STEM

BEST PRACTICE

MAGAZINE

Empowering

The Next Generation

Revolutionizing Education

Artificial

Photosynthesis

Entrepreneurial-STEM Learning

May 2023 \\002v

Kitspire, sponsor of STEM Best Practice Magazine, seeks to inspire STEM learning among the next generation of students, educators, and leaders through a combination of conferences, workshops, competitions and learning portals to imbibe new competencies, future skills, and high impact values.

We encourage curiosity, investigation, inspiration, creativity, and innovation; the foundations of every career passion.

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STEM Best Practice Magazine, is a product of STEM Magazine Inc., and is published quarterly for educators, students, their families and industry professionals.

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 Best Practice 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 skills and STEM careers.

THE LARGEST CONGREGATION OF STEM EDUCATORS IN MIDDLE EAST

12 + COUNTRIES | 200 + SCHOOLS | 600 + EDUCATORS

Date
10th May 2023

STEM BEST PRACTICE SUMMIT

Venue
Dubai Knowledge Park
AUDITORIUM

Welcome to the 4th edition of STEM Best Practice Summit and Awards series designed to provide a platform for STEM Educators, School Leadership Team, and corporates to discuss and share Best Practices in STEM Education.

TOPICS OF DISCUSSION

- Integrating Art into STEM Education
- Preparing Students for STEM Careers
- Strategies for Building a STEM Culture in school
- Innovative teaching methods in STEM Education
- STEM education in schools a case study

OUR SPEAKERS

Nargish Khambatta
CEO of GEMS Modern Academy and Senior Vice President – GEMS Education

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Head of Education at Britus Education

Dr. Marwa Eltanahy
Researcher and author in Academia, Higher Colleges of Technology

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As your family considers how best to plan for future career opportunities, STEM Best Practices Magazine will continue to provide relevant and inspirational information for the best decisions to be made.

Career paths abound with so many possibilities to consider, from aviation careers to dozens of medical career paths and much more.

Thank you for your interest and support as we explore together the wonders that lay ahead for our students and young adults.

Content is always welcome.

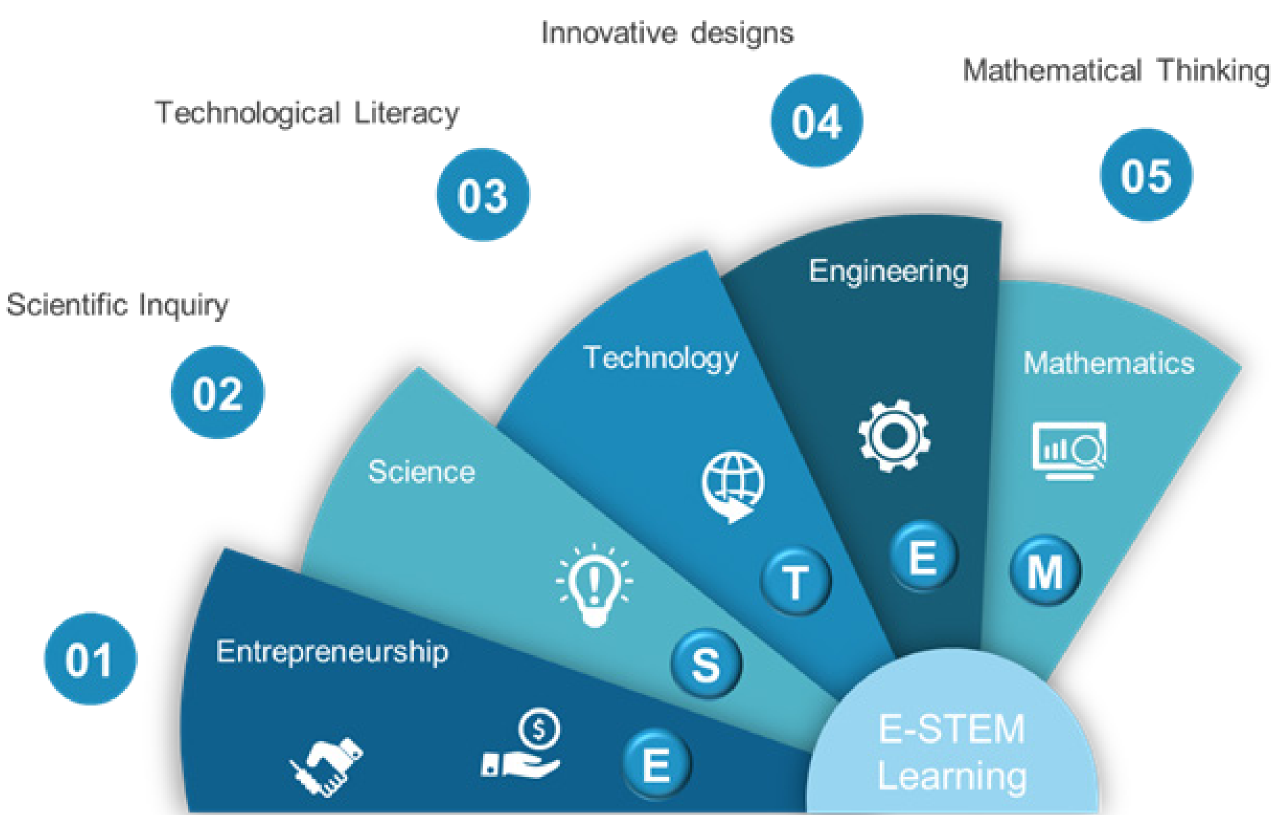
Ann Phillip
ann@stembestpractice.com

Entrepreneurial-STEM Learning

By **Dr. Marwa Eltanahy**
Higher Colleges of Technology

Education has the main responsibility in preparing students for the workplace through acquiring new knowledge, developing skills, and maintaining positive attitude to continue learning. The question is which skills should we focus on? The current society has constant changes which requires new skills to cope with its uncertainty. At the dawn of the industrial age, literacy meant reading, writing and anthemics that enabled peoples to communicate and fulfill their duties.

While, these skills remain essential, they are not sufficient in a fast-paced and a dynamic world where all efforts should be cultivated to serve the community by offering innovative solutions to cope with new and unexpected challenges. That is why, STEM becomes the new literacy of this era. At the same time, acting in an entrepreneurial way and exercising entrepreneurial competencies are essential to open new horizons for students.



Entrepreneurial-STEM learning (E-STEM) is a new and innovative interdisciplinary approach that combines entrepreneurship with science, technology, engineering, and mathematics (STEM) education. It focuses on the development of a valuable set of students' entrepreneurial competencies, including the desired knowledge, skills and attitude that are essential for success in both entrepreneurship and STEM fields.

These competencies, such as creativity, critical thinking, and problem-solving are important skills for STEM professionals and are highly needed for future entrepreneurs. Additionally, it provides meaningful opportunities for understanding the market needs to create new initiatives, designs or services that can add values to the community. E-STEM strategies encourage students to take entrepreneurial risks in a safe learning environment where mistakes and challenges are learning opportunities that are addressed with a growth mindset.

Although E-STEM integration is a complex process because it requires collaboration and coordination between different disciplines, E-STEM implementation proved successful through student-centered pedagogies that emphasizes hands-on experiential learning, and project-based activities.

Therefore, the ongoing process of curriculum development to integrate entrepreneurial practices into STEM education requires significant resources and expertise to scaffold E-STEM learning journeys. Accordingly, inviting business teachers to be involved in the existing STEM practices has a vital role to shift the STEM paradigm to be more business-like. Utilizing real-world problems and scenarios to engage students and to help them apply what they have learned in the classroom is the core principle of establishing a positive E-STEM context.

Instead of creating STEM designs that may easily be lost after educational exhibition, E-STEM learning provides more authentic experiences that have the potential to eliminate the gap between students' outcomes and community needs. Several constructivist strategies are recommended in light of competency-based approach to effectively apply E-STEM learning as follows:

- Project-based Problem Solving (PjBPS): Students work collaboratively on creating projects to solve real-world problems and scenarios that requires developing E-STEM competencies in an experiential learning environment.

- Problem-based Learning (PBL): Students work collaboratively on real-world problems and scenarios that requires developing their E-STEM competencies.

- Project-based Learning (PjBL): Students work collaboratively on designing projects that requires developing their E-STEM competencies to create innovative products or services.

E-STEM learning can be applied all many educational stages in both basic eduaction and higher education. It might be challenging in early childhood than other stages. However, a variety of practices are applicable to incorporate entrepreneurial concepts into existing STEM learning. E-STEM should provide opportunities to be used to promote entrepreneurial practices by having students design and create a "simple marketing plan" for their projects. This activity allows students to explore the business aspect of design, including branding, pricing, and target audience who might be interested in this project.

Figure 1 shows an example of E-STEM designed through project-based learning applications. Undergraduate students designed a big rocket using c simple materials that can be a valuable tool for enhancing early childhood education (ECE) by providing opportunities to enhance students' mathematical thinking, scientific inquiry, technological application, and entrepreneurial practices.

Figure 1: Project-based STEM Learning

Teachers utilized this project to engage students in a variety of activities to develop their design-process skills.

For example: one activity is to have students plan and sketch their own rocket designs using simple materials like cardboard, paper, and tape. This activity allows them to apply their mathematical thinking skills by measuring and cutting materials to specific dimensions, and encourages them to think critically about the design process by testing different designs and making modifications.

Another activity is to involve the use of scientific inquiry, where students can learn about the scientific principles that govern how rockets work. This can be achieved through discussions, reading materials, and hands-on experiments like launching small paper rockets to demonstrate the laws of motion.

Additionally, teachers can incorporate technological applications by having students use computer software or other digital tools to design their rockets in 3D.

This activity allows students to explore the use of technology in the design process, while developing their technological skills. Finally, students can draw a brand logo for this projects, fill in a sheet with the pieces of each materials involved in the design, and learn how to reduce the cost as an essential concept of entrepreneurship. This project effectively demonstrated how teachers can successfully integrate science, math, technology, and entrepreneurship in early childhood education to create engaging and meaningful learning experiences for young students.

Figure 2 illustrates an exemplary project that showcases the integration of entrepreneurial-STEM learning into lower-grade education. The project was initiated by undergraduate students of education who recognized the need for regular incorporation of STEM projects into early childhood education (ECE). The students designed a ship capable of carrying multiple vehicles through different doors.

To accomplish this, they had to apply various mathematical and scientific concepts, including the measurement of size and weight, to determine the appropriate location for each vehicle on the ship based on given criteria. In this context, elementary students learned how to apply critical thinking skills and problem-solving strategies to create a solution to a real-world problem.

Furthermore, the project integrated technology and entrepreneurship, allowing students to explore and develop a deeper understanding of concepts such as cost reduction and branding colors. To enhance their understanding, students should also watch videos and scenarios that discuss similar ideas in real-life. After the exhibition, E-STEM projects are used in many classes to improve students' thinking skills with an unlimited number of scenarios.

This project effectively demonstrated how teachers can successfully integrate science, math, technology, and entrepreneurship in early childhood education to create problem-solving opportunities in an active learning environment.

Figure 2: Problem-based E-STEM Learning

As students progress to higher grades, their capacity to integrate more advanced entrepreneurial concepts and experiences increases. These concepts include business plans, financial awareness, customer development, design functionality, market analysis, modeling and prototyping, competition, and positioning.

Figure 3: Project-based Problem Solving

Figure 3 showcases a prototype created by a group of college students who applied E-STEM practices in the college. They developed an “Autism Control Device” to safeguard individuals with autism. This application tracks their heartbeat, blood pressure, and medication schedule. It can also be used during emergencies when a caregiver is not present. The students integrated different E-STEM disciplines to design their projects, including the application and the prototype. Educational exhibitions offer rich opportunities for students to present their ideas, business plans, and receive constructive feedback to improve and develop their projects, ultimately achieving the main E-STEM goals.

E-STEM learning creates a dynamic environment where students learn to analyze, criticize and, rationalize their decisions to play effective roles in their communities. Thus, professional development programs should be prepared to train teachers in both entrepreneurship and STEM education.

Constructivist alignment between the intended outcomes of E-STEM learning, teachers’ instruction, and possible assessment practices should be emphasized to effectively implement Entrepreneurial-STEM learning.

However, developing both formative and summative assessment practices that accurately measure students’ progress and improve learning outcomes is challenging. Research community concerning E-STEM learning works tirelessly to create new valid and reliable tools of authentic assessment that allow teachers to identify students’ strengths, their needs and how to improve their entrepreneurial companies. Moreover, E-STEM assessment tools should draw a visible roadmap for students to become assessment-capable learners.

Entrepreneurial-STEM learning offers several benefits to both students and the economy, including improved career prospects, enhanced skills, promoted entrepreneurial activity, and economic growth. Thus, the implications of E-STEM learning are very promising because it can contribute to the work place development through preparing more students for of careers in high-demand fields such as engineering, technology, entrepreneurship and any business-based STEM careers to better enhance the economic growth of the countries.

Additionally, it can promote sustainability, social and environmental responsibility by encouraging students to develop solutions to real-world issues that have a positive impact on society and the environment.

In conclusion, education system should be responsive to the world' demands through producing a new generation of students who are scientifically, mathematically, technologically and entrepreneurially literate. Consistent efforts are done in education for a change to the better. E-STEM learning offers tangible solutions to reduce the skill gap between what we are able to do, and what future unknown careers need.

Dr. Marwa Eltanahy

Yet E-STEM learning opens up completely new learning spaces to launch our students in the direction of their new world.

Here are some words (terms) used in this issue you may not be familiar with. See if you can find them.

Anthemics
- that makes you feel happy and enthusiastic / suggestive of an anthem; rousing

Methodology
- a system of ways of doing, teaching, or studying something.

Convective
- movement in a gas or liquid in which the warmer parts move up and the cooler parts move down

Collaboration
- the process of two or more people, groups or organizations working together to complete a task or achieve a goal. Collaboration is similar to cooperation

Entrepreneurial
- the process of developing, organizing, and running a new business to generate profit while taking on risk

Neuromorphic
- any very large-scale system of integrated circuits that mimic neuro-biological architectures present in the nervous system

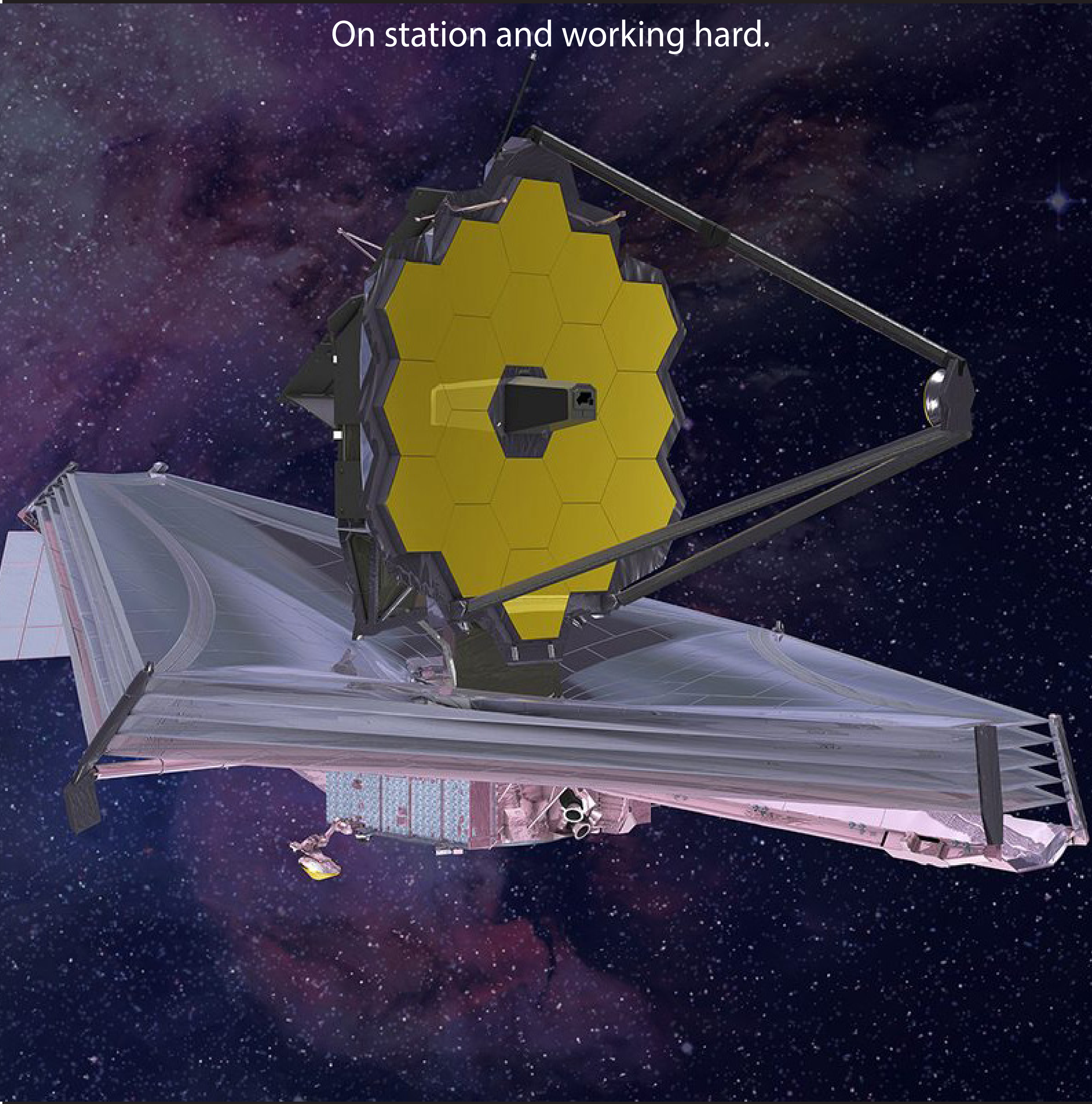
Cognitive
- of, relating to, or being conscious mental activities (as thinking, reasoning, remembering, imagining, learning words, and using language)

Constructivist
Art - a practitioner of a style in which mechanical objects are combined into abstract mobile forms

Mathematics - an adherent of a view that admits as valid only constructive proofs and entities demonstrable by them

James Webb Space Telescope Delivers

On station and working hard.



STEM Magazine has been following the James Webb construction since 2017 as is an excited as anyone about being on station and working hard to inspire and deliver answers and more questions about our universe.

JWST offers never before seen resolution and sensitivity from long-wavelength (orange-red) visible light, through near-infrared to the mid-infrared (0.6 to 27 micrometers). While Hubble has a 7.9 foot mirror (light collector), the JWST features a larger and segmented (multi-part) 21 foot primary mirror.

The **Canadian Space Agency** also played a big part in this project along with an international collaboration of about 17 countries led by the NSA, and with significant contributions from the European Space Agency. It is named after James E. Webb, the second administrator of NASA, who played an integral role in the Apollo program.

JWST's capabilities enable a broad range of investigations across the fields of astronomy and cosmology. One particular goal involves observing some of the most distant events and objects in the Universe, such as the formation of the first galaxies. Another goal is gaining a better theoretical understanding the formation of stars and planets.

The fuel capacity is designed for a ten year mission, we hope, compared to over 25 years so far for the Hubble Telescope. The Hubble cost was about 2.5 Billion dollars where as the James Webb has cost 8.7 Billion dollars.

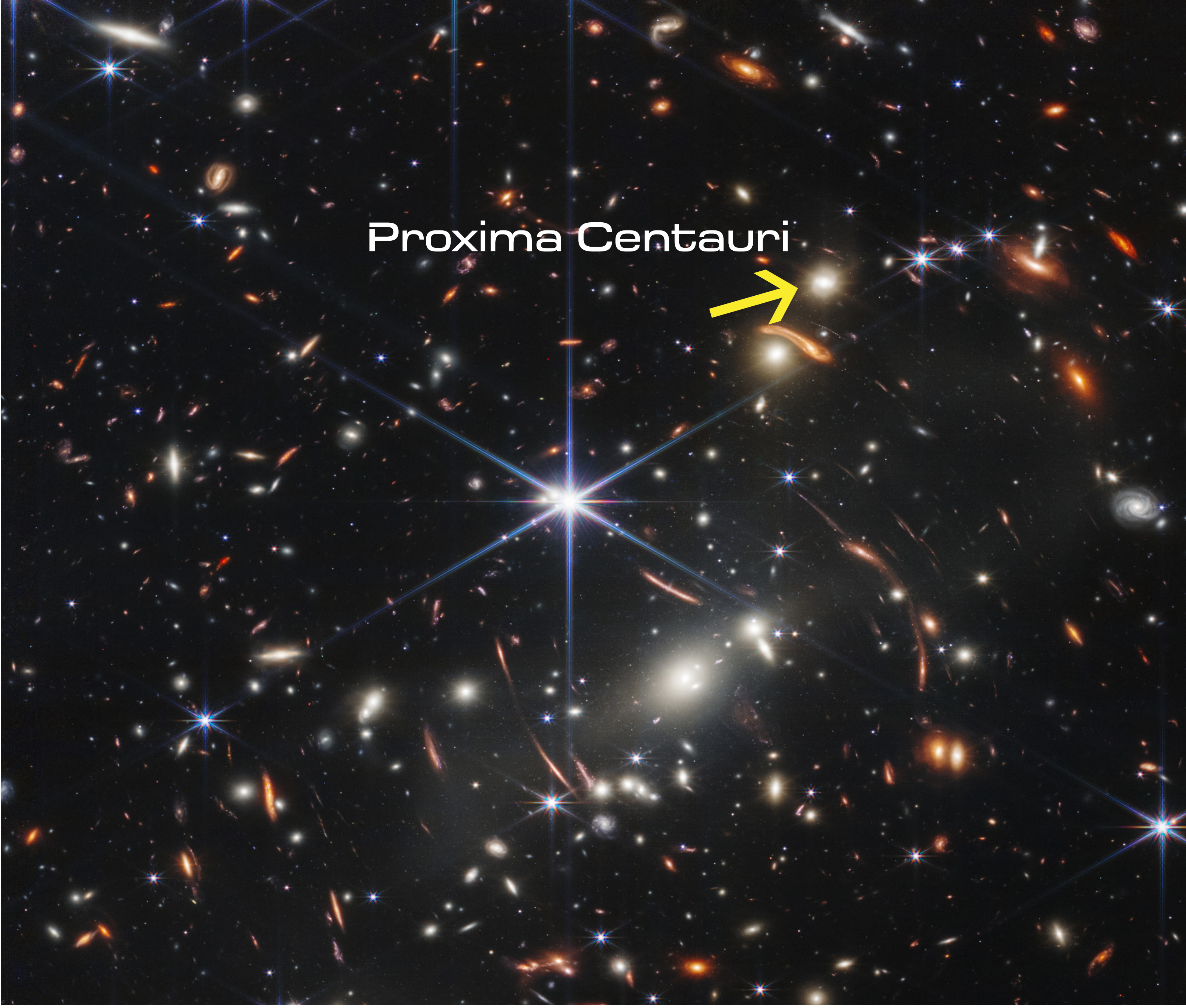
Keep in mind that what we see when we look up at the stars at night, are the light and events that happened millions of years ago and that light is just now getting here. Visible light waves travel at about 670,616,629 mph (miles per hour). How fast is that? A person traveling at the speed of light could circle the earth 7.5 times in one second. By comparison, a person in a jet aircraft, moving at a ground speed of 500 mph, would cross the United States once in 4 hours.

The light from our nearest neighbor star, Proxima Centauri, is 4.2 light years away.

So let's do the math: *How many miles does light travel in one Earth year?*

Hint: Multiply light miles per hour (given in last paragraph) times hours in a day times days in a year. The answer is how many miles per year light can travel.

Now multiply that answer times 4.2 and that's how many earth miles it is to our nearest neighbor star. A really big number (write it down).



For advanced or really curious students, take it to the ***next level:***

We can only travel at about 24,000 miles per hour in a current space craft with our technology.

So take your answer of how many Earth hours it takes to get to Proxima Centauri,

Divide *by how fast we can go*....24,000 miles per hour

Divide *by hours in a day*

Divide *by days in a year*

Your answer: You get ***how many of our Earth years it would take to get to Proxima Centauri.***

Now that we've figured that out, it's about 70,000 light years to our nearest neighboring galaxy. A telescope sounds like a much better idea.

The JWST will operate near the Earth-Sun L2 (Lagrange) point, approximately 930,000 mi (1,500,000 km) beyond the Earth. A Lagrange point is a location in space where the combined gravitational forces of two large bodies, such as Earth and the sun, equal the centrifugal force felt by a the telescope. The interaction of the forces creates a place of equilibrium or balance where a spacecraft or telescope may be "parked" to make observations.

By way of comparison, Hubble orbits 340 miles (550 km) above Earth's surface, and the Moon is roughly 250,000 miles (400,000 km) from Earth. This is too far away for us to repair it or make changes, so we have to get it right before launch. Objects near this point can orbit the Sun while remaining in a constant position with the Earth, allowing the telescope to remain at a roughly constant distance and use a single sunshield to block heat and light from the Sun and Earth.

This has already been a very exciting visual exploration "deep" into space, showing us new and never before seen images of our universe.....gathering lights from about 13 Billion years ago that's just now arriving at Earth.

To the right is an image of a protostar and its dark cloud, both named L1527, are located in the Taurus star-forming region some 460 light-years from Earth. Scientists estimate L1527 to be around 100,000 years old, which is relatively young in star terms—this hot, bright celestial body still has a long way to go before it becomes a full-grown star. (Our sun, meanwhile, is around 4.6 billion years old.) Researchers consider L1527 a class 0 protostar, which represents the earliest stage of star formation.

Eventually, L1527 will create its own energy via the nuclear fusion of hydrogen, which is a hallmark of stars. But for the time being, it's still an unstable, puffy bundle of gas that's continuing to gather mass. For comparison, L1527 is around 20 to 40 percent the mass of the sun.

Take some time and explore the career opportunities that involve astronomy and its related professions. Perhaps you will discover an area of interest you had not considered before. If nothing else, invest in a small and affordable home telescope and be awestruck by what you can see from your own back yard.

Empowering the Next Generation:
An Interview with a Leading Science Educator

By Alaa Hassan
Senior Academic Specialist - Science National Lead / Emirates Schools Establishment

1. What inspired you to pursue a career in science education, and what led you to become a K-12 school science lead?

I was inspired to pursue a career in science education because I have always had a passion for science, exploration and experiments and have wanted to share that passion with others since childhood.

The first time I recall my passion for teaching started to bloom was when I watched my Mom teach my older sisters and me after school. My Mom was an Arabic Language teacher, and I remember how excited I used to be every day at 5:00 pm to have study time with Mrs. Mama.

We would sit around a rectangular table, and my mum would stand against the green chalkboard to explain to us. My mother inspired and helped me develop my educational skills to appreciate teaching and learning.

Becoming a K-12 school science lead was a natural progression for me as I loved Science, and I wanted to help mentor other science teachers and promote science education among the students.

2. What are some of the key challenges that you face in leading science education at the K-12 level, and how do you overcome them?

One of the key challenges is ensuring that all students, regardless of their background or ability level, have access to high-quality science education. This requires a focus on equity and inclusion, as well as targeted support for students who may be struggling.

Another challenge is keeping up with the rapid pace of scientific advancements and incorporating them into the curriculum meaningfully. This requires ongoing professional development and collaboration among educators.

To overcome these challenges, I worked on building strong partnerships with other educators, community organizations, and industry experts. Additionally, I worked on creating a culture of curiosity and inquiry within the schools, encouraging students to ask questions, explore new ideas, and engage in hands-on learning experiences.

Also, as science educators and educators in general, one of the main challenges we face is the vast learning gap created by the COVID-19 pandemic. In our schools, we helped bridge these gaps by providing targeted support, educational, and counselling services to help students cope with the stress and anxiety caused by the pandemic.

By supporting the students' emotional well-being and providing them with the tools they need to succeed, K-12 science education can play a critical role in preparing the next generation of scientists, innovators, and leaders.

3. What are some of the most effective teaching strategies and approaches that you use in your work as a science lead, and how have they helped your students achieve success?

In education, every student learns in their own unique way, and as educators, we need to ensure that we cater to these needs to ensure that the student is benefiting from the learning experience we provide. One of the most essential approaches in science is Hands-on, inquiry-based learning. This approach encourages students to ask questions, make observations, and design experiments to test their hypotheses. By engaging in hands-on activities, students can better understand scientific concepts and build essential skills such as critical thinking, problem-solving, and collaboration.

Another equally important strategy is Real-world connections. Making connections between scientific concepts and real-world applications can help students see the relevance and importance of what they are learning. This can include incorporating current events, case studies, and examples from industry and research.

One more very important strategy is Differentiated instruction. Students come to the classroom with various backgrounds, experiences, and learning styles. Differentiated instruction allows teachers to tailor their instruction to meet the needs of individual students, providing additional support or challenges as needed.

By incorporating these strategies and approaches into their teaching, school science leads can help their students achieve success by building their understanding of scientific concepts, developing important skills, and fostering a love of learning that will serve them well in all aspects of their lives.

4. How do you ensure that your science curriculum aligns with state and national standards, and how do you keep up with changes and updates to those standards?

Ensuring that a science curriculum aligns with national and international standards and staying up to date with changes and updates to those standards requires ongoing effort and dedication Curriculum experts within the organization regularly review our science curriculum. The review is done to ensure alignment with Next Generation Science Standards (NGSS).

To keep up with changes and updates to science standards, as an organization, we are always attending professional development workshops and conferences, joining professional organizations such as the National Science Teachers Association (NSTA), and

regularly reviewing updates to state and national standards.

5. How do you incorporate hands-on and inquiry-based learning into your science curriculum, and what benefits do those approaches offer for students?

To incorporate hands-on and inquiry-based learning into a science curriculum, we use a variety of instructional strategies and resources at school. This includes but is not limited to, lab experiments, STEM challenges, and simulations. Through Lab experiments, students are able to apply scientific concepts to real-world situations and develop important skills such as data collection, analysis, and interpretation. STEM challenges are also an excellent opportunity to involve students in problem-solving, teamwork, and collaboration in order to design, build, and test solutions to real-world problems. Also, simulations are one of the strategies that was recently incorporated, especially after Covid-19, to allow students to explore complex scientific concepts and phenomena that may be difficult or impossible to observe directly.

The benefits of hands-on and inquiry-based learning are numerous. These approaches can help students develop a deeper understanding of scientific concepts, build important skills, and develop a love of learning that can last a lifetime.

By engaging in hands-on and inquiry-based learning activities, students can also develop important social-emotional skills, such as communication, collaboration, and problem-solving, that are essential for success in the 21st century.

6. What advice do you have for other educators who are interested in pursuing a career in science education, particularly at the K-12 level?

First and foremost, I advise educators to develop a strong foundation in science. To be an effective science educator, having a strong foundation in the subject you are teaching is important.

This also includes building your teaching skills. Teaching science requires a unique set of skills, such as the ability to explain complex concepts in simple terms and the ability to create engaging and interactive lessons. To develop these skills, always as educators, consider taking professional development courses focused on teaching science.

Science is constantly evolving, and it is important for science educators to stay up to date with current research and trends. Staying up to date with current research and trends will also help you build your science foundation. And most importantly, keep it fun. Kids are born curious, and science is the best platform to develop this curiosity.

Remember that teaching is about more than just imparting knowledge. Connect with your students, build relationships, and foster a love of learning that will last a lifetime.

7. How do you measure the success of your science education programs, and what metrics do you use to evaluate student learning and growth over time?

Measuring the success of science education programs can be challenging, as student learning and growth can be influenced by various factors both inside and outside the classroom. However, there are several metrics that we can use to evaluate the effectiveness of their programs. These metrics usually assess the students' Cognitive skills, such as the ability to apply knowledge, solve problems, and think critically, in addition to the Non-cognitive skill, such as evaluating students' social and emotional development, including self-confidence, motivation, and perseverance.

Assessment for learning strategies implemented in the classroom can provide more detailed information about student learning and growth over time. Also, students' engagement and participation in science classes and activities can provide insights into their level of interest and motivation, which can influence their learning and growth.

Benchmarking against International Assessments, such as TIMSS, is also one of the metrics implemented in our schools, providing effective strategies to measure students' learning and growth against international standards over time.

By **Breanna Bishop**
The U.S. Department of Energy
(DOE) and DOE's National Nuclear Security Administration

The NNSA announced recently the achievement of fusion ignition at Lawrence Livermore National Laboratory (LLNL) — a major scientific breakthrough decades in the making that will pave the way for advancements in national defense and the future of clean power.

On Dec. 5, a team at LLNL's National Ignition Facility (NIF) conducted the first controlled fusion experiment in history to reach this milestone, also known as scientific energy breakeven, meaning it produced more energy from fusion than the laser energy used to drive it. This first-of-its-kind feat will provide unprecedented capability to support NNSA's Stockpile Stewardship Program and will provide invaluable insights into the prospects of clean fusion energy, which would be a game-changer for efforts to achieve our goal of a net-zero carbon economy.

"This is a landmark achievement for the researchers and staff at the National Ignition Facility who have dedicated their careers to seeing fusion ignition become a reality, and this milestone will undoubtedly spark even more discovery," said U.S. Secretary of Energy Jennifer M. Granholm. "This Administration is committed to supporting our world-class scientists — like the team at NIF — whose work will help us solve humanity's most complex and pressing problems, like providing clean power to combat climate change and maintaining a nuclear deterrent without nuclear testing."

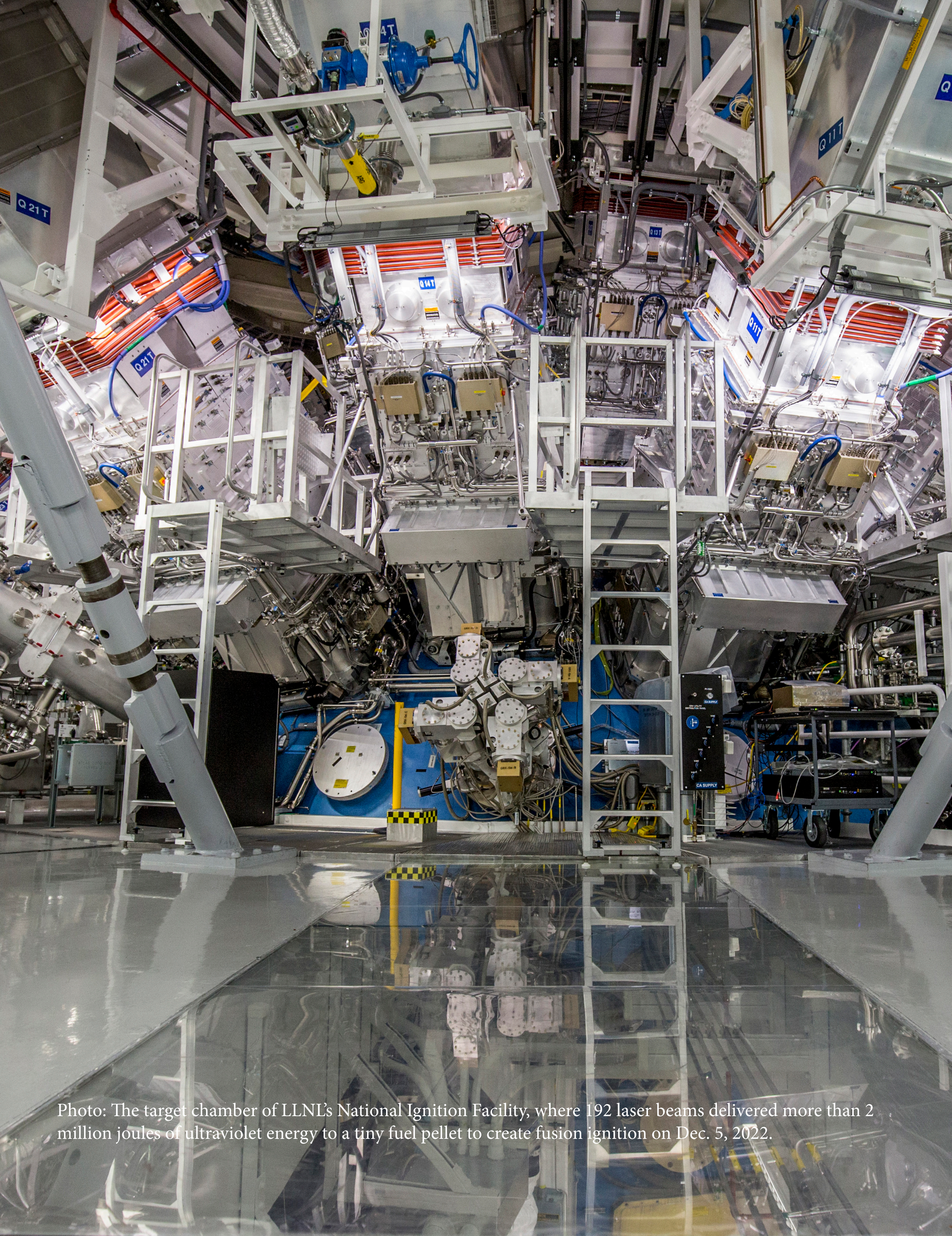


Photo: The target chamber of LLNL's National Ignition Facility, where 192 laser beams delivered more than 2 million joules of ultraviolet energy to a tiny fuel pellet to create fusion ignition on Dec. 5, 2022.

“We have had a theoretical understanding of fusion for over a century, but the journey from knowing to doing can be long and arduous. Today’s milestone shows what we can do with perseverance,” said Dr. Arati Prabhakar, the President’s chief adviser for Science and Technology and director of the White House Office of Science and Technology Policy.

“Monday, December 5, 2022, was a historic day in science thanks to the incredible people at Livermore Lab and the National Ignition Facility. In making this breakthrough, they have opened a new chapter in NNSA’s Stockpile Stewardship Program,” NNSA Administrator Jill Hruby said.

“I would like to thank the members of Congress who have supported the National Ignition Facility because their belief in the promise of visionary science has been critical for our mission. Our team from around the DOE national laboratories and our international partners have shown us the power of collaboration.”

“The pursuit of fusion ignition in the laboratory is one of the most significant scientific challenges ever tackled by humanity, and achieving it is a triumph of science, engineering, and most of all, people,” LLNL Director Dr. Kim Budil said. “Crossing this threshold is the vision that has driven 60 years of dedicated pursuit — a continual process of learning, building, expanding knowledge and capability, and then finding ways to overcome the new challenges that emerged. These are the problems that the U.S. national laboratories were created to solve.”

“This astonishing scientific advance puts us on the precipice of a future no longer reliant on fossil fuels but instead powered by new clean fusion energy,” U.S. Senator Charles Schumer (NY) said. “I commend Lawrence Livermore National Labs and its partners in our nation’s Inertial Confinement Fusion (ICF) program, including the University of Rochester’s Lab for Laser Energetics in New York, for achieving this breakthrough. Making this future clean energy world a reality will require our physicists, innovative workers and brightest minds at our DOE-funded institutions, including the Rochester Laser Lab, to double down on their cutting-edge work. That’s why I’m also proud to announce today that I’ve helped to secure the highest-ever authorization of over $624 million this

“Monday, December 5, 2022, was a historic day in science”

year in the National Defense Authorization Act for the ICF program to build on this amazing breakthrough."

"After more than a decade of scientific and technical innovation, I congratulate the team at Lawrence Livermore National Laboratory and the National Ignition Facility for their historic accomplishment," said U.S. Senator Dianne Feinstein (CA). "This is an exciting step in fusion and everyone at Lawrence Livermore and NIF should be proud of this milestone achievement."

This is an historic, innovative achievement that builds on the contributions of generations of Livermore scientists. Today, our nation stands on their collective shoulders. We still have a long way to go, but this is a critical step and I commend the U.S. Department of Energy and all who contributed toward this promising breakthrough, which could help fuel a brighter clean energy future for the United States and humanity.

This monumental scientific breakthrough is a milestone for the future of clean energy. While there is more work ahead to harness the potential of fusion energy, California scientists continue to lead the way in developing clean energy technologies.

How exactly does nuclear fusion work?

Simply put, nuclear fusion is the process by which two light atomic nuclei (nucleus of an atom) combine to form a single heavier one while releasing massive amounts of energy. Fusion reactions take place in a state of matter called plasma (a gas caused by the 2 nuclei separating), a hot, charged gas made of positive ions and free-moving electrons that has unique properties distinct from solids, liquids and gases.

To fuse on our sun, nuclei need to collide with each other at very high temperatures, exceeding ten million degrees Celsius (18,000,032 degrees fahrenheit), to enable them to overcome their mutual electrical magnetic repulsion. Once the nuclei overcome this repulsion and come within a very close range of each other, the attractive nuclear force between them will outweigh the electrical repulsion and allow them to fuse. For this to happen, the nuclei must be confined within a small space to increase the chances of collision. In the sun, the extreme pressure produced by its immense gravity create the conditions for fusion to happen.

The amount of energy produced from fusion is very large — four times as much as nuclear fission reactions —

and fusion reactions can be the basis of future fusion power reactors. Plans call for first-generation fusion reactors to use a mixture of deuterium and tritium — heavy types of hydrogen. In theory, with just a few grams of these reactants, it is possible to produce a terajoule of energy, which is approximately the energy one person in a developed country needs over sixty years.

Stay with me now - this is a layman's explanation suitable for elementary students.

A "Newton" is the amount of energy needed for you to roll one Cantaloupe (2.20 pounds) across the floor, 3 feet in one second. You could actually try this in class or at home.

A newton is a unit of "**force**".
A joule is a unit of "**energy**".
The ratio is 1:1, so one newton of force requires on joule of energy.

How many joules of energy do you need to roll 2 Cantaloupes, 3 feet in one second? If you said, 2, you are correct.

The exciting reaction that happened on Dec. 5th delivered more than 2 million joules in a split second.

This is a very big deal.

We can celebrate another performance record by the National Ignition Facility. This latest achievement is particularly remarkable because NIF used a less spherically symmetrical target than in the August 2021 experiment," said U.S. This significant advancement showcases the future possibilities for the commercialization of fusion energy.

The challenges facing the world today are even greater than at any time in our past. We must accelerate the research to explore new pathways for the clean, limitless energy that fusion promises, and "you" can be part of it.

LLNL's experiment surpassed the fusion threshold by delivering 2.05 mega-joules (million) (MJ) of energy to the target, resulting in **3.15 MJ of fusion energy output**, demonstrating for the first time a most fundamental science basis for inertial fusion energy (IFE). Many advanced science and technology developments are still needed to achieve simple, affordable IFE to power homes and businesses, and DOE is currently restarting a broad-based, coordinated IFE program in the United States. Combined with private-sector investment, there is a lot of momentum to drive rapid progress toward fusion commercialization.

What’s the big deal?

“We put clean energy into the reaction and got <u>MORE OUT</u> than we put in.”

Imagine putting a one hundred dollar bill into a box and closing the lid. A few minutes later you open the box and pull out **$150** ! Would you be excited?

- no nuclear waste
- no radiation
- no harm
- no pollution
- the energy comes from water

In radiation thermodynamics, a hohlraum is a cavity whose walls are in radiative equilibrium (balance) with the radiant energy within the cavity. This idealized cavity can be approximated in practice by making a small perforation in the wall of a hollow container of any opaque material.

This is the hohlraum that houses the type of cryogenic target used to achieve ignition on Dec. 5, 2022, at LLNL’s National Ignition Facility.

Revolutionizing Education

By Jacobus de Leeuw
Innovation and Technology Coordinator, STEAM Coordinator / Swiss International School, Dubai

Jacobus de Leeuw

Swiss International School, Dubai, is an IB bilingual school, for students aged 3-18 years. Based in Al Jaddaf, the school offers day and boarding education, and has a unique bilingual proposition, with French and German being taught bilingually throughout the school in a co-teaching setting.

Our STEAM programme was specifically developed for our students who are developing their language skills in German or French, through this they can attend language acquisition classes which support them to access the language at a steadier pace.

When the school decided to introduce the STEAM programme, we specifically looked at the advantage that STEAM education will have for our children's future education choices.

STEAM education is an approach to learning that integrates Science, Technology, Engineering, Arts, and Mathematics.
Our programme:

1. Develops critical thinking skills: STEAM education encourages students to think critically and creatively. It promotes problem-solving skills, decision-making skills, and analytical thinking.

2. Promotes teamwork and collaboration: STEAM education involves group projects and activities, which can help students learn to work collaboratively and effectively with others.

3. Provides real-world applications: STEAM education emphasizes the practical application of knowledge and skills, helping students understand how they can use what they learn in the real world.

4. Prepares students for the future: STEAM education equips students with the skills and knowledge they need to succeed in the 21st-century workplace, where technology and innovation are increasingly important.

5. Fosters innovation and creativity: STEAM education encourages students to explore, experiment, and innovate, fostering creativity and a love of learning.

6. Enhances problem-solving skills: STEAM education provides opportunities for students to engage in problem-based learning, where they can use their skills to solve real-world problems.

7. Increases engagement and motivation: STEAM education is hands-on and interactive, which can increase student engagement and motivation.

Our STEAM programme is integrated into our IB PYP (International Baccalaureate Primary Years Programme) units. This allows us to incorporate even greater trans-disciplinary integration when students are introduced to the inquiry that they will work on. The programme is further enhanced by the rich Language and Arts integration classes we offer.

Transdisciplinary learning is characterized by a focus on real-world issues, a commitment to collaboration and dialogue across disciplinary boundaries, and an emphasis on experiential learning and reflection. It involves engaging students in problem-solving and critical thinking activities that draw on a range of knowledge and skills from different fields, such as science, mathematics, social studies, arts, and humanities.

Transdisciplinary learning is becoming increasingly important in today's world, as many of the most pressing challenges facing society, such as climate change, poverty, and inequality, are complex and require solutions that draw on multiple perspectives and areas of expertise. By promoting transdisciplinary learning, our educators help students develop the skills and knowledge needed to address these challenges and create a more sustainable and equitable future.

At the start of each unit, our students are introduced to a problem, the problem is also related to the IB Unit of inquiry that students are working on. We usually introduce our problem through Language Arts, since students can make a connection with the character that is facing the problem, making a real-world connection with students, and this was the case with the STEAM activities too.

Problem-based learning is a student-centered approach in which students learn about a subject by solving an open-ended problem in groups. This issue is what drives student motivation and learning.

As students dive into the problem, they are introduced to their learning team and the parameters of the project that they will collaborate on. Project-based learning allows students to investigate and develop opportunities to change or overcome obstacles in their 'real world.' We ask our students to think critically, solve problems, and investigate ways to answer the driving question. This is then where the "magic" starts.

The students will now decide which facet of the transdisciplinary skills they want to use to solve the problem. When they choose to use Science, teachers then help them to identify the specific Science concept that they want to learn about. They complete Scientific Investigations, research and compare their results with others.

If the students decided they require a mathematical solution, teachers will then facilitate the required mathematical support. Even more fun happens when students start designing the solution, for this, we follow a simplified version of the IB MYP (International Baccalaureate, Middle Years Programme).

The goal of the engineering design cycle is to create a prototype that is the solution to the stated problem, and it helps to structure:

- *inquiry and analysis of design problems*

- *development and creation of feasible solutions*

- *testing and evaluation of students' models, prototypes, products or systems.*

Throughout all projects and problems, our students will learn a significant number of transferable skills and an appreciation for our world and our environment.

Some example activities that students have completed:

Grade 1:
Students were introduced to the story of the Gingerbread Man, running away from everyone that wants to eat him. Once the Gingerbread Man arrived at the river, the story was stopped. Students then collaborated on a plan to help the Gingerbread Man.

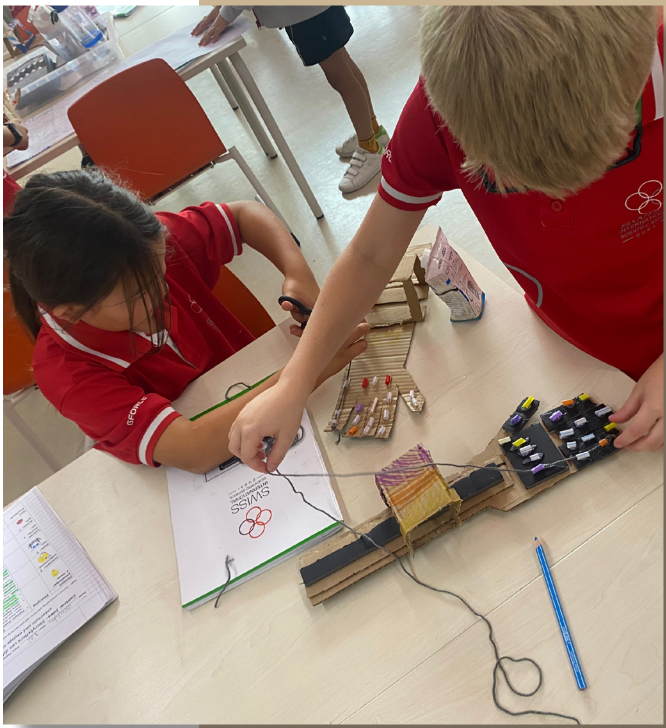
The students were then given different types of weak materials to build a bridge or a boat for the main character. Testing the initial prototype through a scientific inquiry, students realized that they would need stronger materials that should be waterproof.

This opened many different lines of inquiry, allowing students to learn about floating, sinking, waterproofing and strength.

Finally, after students explored the scientific principles of the materials, they completed a final design. Throughout the project, students developed a range of skills, including measurement, storytelling, scientific investigations, and key understandings of materials.

Grade 2:

Students were introduced to the story of Bethany Hamilton, who tragically lost her arm in a shark attack. The problem the students had to approach was: Having a physical disability can be a challenge many people face worldwide. As students were introduced to the problem, they created their own stories that had to explain what challenges they would face if they lost a limb in an accident.



The students were then challenged to create a functioning prosthetic using cardboard. Students inquired into elementary robotics attaching string and straws to make the hand of the prosthetic functional. Finally, students retold the story using their prosthetics while recording it using a digital device, learning more about video editing and green screening.

Grade 3:

Students inquired into: Food scarcity and the availability of natural resources to cook are challenging. Students were introduced to this problem by watching a news clip highlighting the cost of living for people living in rural areas around the world. Student teams designed and constructed a functional solar over model demonstrating knowledge and understanding of renewable energy.

Throughout the inquiry, students learned about the types of materials and their characteristics, heat retention, conducting heat and reflecting light. As part of the design and construction, students had to carefully measure their parts and join them together to create a functional solar oven, capable of heating a marshmallow past its melting point.

The transdisciplinary learning that took place during this project, allowed students to gather a significant number of skills and understandings that will be transferable for future projects and activities.

Grade 4:

Students are currently focusing on the central idea that the condition of interrelated body systems determines individual needs. During this unit, students prepare for a "Bodyology Fair" where they will present their knowledge and understanding of a specific body system. Students become medical experts that will identify a related illness or disease related to the body system and then create a solution that will solve or prevent the illness.

Students will follow the engineering design cycle to create a prototype for the solution. Throughout the unit, students use their Science, Technology, Arts and Mathematics skills to create a final product which they then present to parents and other visitors.

Grade 5:
Students inquired into the following question: What happens when something disrupts the ability of an ecosystem to meet the needs of the organisms in it?

Students were introduced to a modern-day threat to agriculture across the globe, called the red palm weevil (Rhynchophorus ferrugineus) which is responsible for destroying date palm groves across the UAE and the world.

Learner teams inquired into the weevil, how it can be identified, its life cycle and the palm species that are most at risk. Student teams were then set the scenario that they are going to be responsible for saving the last remaining date palm trees and that they will need to construct a biodome that will need to be a suitable ecosystem for the plants while protecting them from the threat. Students designed their biodomes using a 3D modelling programme and then transferred their designs to Minecraft Education.

Once the biodomes were constructed, students had to create a video tour of their biodome, explaining how they will maintain the dynamic equilibrium.

Our programme is constantly evolving as we develop our teachers' and students' skills, and we know we are preparing our students to become problem solvers, innovators, and creative critical thinkers.

Some STEM careers covered in this issue:

- Entrepreneurial opportunities
- Teaching / best practices / supporting educators
- Department of Energy careers
- Tidal energy programs and solutions
- Astronomy / research and development
- Helping parents support their students (parenting is a real full-time job)
- Engineering design tools and uses

Turbulence
Climate Impact

By The Environmental Defense Fund

5 Ways Climate Change Is Making Air Travel Worse

By The Environmental Defense Fund & Wayne Carley

Climate change is contributing to hotter heat waves and more damaging storms. When it comes to air travel, these events can lead to delays, cancellations and bumpier skies, as if our world wasn't turbulent enough already.

At hotter temperatures, planes need to go faster to take off due to lower air density. In extreme heat, planes might not have enough runway to get the speed they need to go airborne. That heat can ground aircraft: A 119-degree day in 2017 led American Airlines to cancel more than 40 flights out of Phoenix.

Scientists are studying climate changes effects on jet streams – bands of air currents – and are noting stronger variations in wind speed, which can cause more severe turbulence. Paul Williams, a noted atmospheric scientist at the University of Reading in Britain, calculated in a 2017 study that climate change could boost incidents of severe turbulence by 149 percent within a decade.

"Even the most seasoned frequent fliers may be alarmed at the prospect of a 149 percent increase in severe turbulence", said Paul Williams, atmospheric scientist. High temperatures on the tarmac can lead to heat stress and other illnesses associated with extreme working conditions.

During hot weather, concrete and asphalt turn into "heat islands" – spots that are hotter than the surrounding areas – making airport employees especially vulnerable. Scientists are confident that continued warming threatens human health, potentially making working outdoors impossible in many regions.

Heat or flooding can make airports inoperable. When temperatures soar toward 100 degrees Fahrenheit, tarmacs can get soft and cause the wheels of planes to get stuck. In addition to extreme heat, climate change – triggered by humans – is contributing to rising sea levels, which are leading to higher storm surges and more floods.

Turbulence

Turbulence is one of the most unpredictable of all the weather phenomena that are of significance to pilots. Turbulence is an irregular motion of the air resulting from eddies and vertical currents. It may be as insignificant as a few annoying bumps or severe enough to momentarily throw an airplane out of control or to cause structural damage.

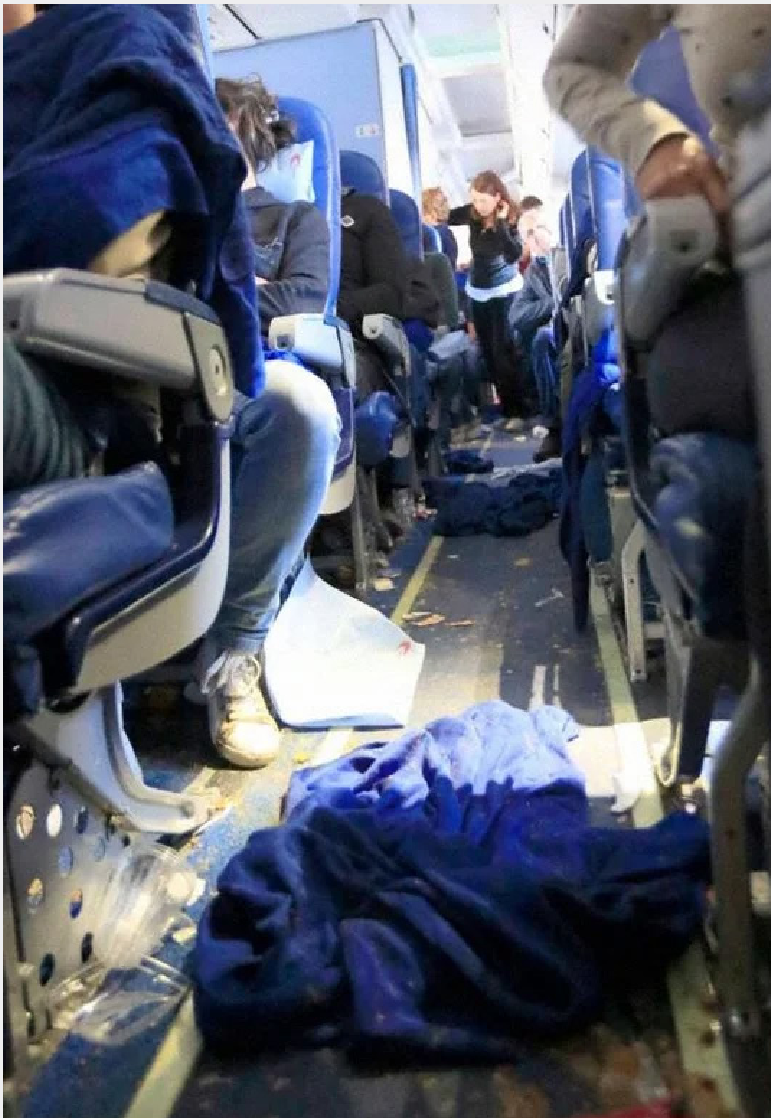
Turbulence is associated with fronts, wind shear, thunderstorms, and all are increasing at alarming rates, some would attribute to climate changes and more erratic and unpredictable weather events.

Mechanical Turbulence

Friction between the air and the ground, especially irregular terrain and man-made obstacles, causes eddies and therefore turbulence in the lower levels.

The intensity of this eddy motion depends on the strength of the surface wind, the nature of the surface and the stability of the air. The stronger the wind speed (generally, a surface wind of 20 knots or higher is required for significant turbulence), the rougher the terrain and the more unstable the air, the greater will be the turbulence. Of these factors that affect the formation of turbulence, stability is the most important. If the air is being heated from below, the vertical motion will be more vigorous and extensive and the choppiness more pronounced. In unstable air, eddies tend to grow in size; in stable air, they tend not to grow in size but do dissipate more slowly.

Strong winds are usually quite gusty; that is, they fluctuate rapidly in speed. Sudden increases in speed that last several minutes are known as squalls and they are responsible for quite severe turbulence.



Thermal (Convective) Turbulence

Turbulence can also be expected on warm summer days when the sun heats the earth's surface unevenly. Certain surfaces, such as barren ground, rocky and sandy areas, are heated more rapidly than are grass covered fields and much more rapidly than is water. Isolated convective currents are therefore set in motion with warm air rising and cooler air descending, which are responsible for bumpy conditions as an airplane flies in and out of them.

Turbulence extends from the base to the top of the convection layer, with smooth conditions found above. if cumulus, towering cumulus or cumulonimbus clouds are present, the turbulent layer extends from the surface to cloud tops.

Turbulence intensity increases as convective updraft intensity increases. In weather conditions when thermal activity can be expected, many pilots prefer to fly in the early morning or in the evening when the thermal activity is not as severe.

Convective currents are often strong enough to produce air mass thunderstorms with which severe turbulence is associated. Turbulence can also be expected in the lower levels of a cold air mass that is moving over a warm surface. Heating from below creates unstable conditions, gusty winds and bumpy flying conditions.

Thermal turbulence will have a pronounced-effect on the flight path of an airplane approaching a landing area. The airplane is subject to convective currents of varying intensity set in motion over the ground along the approach path. These thermals may displace the airplane from its normal glide path with the result that it will either overshoot or undershoot the runway.

Frontal Turbulence

The lifting of the warm air by the sloping frontal surface and friction between the two opposing air masses produce turbulence in the frontal zone. This turbulence is most marked when the warm air is moist and unstable and will be extremely severe if thunderstorms develop.

Wind shear is the change in wind direction and/or wind speed over a specific horizontal or vertical distance. Atmospheric conditions where wind shear exists include: areas of temperature inversions, along troughs and lows, and around jet stream. When the change in wind speed and direction is pronounced, quite severe turbulence can be expected. Clear air turbulence is associated at high altitudes (i.e, above 15,000 feet AGL) with the jet stream.

The greatest shear, and thus the greatest turbulence, is found at the tops of the inversion layer. Turbulence associated with temperature inversions often occur due to radiational cooling, which is nighttime cooling of the Earth's surface, creating a surface-based inversion.

Turbulence associated with lows and troughs is due mainly to horizontal directional and speed shear. Turbulence is generally found along troughs at any altitude, within lows at any altitude, and poleward of lows in the mid and upper altitudes.

A jet stream is core of strong horizontal winds that follows a wavelike pattern as a part of the general wind flow. It is located where there are large horizontal differences in temperature between warm and cold air masses.

Meanwhile, many airports are located in flat, coastal areas or in vulnerable floodplains where extreme storms can inundate runways. Weather causes about a third of flight delays, according to federal statistics. Delays overall cost industry and passengers billions a year.

One reason passengers take such a financial hit: Airlines consider weather an "act of God" out of their control. It's up to them whether to offer refunds or compensation. Scientists say climate change will likely bring more and increasingly intense storms, which could lead to more delays and cancellations in the coming years.

While more planes are coming into service, the global aviation industry, which accounts for 2 percent of global carbon dioxide emissions, is taking initial steps to reduce emissions. What we need to do now is demand action – from leaders at every level – while urging companies to adopt sustainable business practices.

Turbulence, in all shapes and forms may be here to stay and we are in for a bumpy ride. It does help to understand it scientifically while keep our seat-belts on and seats in their upright position!

Set up students for success with

Autodesk Fusion 360 for Education

by Peter Kruger

While summer is only just now upon us, before you know it, new graduates will be celebrating their procession into the next phases of their lives, whether that be higher education or budding careers. Fortunately, it's always the right time to prepare students for the next-generation workflows and technologies of the future of design and manufacturing. You can do that with free educational access to Autodesk Fusion 360® software, the cloud-connected platform for teaching integrated CAD/CAM/CAE concepts and skills in a single, easy-to-use software platform.

Next-generation software for advanced design and manufacturing educations

When Sunset High School near Portland, Oregon, started a Career and Technical Education (CTE) engineering program, its advisory board stressed how important 3D design and manufacturing is to employers, and recommended Fusion 360 software. Since then, Sunset has integrated the software to pair with its computer numerical control (CNC) machines, laser cutters and 3D printers to teach multiple CAD/CAM/CAE concepts from a single, easy-to-use platform, rather than needing multiple programs. "One of the things that I really enjoy about Fusion 360 is that it has a very short on-ramp, and we really get to move through a lot of physical projects quickly," says Cady Greer, CTE instructor at Sunset High School.

Greer also explains how Fusion 360 helped the school in a less expected way. Beaverton School District's HVAC system had a problem with a bushing part that was difficult to replace, so Greer and her students used Fusion 360 to model and 3D print the part themselves. The part now has been used in several schools, and Greer estimates it will save the district $5 million over the next few years.

So why is Fusion 360 having this level of impact in schools, colleges and universities? That's easy. Fusion 360 has a simple, intuitive design that allows students to work with its various features and tools easily, so they can engage quickly with course content. When they need additional support, in-software tool tips are there to guide them in using features and workflows. They can work from any computer—either with Mac or PC software or through a web browser—and the cloud-connected data is accessible from anywhere.

Fusion 360 software utilises a top-down design approach that today's students love, letting them create assembly components in the space they're supposed to fit. Students can work together seamlessly with collaboration features and version control that makes it easy to roll back to previous versions. As continued convergence in industry makes projects more complex, students learning on the Fusion 360 collaboration-first foundation will be comfortable sharing models and data in the same manner in which they'll work in the professional world.

Features like the Fusion 360 timeline help educators see how students approach projects conceptually, bringing a visual, step-by-step workflow to teaching. It also gives students insight into their decisions to see if they're absorbing new concepts like the soft-

ware's Generative Design extension, as well as its advanced simulation tools and end-to-end design-for-manufacturing workflows. All told, Fusion 360 software was built for the way today's digital-native students approach technology. It's easy to learn, allows them to iterate faster on projects and prepares them for the modern industry workplace.

Schools thriving with Fusion 360

Educational institutions can set up their students for success in the advanced design and manufacturing job market by incorporating Fusion 360 software into their curricula, whether they are high schools, community colleges or universities. It's not only

Sunset High School that's benefitting from using Fusion 360 in its program.

In California, Lawrence Equipment designs and manufactures automated machines that make tortillas, flatbread and other foods. After the company invited instructors from nearby Pasadena City College to see how Fusion 360 significantly improved its manufacturing productivity, the school added the software to its curriculum. Doing so has helped the instructors reduce the number of steps in design and manufacturing workflows while preparing students for in-demand industry jobs. "The number one complaint we had from students was that they needed more time on the machines," says Jacob T. Tucker, CTE, Pasadena City College. "With Fusion 360, students were spending less time at the desks and more time on the machines."

At British research University Imperial College London, a group of students working collaboratively cites Fusion 360 as essential to their project. "Fusion 360 allows us to operate like modern engineers," says Kiran de Silva, student at Imperial College London. "The software lets us integrate four different major sub teams all developing different designs with different requirements into one big assembly." The student team particularly appreciates the Fusion 360 simulation tools, which let them move seamlessly from CAD designs to simulation, and the generative design workspace, which provides a simple interface in which they can refine rocket parts to be as mass-efficient as possible.

It's time to shine with free Fusion 360 software and instruction

Unique features of the Fusion 360 platform make teaching and learning with the software easier and more effective. Its intuitive and modern 3D modelling, engineering and production features convey the next-generation skills that changing industry technology and workflows require. The Fusion 360 cloud-connected platform integrates CAD, CAM, CAE and PCB software in one place available from any device. This helps enable better collaboration and better insights from centralised data.

Autodesk can support you every step of the way to incorporate Fusion 360 software into your curriculum, with detailed getting-started guides as well as learning pathways for a range of skill levels and career trajectories, which can help you build courses and curricula. Across the region there is a network of Autodesk Learning Partners who can help you with your Fusion 360 journey.

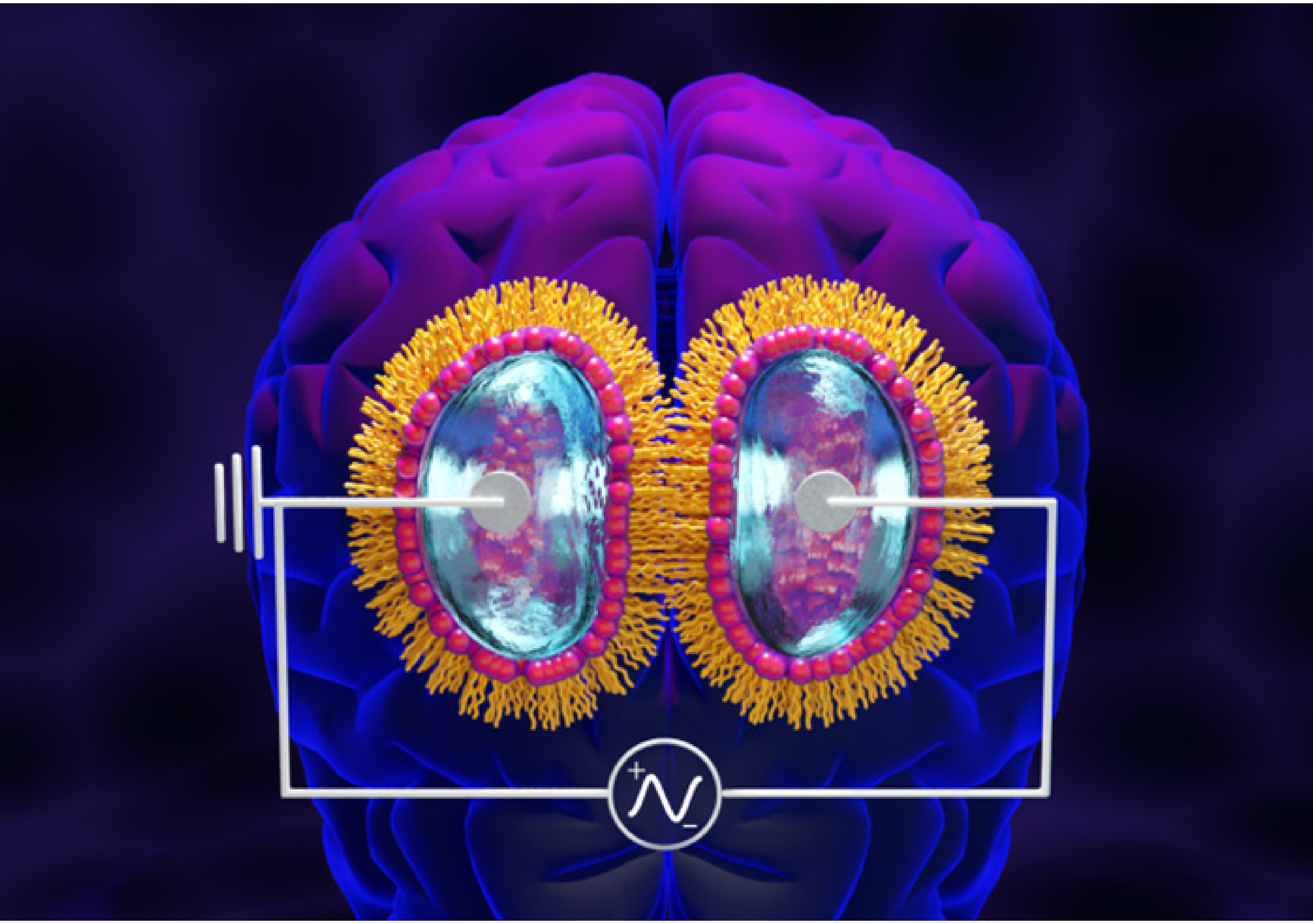
About the author-

Peter Kruger is a senior product marketing manager for Autodesk Education. He has worked in EdTech throughout most of his career and has a passion for education.

Peter oversees product marketing for Higher Education as well as Learning and Certification.

Biomembrane research findings could advance understanding of computing and human memory

By Emily Tomlin / ORNL



A pure lipid membrane formed using lipid-coated water droplets exhibits long-term potentiation, or LTP, associated with learning and memory, emulating hippocampal LTP observed in the brains of mammals and birds. Credit: Jill Hemman/ORNL, U.S. Dept. of Energy

While studying how bio-inspired materials might inform the design of next-generation computers, scientists at the Department of Energy's Oak Ridge National Laboratory achieved a first-of-its-kind result that could have big implications for both edge computing and human health.

Results published in Proceedings of the National Academy of Sciences show that an artificial cell membrane is capable of long-term potentiation, or LTP, a hallmark of biological learning and memory. This is the first evidence that a cell membrane alone – without proteins or other biomolecules embedded within it – is capable of LTP that persists for many hours. It is also the first identified nanoscale structure in which memory can be encoded.

"When facilities were shut down as a result of COVID, this led us to pivot away from our usual membrane research," said John Katsaras, a biophysicist in ORNL's Neutron Sciences Directorate specializing in neutron scattering and the study of biological membranes at ORNL. "Together with postdoc Haden Scott, we decided to revisit a system previously studied by Pat Collier and co-workers, this time with an entirely different electrical stimulation protocol that we termed 'training.'" This eventually led to data that are practically indistinguishable from the LTP signal observed in human brains.

Encoding memory in nanoscale systems has the potential to advance the development of next-generation computing materials and architectures that seek to match the efficiency and flexibility of human cognition — known as neuromorphic computing. While the implications for artificial intelligence may be obvious, brain-like computation will also dramatically alter the energy efficiency and computing capabilities of next-generation devices.

"Memory and logic in the brain are intertwined," said Collier, staff research scientist at the Center for Nanophase Materials Sciences, a DOE Office of Science user facility at ORNL where the research was performed. "But in modern computers, these functions happen in different locations — a bottleneck the brain does not have."

Even today's supercomputers have separate locations for processing and memory. By merging these functions, neuromorphic computers could help keep pace with exponentially growing data sets that are becoming more complex as the Internet of Things, or IoT, and the interconnectivity of devices become commonplace in homes and workspaces. It would also greatly advance edge computing, the ability of a device to do its own logic at the site of data collection, without having to send information to a central server or cloud.

Also, scientists have not yet identified a nanoscale structure in the brain where memory is stored. Large sections of the brain, such as the hippocampus, are known to store memory, but much remains unknown about where memory is stored in the hippocampus and the molecular mechanisms responsible for it. Importantly, cellular membranes have been overlooked as structures in which information could be encoded, even though lipids, a major component of membranes, make up most of the brain's mass.

The unexpected result of achieving LTP in a pure lipid membrane will initiate a re-examination of where and how memory is stored in a living brain. If neural cell membranes are found to be a critical feature in human memory, this could lead to novel treatments for the more than a billion people worldwide that are living with neurological disorders.

"If neurobiologists can find evidence of this in the brain, it could have dramatic impacts on how we understand dementia and learning," said Katsaras. "Importantly, the membrane can offer a novel therapeutic target for brain diseases that do not respond to drugs targeting proteins."

The nanoscale systems used in this study create an artificial membrane by bringing together two micron-sized lipid-coated water droplets within an oil suspension. At the interface between the two droplets, a lipid bilayer forms that mimics the cell membranes of neuronal synapses in the human brain.

Previous ORNL research showed that this biomembrane system is capable of storing an electric charge, but only for short periods of time. In the new study, the presence of LTP means that there are new avenues for how this soft material system could be used in neuromorphic devices or how it could serve as a model for the construction of solid-state devices with similar features.

"Now that we've begun to define the electrical protocols to induce LTP in lipid bilayer membranes, we are preparing to make two-terminal crossbar architectures in which multiple nanoscale membranes interact, allowing for active logic to be performed, not just passive storage," said Collier.

"Right now, we're using single systems; going forward, we need to learn how to wire them together." In addition to partnering with neurobiologists to explore the biomedical implications of this finding, future neuromorphic computing work on the biomembrane system will involve simulations and use of ORNL's leadership facilities in neutrons and computing.

"What we're seeing are serendipitous discoveries that came from somewhat curiosity-driven research conducted during the pandemic," said Collier. "But it's a significant finding for neuromorphic computing. We don't know exactly how this is going to work, but that's the fun part."

The journal article is published as "Evidence for long-term potentiation in phospholipid membranes."

The research was supported by the DOE Office of Science. Data collection and analysis were performed at the CNMS, while all samples were prepared at The University of Tennessee Shull Wollan Center, co-located at ORNL.

UT-Battelle manages ORNL for the DOE Office of Science. The single largest supporter of basic research in the physical sciences in the United States, the Office of Science is working to address some of the most pressing challenges of our time.

Emily R Tomlin / ORNL

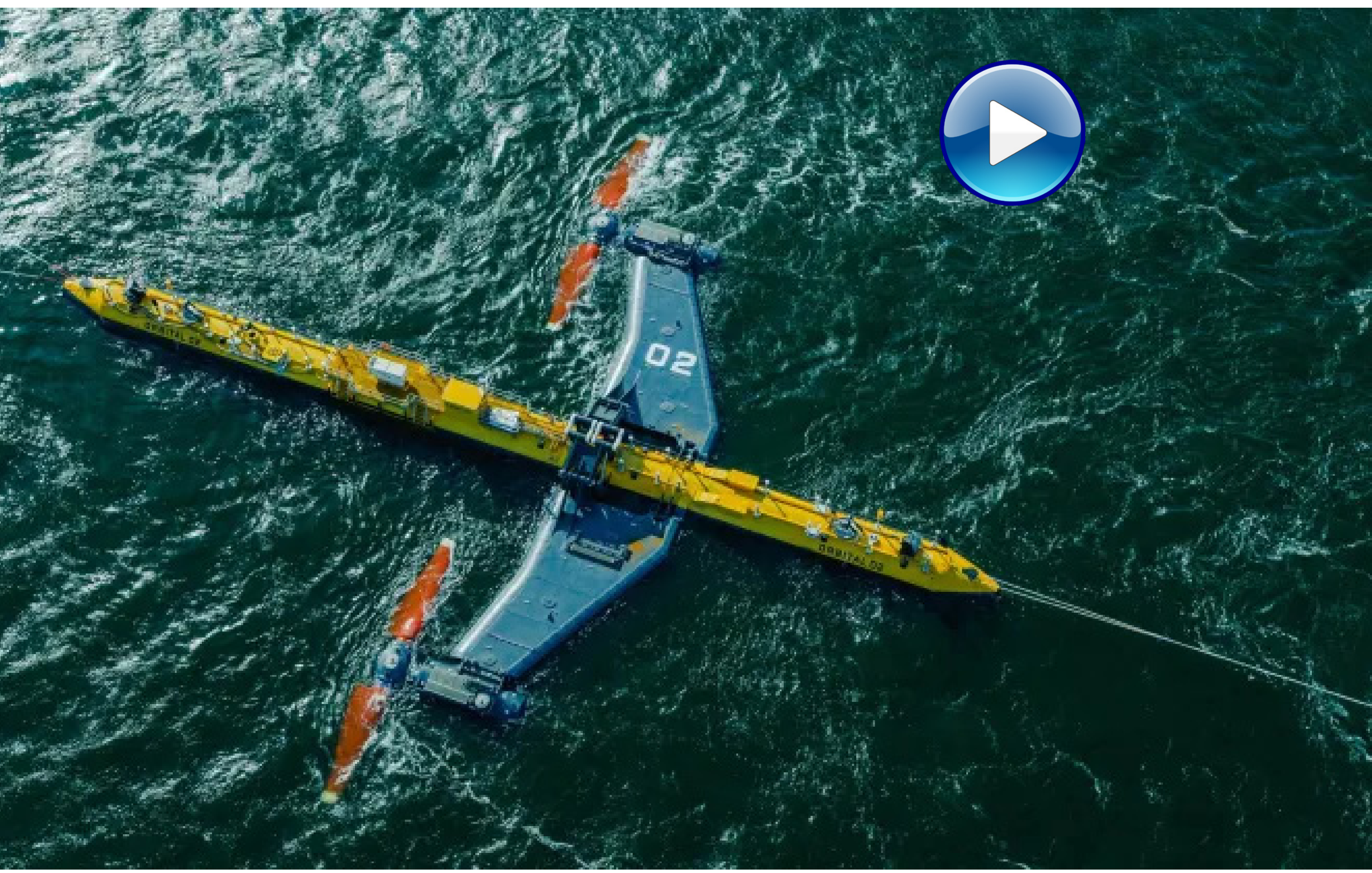
Tidal Power

by Dr. Carl Peterson

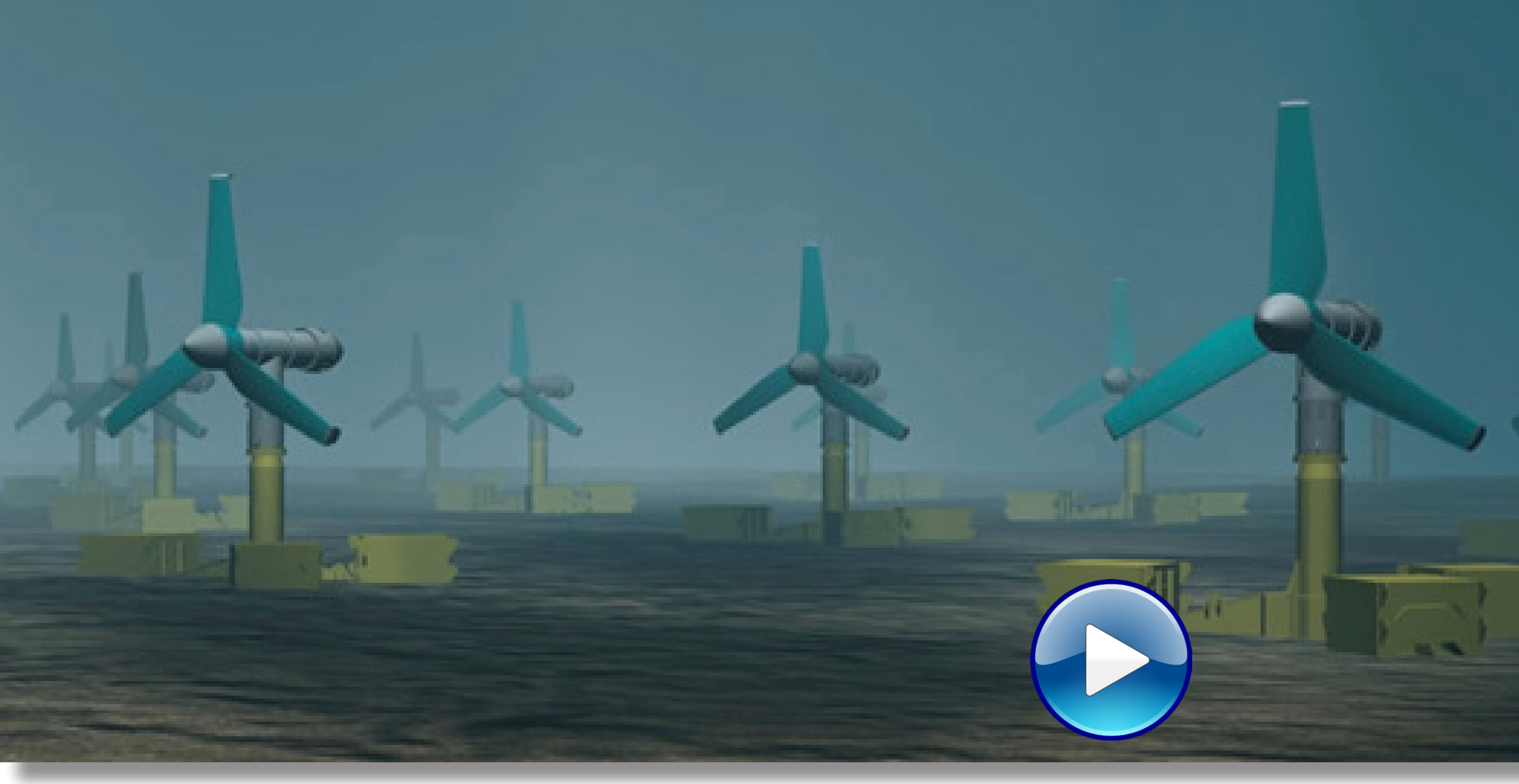
The gravitational pull of the moon and sun along with the rotation of the earth create tides in the oceans. In some places, tides cause water levels near the shore to rise and fall up to 40 feet. People in Europe harnessed this movement of water to operate grain mills more than a 1,000 years ago.

Today, there are tidal energy systems that generate electricity producing tidal energy economically within the required tidal range of at least 10 feet.

There are a number of ways in which tidal power can be harnessed. Tidal barrage power systems take advantage of differences between high tides and low tides by using a "barrage," or type of dam, to block receding water during ebb periods. At low tide, water behind the barrage is released, and the water passes through a turbine that generates electricity. Tidal stream power systems



A tidal turbine weighing 680 metric tons and dubbed "the world's most powerful" has started grid-connected power generation at the European Marine Energy Centre in Orkney, an archipelago located north of mainland Scotland.



are used around islands or coasts where these currents are fast. They can be installed as tidal fences where turbines are stretched across a channel or as tidal turbines, which resemble underwater wind turbines.

The total energy contained in tides worldwide is 3,000 gigawatts (GW; billion watts). By comparison, a typical new coal-based generating plant produces about 550 megawatts (MW; million watts).

Although total global electricity consumption approached 21,000 terawatt-hours in 2016 (one terawatt [TW] = one trillion watts), energy experts speculate that fully built-out tidal power systems could supply much of this demand in the future.

Estimates of tidal stream power—which uses ocean currents to drive underwater blades in a manner similar to wind power generation—in shallow water is capable of generating some 3,800 terawatt-hours per year.

Environmental concerns raised about tidal power stations are largely focused on the tidal barrage systems, which can disrupt estuarine ecosystems during their construction and operation. Tidal fences and turbines are expected to have minimal impact on ocean ecosystems. Tidal fences do have the potential to injure or kill migratory fish, however, but these structures can be designed to minimize such effects.

Tidal power leverages the rise and fall of oceanic tides to capture potential or kinetic energy and convert it into other energy forms, often electricity. There are two methods of harnessing tidal power. One method resembles a hydroelectric dam, called tidal barrages, and another relies on underwater turbines that have blades that rotate as water flows by, powering a generator in the process.

Tidal turbines may be installed in water sources ranging from areas with strong ocean currents to tidal streams and estuaries. They may be installed on their own, but larger energy projects commonly install connected rows of turbines, called an array. Variations in wind patterns, weather, and turbulence make it inherently challenging to predict while the benefit of tidal power is its relatively high power output. Because water is roughly 830 times denser than air, tidal or ocean currents can generate more energy per unit area than winds.

Despite these advantages and the skyrocketing demand for clean, renewable energy, tidal power hasn't taken off in the same way that solar and wind energy have. There are only a handful of commercially-operating tidal power plants worldwide, the largest of which is the Sihwa Lake Tidal Power Station in South Korea.

"The fundamental question is one of economics," says Brian Polagye, Associate Professor of Mechanical Engineering and Director of the Pacific Marine Energy Center at the University of Washington. Because of the early stage of the technology, tidal power is an expensive source of energy: according to a 2019 study, commercial-scale tidal energy is estimated to cost \$130-\$280 per megawatt-hour compared to \$20 per megawatt-hour for winds.

High upfront costs of building plants, expenses associated with maintaining machinery that can survive corrosive seawater, and the costly engineering work that goes into them make up a significant portion of that cost challenges. Much of the current manufacturing efforts associated with wind and solar power use hardware and tech that do not work in an underwater environment, so we would have to start fresh manufacturing those physical parts.

The future

Tidal power is thriving in some countries. In Scotland, a 600-ton turbine anchored right off of the Orkney Islands is already generating power. The turbine, named the O2, is projected to meet the energy demands of 2,000 homes for the next 15 years. Recently, the UK also introduced a new set of incentives that specifically support tidal energy.

The tide may also be turning globally- Countries around the world are investing in research and development around tidal and wave energy technology.

Artificial Photosynthesis

to help make food production more energy-efficient here on Earth, and beyond

By Holly Ober / University of California

pho·to·syn·the·sis
/ˌfōdōˈsinTHəsəs/

noun: photosynthesis

- the process by which green plants and some other organisms use sunlight to synthesize foods from carbon dioxide and water. Photosynthesis in plants generally involves the green pigment chlorophyll and generates oxygen as a byproduct.

Photosynthesis has evolved in plants for millions of years to turn water, carbon dioxide, and the energy from sunlight into plant biomass and the foods we eat. This process, however, is very inefficient, with only about 1% of the energy found in sunlight ending up in the plant.

Scientists at UC Riverside and the University of Delaware have found a way to bypass the need for biological

photosynthesis altogether and create food independent of sunlight by using artificial photosynthesis.

The research, published in Nature Food, uses a two-step electrocatalytic process to convert carbon dioxide, electricity, and water into acetate, the form of the main component of vinegar. Food-producing organisms then consume acetate in the dark to grow. Combined with solar panels to generate the electricity to power the electrocatalysis, this hybrid organic-inorganic system could increase the conversion efficiency of sunlight into food, up to 18 times more efficient for some foods.

"With our approach we sought to identify a new way of producing food that could break through the limits normally imposed by biological photosynthesis," said corresponding author Robert Jinkerson, a UC Riverside assistant professor of chemical and environmental engineering.

In order to integrate all the components of the system together, the output of the electrolyzer was optimized to support the growth of food-producing organisms. Electrolyzers are devices that use electricity to convert raw materials like carbon dioxide into useful molecules and products. The amount of acetate produced was increased while the amount of salt used was decreased, resulting in the highest levels of acetate ever produced in an electrolyzer to date.

Experiments showed that a wide range of food-producing organisms can be grown in the dark directly on the acetate-rich electrolyzer output, including green algae, yeast, and fungal mycelium that produce mushrooms. Producing algae with this technology is approximately fourfold more energy efficient than growing it photosynthetically. Yeast production is about 18-fold more energy efficient than how it is typically cultivated using sugar extracted from corn.

"We were able to grow food-producing organisms without any contributions from biological photosynthesis. Typically, these organisms are cultivated on sugars derived from plants or inputs derived from petroleum—which is a product of biological photosynthesis that took place millions of years ago. This technology is a more efficient method of turning solar energy into food, as compared to food production that relies on biological photosynthesis," said Elizabeth Hann, a doctoral candidate in the Jinkerson Lab and co-lead author of the study.

The potential for employing this technology to grow crop plants was also investigated. Cowpea, tomato, tobacco, rice, canola, and green pea were all able to utilize carbon from acetate when cultivated in the dark.

By liberating agriculture from complete dependence on the sun, artificial photosynthesis opens the door to countless possibilities for growing food under the increasingly difficult conditions imposed by anthropogenic climate change. Drought, floods, and reduced land availability would be less of a threat to global food security if crops for humans and animals grew in less resource-intensive, controlled environments. Crops could also be grown in cities and other areas currently unsuitable for agriculture, and even provide food for future space explorers.

“Using artificial photosynthesis approaches to produce food could be a paradigm shift for how we feed people. By increasing the efficiency of food production, less land is needed, lessening the impact agriculture has on the environment. And for agriculture in non-traditional environments, like outer space, the increased energy efficiency could help feed more crew members with less inputs,” said Jinkerson.

This approach to food production was submitted to NASA’s Deep Space Food Challenge where it was a Phase I winner. The Deep Space Food Challenge is an international competition where prizes are awarded to teams to create novel and game-changing food technologies that require minimal inputs and maximize safe, nutritious, and palatable food outputs for long-duration space missions.

“Imagine someday giant vessels growing tomato plants in the dark and on Mars—how much easier would that be for future Martians?” said co-author Martha Orozco-Cárdenas, director of the UC Riverside Plant Transformation Research Center.

Andres Narvaez, Dang Le, and Sean Overa also contributed to the research. The open-access paper, “A hybrid inorganic–biological artificial photosynthesis system for energy-efficient food production,” is available here.

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