product is worth buying, or when lawyers have to procure clients for their services by marketing their legal skills.

Similarly, as an industry scientist in a discovery research group, I have to routinely deliver compelling presentations with strong scientific evidence to convince my colleagues and managers that the drug target is worth pursuing, allowing the timeline of the product development cycle to move forward, with the ultimate goal to reach to patients in need faster.

My PhD academic training helped me become well-prepared to shoulder this responsibility and improve on it every day.

As I continue to practice communicating my science with others, I became better at building professional relationships with my colleagues, peers, managers, upper management, and cross-functional teams, and larger networks. I also learned so much from them and their functions and feel very satisfied to meaningfully contribute to the organization as a whole.

Another key skill that is an incredibly valuable asset of a PhD scientist is their problem-solving mindset that drives them to solve complex problems with a sense of urgency and persistence. We become relentless in pursuing the research questions without fearing failure. In fact, we actually thrive in it, because we are not afraid to take risks and keep moving forward. This essentially drives the discovery research and innovation programs forward, because without someone actually doing the work to figure out if novel drug target are worth working on, these programs will stop and nothing will get delivered.

I routinely have to deliver on this as part of one of my performance goals. The best part is it is it all feels like solving puzzles. Every day is a different day, with different challenges and problems to solve. Figuring out what resources needs to be allocated to what projects, and how to design experiments strategically to answer the right research questions, are the skills we all learn in our academic training.

This is tremendously valuable in the industry context as well. I have the ability to find the answers to complex questions, to find novel and creative solutions, to generate new valuable data, improve on processes that may have become outdated, or require new fresh perspectives. I am able to critically reason research ideas, by applying my own knowledge and experience. At the same time, I am able to leverage my team's expertise, and efforts, and build on working together to bring the solutions forward.

In concluding, I hope that through the snippets of my experiences that I shared above, I was able to show you that you too are able to take leaps forward into applying to those dream industry jobs that you always wanted and be successful in your scientific careers outside of academia.

Make them

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21

Curious

today

Jules Verne: Literary Engineer (part 2)

By Quentin R. Skrabec Jr., Ph.D.

Vernian Project Management

Verne's stories were those of significant engineering challenges and scientific adventures. Verne approaches these challenges as engineering projects, not as individual inventions. Verne's novels Twenty Thousand Leagues Under the Seas and From the Earth to the Moon are project management manuals for aspiring engineers. Verne's project engineers are holistic and problem-solving-oriented.

Most modern readers and reviewers of From the Earth to the Moon (1865) are amazed at coincidences of the actual 1960s (a hundred years later) moon landing, such as the Florida launch location, the soft water landing, retro-jets, and the use of an aluminum capsule. However, the novel's practical outline for engineering project management is more impressive for engineers. It is written like the project files of today's engineering companies.

Verne's moon project included team selection, location analysis, cost analysis, comparison of competing materials and technologies, intermediate necessary design changes, community impact, worker health and welfare, and identifying the need for technical development in needed components, testing, and prototypes.

Verne's moon project was led by the fictional Impey Barbicane, who had been Chief of Artillery for the Union Army. Verne describes Barbicane as "contributed mightily to the development of weaponry and constantly inspired new research."[10] Barbicane's vision is using a giant cannon to propel a capsule to the moon. Barbicane sets the goal and makes it a national project, announcing it before a group of military artillery experts.

Barbicane goes to the scientists at the Cambridge Observatory for a feasibility study to set his plan's scientific and astronomical requirements. The feasibility study defined the precise details such as the launch location, velocity requirements to achieve breaking from the pull of gravity and launch timing requirements. Barbicane then moves to build national support, set a national goal, and make a mission statement. Of course, the Vernian approach can also be applied at the organizational level.

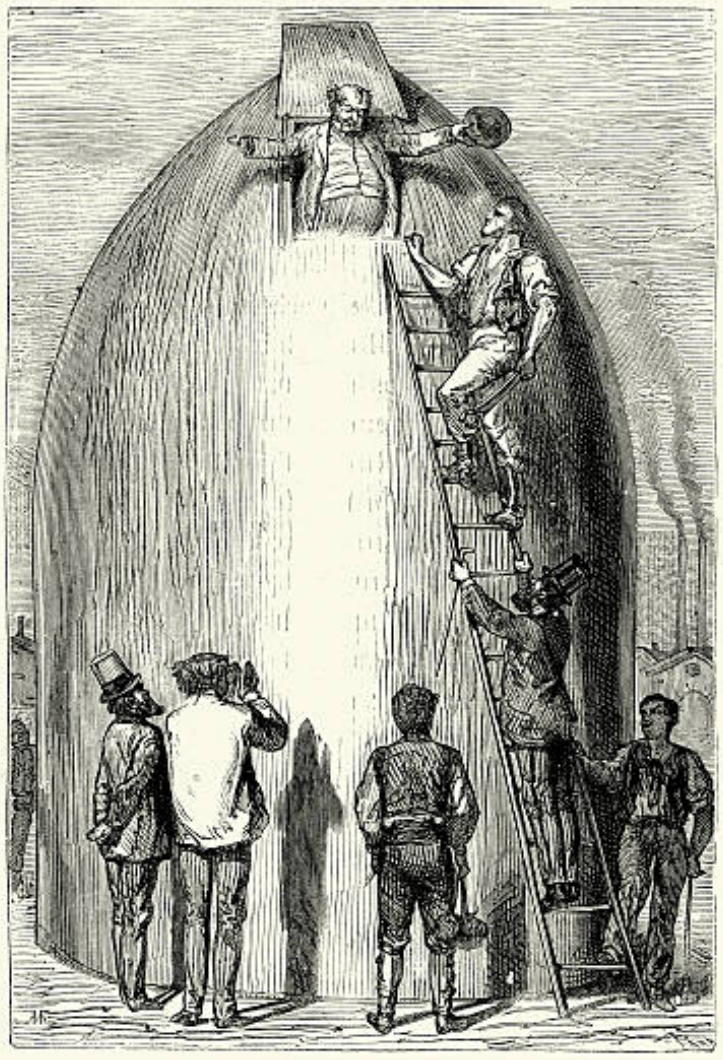
Verne realized the importance of public involvement and investment in a project such as a trip to the moon. Impey Barbicane would combine the leadership of John F. Kennedy and the imagination of Wernher von Braun (1912–1977), who headed the American NASA moon project a hundred years later.

Like von Braun's famous 1960s educational tour of the United States to teach science to the public and gain their support, Verne's Barbicane used the national press to make it "no longer permissible for the least learned of the Yankees to be ignorant of even one known fact of his satellite."[11] Again like NASA's early informal motto, "Everything we do is to get there," Barbicane notes, "their sole ambition now was to take possession of [Moon] … and plant on its highest peak the starry flag of the United States of America."[12]

Finally, Verne created a team and steering committee to address the significant engineering considerations of the cannon, projectile, and powder that needed to be discussed. Verne's project teams use the basics of what is known today as Design Thinking to understand project needs, challenge assumptions, redefine problems, use dimensional analysis, and create innovative solutions.

Verne also applies Failure-Mode-Effect Analysis (FMEA) to identify historical obstacles and explore alternative solutions to technical roadblocks. Design Thinking, FMEA, and project management are integrated processes for Verne. Verne's chapters read like an actual discussion of an engineering team today. Verne's team dialogue is a literary technique that moves the story

LE WAGON-PROJECTILE.



J.-T. Maston avait engraissé! (p. 145).

along and conveys technical knowledge. This part of Vernian science fiction engages the reader in learning science and history, avoiding a dry textbook-type approach.

Verne dedicates an entire chapter to each project's engineering issues: cannon, projectile, gunpowder, location selection, and construction. Although Verne made some scientific errors, he used fundamental engineering analysis to arrive at his cannon and lunar projectile design.

In Chapter 7, "Hymn to the Cannonball," a design committee discusses the history of big projectiles and the project requirements. Here Verne details historical obstacles to the project's success. The chapter also describes the various design calculations, such as needed escape velocity and cost estimates, but Verne's project design is broader than the physical requirements.

One of the artillery experts, J. T. Maston, exemplifying Verne's type of holistic engineer, takes the floor at the meeting. Maston takes a different view of the project's needed projectile, "This cannonball that we are sending to the moon is our messenger, our ambassador, and I ask to consider it from a strictly moral, intellectual point of view. . . in order to ponder the mathematical cannonball, the moral cannonball, and philosophical cannonball." [13]

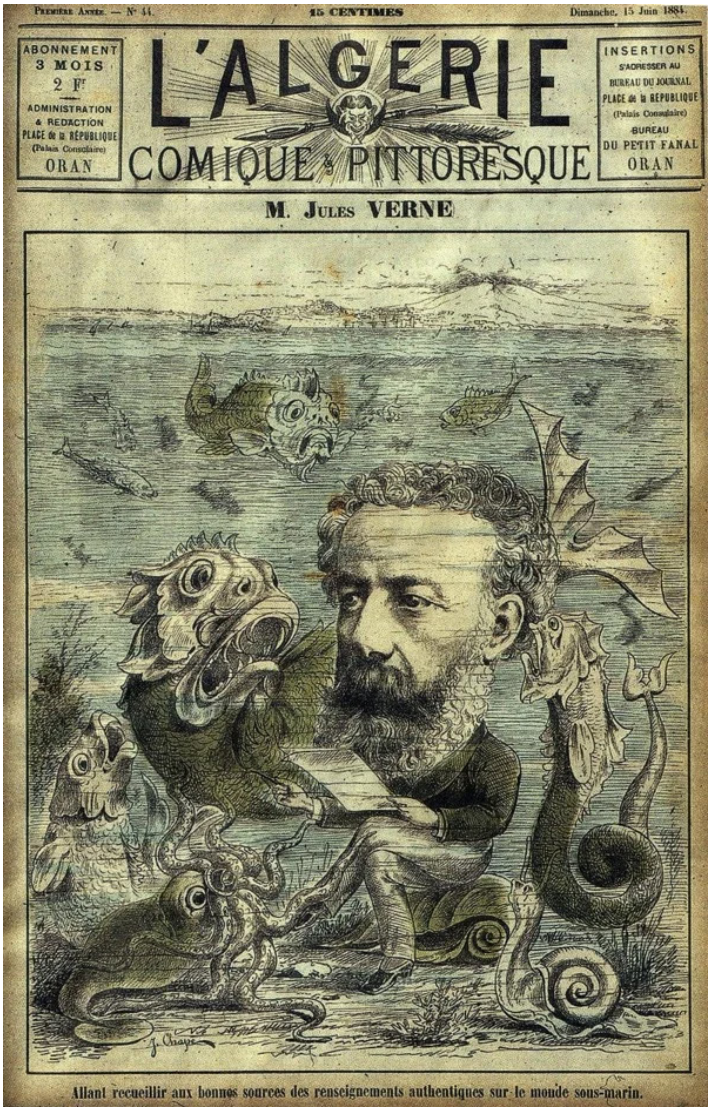
Its size takes in the idea that earth telescopes would have to see it and the landing to supply the needed verification of success. The design considers that should there be beings on the moon, how they might perceive the engineering of men. This approach reflects the holistic method of French engineering schools of the time.

When the committee chose an aluminum capsule for weight considerations,

they also noted that such an exotic metal would demonstrate the level of earthling technology. The design requirements for a 20,000-pound aluminum projectile were visionary for Verne. Verne's character Barbicane admits it would be the largest order ever for aluminum in 1865. Here Verne proves himself both prophet and writer.

Verne's translator, Walter Miller, notes that Verne is extrapolating, realizing the exponential growth of technology. His readers at the time would have known about aluminum from the daily Victorian articles about this new wondrous metal. Furthermore, his readers would live to see his predictions of such an order of aluminum in the 1890s.[14]

The following chapter, "The Story of the Cannon," takes place at another committee meeting with "mountains of sandwiches and a veritable ocean of tea,"[15] reminiscent of the famous pizza and Coke endless project design meetings in the early days of Apple and Microsoft. The design, dimensions, material, cost, and fabrication issues for the cannon were considered based on the artillery experience of the committee members. The giant guns of Verne's time were in the 25-foot length range. Verne takes us through the historical evolution of cannon size to estimate his moon cannon size using dimensional analysis.


Première Année. — N° 44. 15 CENTIMES Dimanche, 15 Juin 1884.

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L'ALGERIE COMIQUE & PITTORESQUE

INSERTIONS S'ADRESSER AU BUREAU DU JOURNAL PLACE de la REPUBLIQUE (Palais Consulaire) BUREAU DU PETIT FANAL ORAN

M. Jules VERNE

Allant recueillir aux bonnes sources des renseignements authentiques sur le monde sous-marin.

Brass and cast iron cannons' advantages and disadvantages were considered. Cast iron won out based on cost and ease of casting. Based on cannon design rules of thumb used during the Civil War, J. T. Maston requested a half-mile-long cannon, which the committee found impractical. Here Barbicane uses a different solution of casting the gun into the ground of 900 feet and a bore nine feet. The cannon would require 68,000 tons of cast iron. Verne details the Rodman design and manufacturing in the following chapters.

In later meetings, New York's Cold Spring Foundry[16] was selected to supply the pig iron and be a subcontractor to "recruit and manage the workforce." [17] Cold Springs engineer, J. Murchison, is added to the project management team. A city of modular iron sheet cabins would be needed to house the workers. The city design took into consideration the health of the workers.

Verne realized that for such a colossal cannon to be made in 1865 would require engineering beyond that available at the time. Here Verne proves himself an engineer. He combines Rodman's cutting-edge casting technology with Krupp Steel's casting methodology of the 1860s. Verne details his casting methods in several chapters. Initially, the Parrot design was selected, but eventually, a modified Thomas Rodman design[19] for a "Columbian" as construction problems occurred. Barbicane changes the initial Parrott cannon design. Verne notes, "A clause in the required that the Columbian with hoops of wrought iron be put in place," [20] which were the hallmark of the Parrott design. Barbicane cancels this clause as construction is near its end.

Verne's hybridized design augured the 1960s space race and arms race design methods. Verne anticipates that applying new scientific principles could be amalgamated to achieve the engineering needed for the project.

He saw technology as exponential growth. When the project team feels overwhelmed by the engineering advances needed, chief engineer Barbicane enforces their faith, "if we put our minds to it and take advantage of scientific progress, we should be to make cannonballs ten times heavier." Verne uses the same exponential thinking in his chapter "The Powder Question." When the project team seemed blocked by the sheer amount of gunpowder needed, Verne had Barbicane gamble on the emerging technology of guncotton, even though, in 1865, it was considered too unstable for use by the military. Verne's exponential-based guess would be justified in a few years by the development of chemical stabilizers for guncotton in the 1870s.

This 3 part series on Jules Verne will continued in the next issues. Be sure and follow up as we cover the amazing life and literary works of this great author.

Comments from the publisher -

Why is STEM Magazine important to every industry professional, parent, student, and educator?

The skills used day to day in any career field defines that career. The articles included in our monthly issues suggest a variety of career fields that all include STEM skills, but may not have been considered a STEM career by the reader previously.

Pick any career that comes to mind, from retail sales to robotics and AI design and the skills necessary for either are surprisingly aligned. Neither requires a STEM degree, but both use the very same STEM skills to be successful and innovative.

Any career you choose requires the systematic accumulation of knowledge, or continued learning about that chosen field, its tools, trends and innovations. This is the definition of "**science**".

All careers require the practical application of what you've learned via some form of technology that may include computers and software applications, apps or social media needs, cameras, drones, advertising venues and their requirements as well as emerging tech that does not currently exist.

I've yet to see any career field, volunteer effort or hobby that does not demand the ability to make informed decisions and solve problems. This is the definition of the Engineering Method, which is clearly a step by step process to achieve both, and we do it daily, at home and work, often without being aware.

The math of STEM ranges widely in applications, by simply measuring for a cooking recipe, to plotting the astronomical course of a space craft into the unknown. Both use the science of numbers, their operations, interrelations, combinations, generalizations, and abstractions. From a simple calculation for your discount coupon, successfully throwing a football to a receiver running their route, or to mapping the human genome, we use math dozens of times per day regardless of the activity we're involved in.

Everything has not been discovered or invented. Generations to come will pursue those unknowns using STEM skills without a STEM degree. These individuals will need inspiration, ideas, unrealized creativity and vast amounts of curiosity.

Who are these people? **Everyone** of all ages and interests. STEM Magazine will continue to offer career paths to consider, innovation needs to explore and the satisfaction of the journey.

Wayne Carley
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