Enjoy Science

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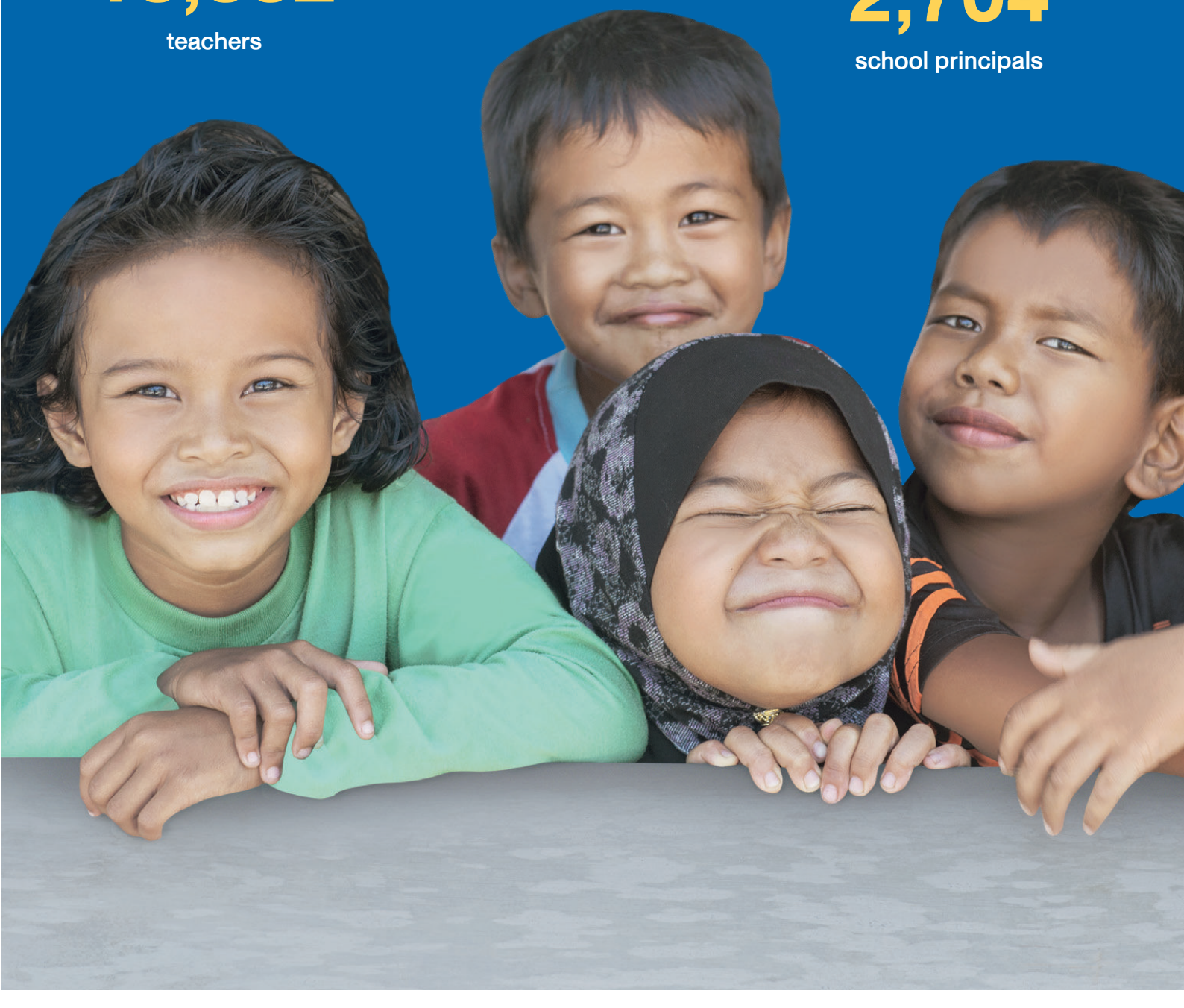
Enjoy Science Achievements

The Enjoy Science project, a collaboration between Chevron, Kenan, eight government agencies, and dozens of private sector organizations, strengthened STEM education as a foundation for Thailand's sustainable growth. Through its innovative initiatives, it inspired students, educators, and the public throughout the country.

2,385,700
students

13,332
teachers

2,704
school principals



1,000,000,000 Thai baht ($30 million)

152
government agencies

12
STEM hubs

61
vocational colleges

28
vocational colleges with Industrial Robotics classes

724
secondary schools



3,133,617
beneficiaries

5 years (2015–2020)



Change Starts in the STEM Classroom

For the children of Thailand, secondary school is a formative time, when they can explore their interests before choosing a field for further study. That's why the first priority of the Enjoy Science team was to teach STEM skills at this critical phase in their schooling, when they benefit from it most. An education in STEM broadens their horizons and opens the door to a lifetime of opportunity, appreciation, and enrichment.

As an interdisciplinary and applied educational approach, STEM encourages students to integrate learning and action to innovatively tackle challenges in real life. A successful education in STEM is demonstrated by going beyond simple academic exercises, and learning to adapt and thrive in a technology-driven world. A STEM-educated workforce pumps new energy into industries as wide-ranging as healthcare, logistics, agriculture, energy, and the environment.

It All Begins with Teachers

The Enjoy Science project encouraged teachers to become change agents who transform a passive classroom into an active learning space. Forget the static, one-way communication format of old; the Enjoy Science team fostered a new approach that encouraged students to get involved, share their ideas, ask their own questions, and find their own answers.

The Enjoy Science team worked directly with science and maths teachers in a professional development program that taught them how to turn their classrooms into lively learning labs. They trained teachers to lead inquiry-based and problem-based learning activities, and promote other high-impact instructional practices. This training was based on years of expertise developed at Kenan Foundation Asia with its partners across the globe, including the Smithsonian Institution and Activate Learning in the U.S., Tokyo Shoseki in Japan, and the Chisholm Institute in Australia.

Having worked in STEM education in Thailand for over a decade, Kenan's learning modules and materials have been adapted from international best practices and matched to meet the local Thai context and curriculum to ensure learning is fun and relevant to school as well as the real world. Kenan experts leveraged this research expertise into high-impact teaching practices focused on science, technology, engineering, and maths content. Teachers inspired and prepared "smart students" to apply a combination of communication, critical thinking, collaboration, and creativity skills to solve the challenges of the 21st century and achieve their dreams.





For example, instead of rote memorization, students in Enjoy Science classrooms explored diverse mathematics and scientific phenomena on their own terms, and saw academic concepts demonstrated in real life. Using cutting-edge materials, such as the Smithsonian's Science and Technology Concepts (STC), and high-impact practices, like problem-based learning, students work together with their classmates to advance their collaboration and critical thinking skills. STEM lessons were no longer dry textbook passages but rather dynamically integrated into students' daily lives and activities.

Meanwhile, teachers become learners too. Sharing their experiences and skills with other teachers via Professional Learning Community (PLC), a program pioneered in Thailand by Kenan and its partners, where teachers work together to improve and craft lessons that are appropriate for learners in different classrooms. In the PLC model, teachers invite their peers from neighboring schools to come and observe an open class for lesson study and to exchange best practices and ideas to support student achievement.

In partnership with 14 universities nationwide, the Enjoy Science project also established 12 "STEM hubs" at universities in all regions of Thailand to provide home bases for enriching STEM education for local schools. As knowledge centers, these hubs offered mentoring for maths and science teachers, distributed proven teaching materials, enhanced maths and science curricula, and built school networks to continuously advance STEM education.

As a result of the Enjoy Science initiative in STEM education, Thailand will keep moving forward, shifting learning from the classroom to the wider world, cultivating a knowledge-based society, and encouraging lifelong learning for all Thais.

A New Way of Learning

Opens New Doors

School principal Mr. Somchart Leungsa-ard remembers what lessons used to be like at Tedsaban 5 (Wat Hua Pom Nok) School. "The school had only one textbook, and it was outdated," he says. "Teachers would ask their students very simple academic questions to test their memory of a lecture."

But Principal Somchart has witnessed major changes at Tedsaban 5 School after participating in the Enjoy Science project. *"The program has provided our teachers with modern, up-to-date instructional media, and has changed the teacher's role from an instructor to that of a 'learning facilitator' who is able to inspire students to seek knowledge and improve their skills."* Principal Somchart also credits the Enjoy Science professional development and coaching his leadership team received for this transformation. Based on a model of school improvement promoted by Kenan Foundation Asia, the school has raised the performance of students and staff alike.

Through Enjoy Science trainings, teachers have implemented new active-learning methods. Instead of the rote memorization of old, students are now enticed to actively think for themselves and create their own work. *"The pedagogical approach of Kenan Foundation Asia and its network of partners gets students excited to learn,"* says Principal Somchart. *"It lets them have fun and fosters a natural learning process. They gain a better understanding of the course content and become more enthusiastic about their studies."*

The Enjoy Science project focused on building the capacity of junior high maths and science educators teaching grades 7 through 9. As the last stage of compulsory education in the Thai system, junior high is a crucial time for students to evaluate their skills and interests before deciding to pursue further education or enter the workforce.

Throughout the past five years, Enjoy Science systematically developed maths and science teachers by cultivating and fostering networks of change. The project also selected highly experienced "master teachers" to receive direct trainings on cutting-edge instructional tools and pedagogies from global experts. These master teachers then extended the trainings to other local teachers through project workshops and Professional Learning Community (PLC), a program pioneered in Thailand by Kenan and its partners. Over the five-year span, the project trained approximately 11,500 teachers, allowing over 1,190,000 students to experience a new and dynamic way of learning.

Principal Somchart believes Enjoy Science pushed Thailand's science education in the right direction.

"The world is moving forward at a very fast pace. If we do not prepare our students, they will be left behind," Principal Somchart suggests.

He thinks the support from the Enjoy Science project couldn't have come at a better time to develop new ways of thinking and learning. *"In my view, it is the right way to prepare learners to be ready for the future."*



Somchart Leungsa-ard
Principal
Tedsaban 5 (Wat Hua Pom Nok) School

The pedagogical approach gets students excited to learn. It lets them have fun and fosters a natural learning process. They gain a better understanding of the course content.



Krissada Karaket
Mathematics Teacher
Takuapa Senanukul School

When I run the class using the new teaching method, students are more engaged. They enjoy the class and are eager to know what they will learn next.

Making Maths a Part of Life

"Although maths is a crucial foundation for engineering and technology, students often struggle to connect maths concepts to their daily lives," explains Mr. Krissada Karaket, a mathematics teacher from Takuapa Senanukul School in Phang-nga province.

"It's abstract by nature. In order to engage students, maths teachers must connect mathematical concepts to real life — only then can students see the relevance to the world around them."

To help his students better connect to mathematics, Mr. Krissada joined Enjoy Science's master teacher professional development program, where he received training from an international partner of Kenan Foundation Asia, Dr. Makoto Yoshida, director of the Center for Lesson Study (CLS) at William Paterson University.

Dr. Makoto specializes in improving mathematics teaching and learning through lesson study, a term he coined in his doctoral dissertation by translating the original Japanese word "jugyō kenkyū". Lesson study centers on the development of students' critical thinking, systematic thinking, and problem-solving skills. Dr. Makoto has developed lesson study as a core approach in the professional development of teachers, and he is considered one of the foremost researchers and educators of lesson study in the U.S.

Mr. Krissada says lesson study involves teaching mathematics by using everyday items students can relate to. *"For example, when teaching how to calculate the surface area of a sphere, I might start from a simple question such as, 'How many oranges do we need if we want a specific amount of orange peels for making herbal medicine?'"*

He'll let students draw circles around the oranges, and fill them up with orange peels. *"After pointing out the relationship between the diameter, center, and radius, we calculate the surface area of the sphere with a formula."*

In Mr. Krissada's class, students are encouraged to think and share their ideas while tackling mathematical problems. Group discussion, which is still rare in Thai maths classes, enhances their critical and analytical thinking skills. Furthermore, it makes the classroom livelier and more colorful.

"So far, I've noticed some changes, especially in the students who used to be desperate for maths class to be over," says Mr. Krissada, with a grin. "When I run the class using the new teaching method developed by Enjoy Science, the students are more engaged. They enjoy the class and are eager to know what they will learn in the next session."

Mr. Krissada's role as a master teacher does not end in his own classroom. He is responsible for passing on his knowledge and experience to other maths teachers as a part of the Professional Learning Community (PLC) program.

"Being a master teacher is a challenge," Mr. Krissada adds. *"I have to prove why the new method is the most practical way to teach mathematics in our classrooms."* By using techniques he learned from Dr. Makoto, that should be easier than ever before.

STEM Hubs

Create Centers of Learning and Teaching

The Enjoy Science project launched 12 STEM hubs in universities based in each region of Thailand as part of a concerted effort led by Kenan Foundation Asia to create a coalition of educators devoted to improving STEM education across the country.

As a member of the Faculty of Education at Chiang Mai University, Assistant Professor Dr. Natcha Kamol uses the resources and networks provided by the STEM hub at her university to support her training of new teachers. Her job is to prepare her students who will go on to shape future generations as teachers.

"I always tell my student teachers that you don't just stand in front of the classroom — teachers have to get closer to the students to evaluate the real situation," says Dr. Natcha.

"We have to check the learning progress of each student. If one student asks 'Teacher, is it correct?', we don't respond 'yes' or 'no'. Rather, we ask the student, 'What do you think? Please share your thoughts. Let me see if you truly understand or not.'"

At the STEM hub in Chiang Mai University, Dr. Natcha has formed a rich network of master teachers and mentors who are available for providing advice to local schoolteachers and undergraduate students studying to become teachers. She also helps teachers design and develop interactive lesson plans to engage students. This holistic approach was fundamental to Kenan's overall approach to ensure the sustainability of the STEM hub program by embedding change within the university system.

"In addition to trainings at the STEM hub, we plan lesson activities together and assist teaching students running a maths camp," adds Dr. Natcha. *"Science teachers from other schools can borrow our equipment or consult us for advice on pedagogy."*

Dr. Natcha believes that teachers are the first line of change in transforming classrooms into creative spaces for learning. They know best each student's passion and progress, and which pedagogical techniques can be adapted to fit students' learning styles and needs.

"Teachers play a very important backstage role," Dr. Natcha informs. *"We say learners are at the center of the learning process, but teachers face the challenge of facilitating the learning. How can we design an activity that produces a 'wow' effect on children, and makes them want to solve problems and learn?"*

At the STEM hub, change is on the horizon, with teachers coming together, and receiving guidance from experienced model teachers and university lecturers, to form educational communities tailored to the unique context of each school. Working together, teachers can turn classrooms into spaces for creativity that prepare students to not only passively absorb knowledge, but also to actively create knowledge and apply lessons for solving problems in their daily lives.

As Dr. Natcha wisely says, *"When children can learn on their own, the knowledge will stay with them forever."*



Asst.Prof. Dr. Natcha Kamol
Faculty of Education,
Chiang Mai University

**If one student asks 'Teacher, is it correct?',
we don't respond 'yes' or 'no'. Rather, we ask the student,
'What do you think? Please share your thoughts.'**



Wanna Fuangfoo

Mentor

Chevron Enjoy Science Project

I was in a classroom and saw students laughing while they were learning. They could understand the concepts, and the lesson was fun. I was so happy for them.

Mentoring
Makes STEM Better

A classroom can be a stage, where teachers craft a creative performance that engages students in learning. But even teachers can get stage fright. That's where a mentor can help.

Ms. Wanna Fuangfoo is a science mentor, a former teacher who is one of well over a hundred experienced and accomplished educators in the Enjoy Science project supporting teachers on and off the classroom stage.

"The duty of a mentor is to assist teachers. To do so, we have to foster a good relationship with both school management and teachers themselves. We have to create trust," Ms. Wanna says.

She helps teachers improve every step of the way, from lesson preparation to teaching techniques. Sitting in on classes and sharing her insights, she draws from 30-plus years of classroom experience.

"We want everyone to understand that we do not come to evaluate them but to help them develop. That's why fostering trust is paramount. We are there to provide academic consultation, recommendations, and support," informs Ms. Wanna, or 'Aunty Wanna' as she is known by many teachers.

"What we really are is a mirror that reflects the teacher's instructional process back to them. When a teacher is in front of a classroom, they don't know what each student is doing. So, we jot down students' behaviors to discuss with the teacher later on," Ms. Wanna adds.

Another important role for mentors is to help teachers open up about their own teaching. To improve, teachers must be willing to hear feedback, positive or negative. Ms. Wanna emphasizes the most important thing to know is whether students have met their learning goals.

"Have students reached their objectives? What are those objectives? Is there any proof to show that the students have actually reached them? These are the types of questions that we urge teachers to reflect on," Ms. Wanna explains.

When Ms. Wanna first began asking to observe teachers' classes, most declined, saying they were busy. These days, things are completely different.

"After the first year, I never had to reach out for an appointment," says Ms. Wanna. *"The teachers all said 'Aunty, please come here quickly!' because they enjoyed having someone to advise them. They could see how their improvement was enhancing their students' enjoyment of learning and increasing engagement in the class."*

When asked about the most joyous moment of being a mentor, Ms. Wanna smiled.

"When I was in a classroom and saw students laughing while they were learning. They could understand the concepts, and they laughed because the lesson was fun. I was so happy for them."

Teacher Development

The Key to Our Future

The most important variable in the improvement of student learning is the teacher. Instead of urging students to memorize content and pass exams, teachers must actively find ways to motivate them to connect what they learn in a classroom with the world around them.

"We want to educate students in the kind of thinking that will help them thrive in the future," says Associate Professor Dr. Montree Yamkasikorn, Advisor for the Teachers' Council of Thailand, or Khurusapha, a government organization under the Ministry of Education dedicated to developing the teaching profession.

Dr. Montree believes that STEM education, which takes an interdisciplinary approach to learning, helps students develop these types of critical thinking muscles.

"STEM is more than scholastic content. As an interdisciplinary education, it's a way of life," informs Dr. Montree.

The Teachers' Council of Thailand teamed up with the Enjoy Science project to enhance teachers' instructional practices and skills through Professional Learning Community (PLC) that encourage this kind of learning. PLCs are networks of educators and mentors who support teachers and provide feedback.

"The process of PLCs could be a prototype for teacher development nationwide," says Dr. Montree. *"When we see a teacher able to raise children's competencies, such as science literacy, critical thinking, systematic thinking, and problem solving, we recognize them as successful."*

Dr. Montree believes that STEM education provides a way for students and teachers to embrace these essential skills.

"The bright side of STEM education as developed by Enjoy Science is that it trains teachers to teach students to think," suggests Dr. Montree. *"It isn't easy. Teachers must be calm and patient in initiating inquiries to engage children's curiosity. They must mentor students and seek different ways to encourage them. STEM is a great teaching and learning model for that. If we can use it to develop Thai children, I know our country will grow more competitive in the global arena."*

Dr. Montree added that one of the strengths of the project is the proven success of new PLCs pioneered by Kenan and expanded in partnership with the Teachers' Council of Thailand.

"The professional learning and development process helps teachers to become more confident in their own teaching skills. They have experts assisting them with feedback on their classroom teaching, as well as a team of colleagues with whom to discuss and reflect on their questions and thoughts. This coaching and mentoring function will develop teachers into professional teaching experts. The program has had an undeniable impact on Thai teaching professionals. This is what Thailand needs. This is the art of teaching — enabling teachers to refine their skills and apply them for the best possible benefit of their students."

Kenan's efforts to embed the project's PLC practices into Khurusapha's work with schools across Thailand is helping to ensure the sustainability of the Government of Thailand's approach to education.



Assoc.Prof.
Dr. Montree Yamkasikorn
Advisor
Office of the Secretary General,
Teachers' Council of Thailand

STEM is a great teaching and learning model.
If we can use it to develop Thai children, I know our country will grow more competitive in the global arena.



TVET Teaches the Technicians of Tomorrow

In this era of disruptive technology, there will be an increasing demand for workers with multidisciplinary and adaptable skills who can learn and develop as the workplace evolves and the labor market adopts ever-changing technologies.

Vocational education is vital to preparing technicians for the needs of modern industry in today's world economy. That's why a major pillar of the Enjoy Science initiative was a concentration on Technical and Vocational Education and Training (TVET). While STEM education in secondary schools teaches students to think critically and apply creativity to problem-solving, TVET readies students to work with technology and apply their technical knowledge to a variety of applications.

Training new generations of technicians to work with flexibility and adaptability in future market sectors and industries requires a well-planned strategy and far-ranging implementation. The Enjoy Science team accomplished this mission by establishing "TVET hubs" in six major industrial zones across Thailand.

To achieve this ambitious plan, Chevron and Kenan Foundation Asia partnered with numerous private and

public sector organizations, including the Office of the Vocational Education Commission (OVEC), Office of the National Higher Education, Science, Research and Innovation Policy Council (NXPO), and Department of Skill Development (DSD).

TVET hubs focused on four major industrial groups — automotive parts, energy, microelectronics, and food processing — all of which are part of the government's Thailand 4.0 strategy. Each hub was responsible for facilitating new curricula, materials, and training for lecturers, educators, and students that are modern and contextualized for Thai industries. The hubs also formed platforms for private sector companies to participate directly with local vocational institutions to prepare students for real work on the job.

In cooperation with various government agencies, including OVEC and NXPO, the Enjoy Science project set up a committee to select internationally acclaimed STEM learning materials that would translate well to the Thai context. For science education, the Active Physics curriculum, developed by a team of experts in the United States, was identified as a global best practice, while the Interactive Maths curriculum was selected for maths education. Both were chosen by a top-level local panel of government, industry, and academic experts for their ability to illustrate complex abstract mathematical ideas through hands-on activities. Translated, distributed, and implemented in Thai schools, the new curricula came with learning kits, teaching aids, and a professional development program for teachers conducted by leading Thai and international educators.

TVET hubs organized workshops to engage a vast network of education stakeholders: vocational teachers considered "master trainers" chosen from a pool of outstanding classroom instructors; mentors who are veteran teachers advising on individual teacher development; and university education experts from academia. All of these educators work in concert to drive the development of STEM learning.

The Enjoy Science vocational teacher training course encouraged educators to motivate students to learn, think analytically, experiment, and solve problems on their own. After the training, lecture-based classrooms turned into active learning sites through project-based learning, where students had the opportunity to perform scientific and mathematical processes themselves and directly apply theories in action. As a result, students emerge better prepared to apply science and maths concepts in the industrial workplace as well as their daily lives.

To bridge the gap between schools and industry, the project promoted workplace training programs and short-term courses to familiarize students and professors with new industrial skills. By creating a network of sustained dialogue between technical teachers and industrial workers, professors can stay up to date with the skills most needed for today's S-curve industries. An industrial robotics curriculum, developed by the project, lent state-of-the-art robots to technical colleges, allowing students to learn through hands-on work with real machines used in the field.

A good TVET education provides vocational workers with hard skills based on science and mathematics knowledge, as well as communication, collaboration, management, critical thinking, and other crucial soft skills. These qualities are necessary for the cutting-edge industrial personnel who will drive the future development of Thailand's economy.



Learning
to Love Maths

Napalinchanok Chaiprasert, a mathematics teacher at Chiang Rai Technical College, emphasizes the importance of mathematics in technical and vocational training.

"*Maths enables students to visualize their thoughts clearly, from concrete to abstract,*" says Ms. Napalinchanok. *"Maths applies directly to their future jobs. For example, engineers must understand trigonometry to measure the height of a building."*

Unfortunately, however, Ms. Napalinchanok says many students tend to overlook the beauty of maths. *"They even view it as boring and meaningless."*

Like Ms. Napalinchanok, the Enjoy Science program also recognized the primary importance of mathematics for future workforce development, which is why it worked to strengthen STEM curricula in technical and vocational education. The program began by building the teaching capabilities of maths teachers at technical colleges through teacher professional development workshops — organized by Kenan Foundation Asia and international partners — utilizing the internationally recognized Interactive Mathematics Program (IMP) curriculum.

Ms. Napalinchanok adds the professional development transformed her classroom. *"My classes used to be dead silent, even though I prodded them with questions. Sometimes their eyes wandered off, staring out the window. It was clear that maths was torture to them. My voice may as well have been the wind blowing by,"* Ms. Napalinchanok jokes.

But now, she says, everything has changed. *"As soon as I began implementing new active-learning techniques, the students got excited about mathematics."*

Surprised when told not to open their textbooks, Ms. Napalinchanok's classes became engaged with the Interactive Maths Program instructional practices she employed. Hands-on learning toolkits encouraged them to be inquisitive and get involved.

"Today, when I enter a classroom, students greet me with anticipation, wondering what I have in store for them. I used to be the only one in the class who talked, but now students working in groups discuss the material with me at length." Ms. Napalinchanok says this kind of exchange enhances teacher-student interaction. *"Sometimes, they ask me unexpected questions that I do not have the answer to. I tell them I will go figure it out!"*

She went on to explain that the Enjoy Science project showed teachers and students that maths classes do not have to be dreary and tedious. As she adapted her teaching techniques, students changed their learning styles.

"The teacher was previously the sole speaker while students passively listened. After implementing STEM education, teachers actively listen to their students more, and students speak up often. I can clearly see that my students are now much happier and more willing to learn. If I can start their mornings with my teaching, I feel that I can make them happy for the rest of the day. I love the look in their eyes. It shows that they are interested in maths and eager to learn more."



Napalinchanok Chaiprasert
Mathematics Teacher
Chiang Rai Technical College

After implementing STEM education, teachers listen to their students more, and students speak up. I can clearly see that my students are now much happier and more willing to learn.



Asst.Prof. Adisak Jitphusa

Faculty of Science and Technology,
Rajamangala University of
Technology Srivijaya

When we support (students) with STEM education through the Active Physics curriculum, which promotes learning by doing, students can clearly see the relationship between their studies and future employment and get excited about it.

Enlivening the Science Classroom

with Active Physics

Many Thai students pursue the vocational path to avoid studying maths and science, which are compulsory in the general education curriculum. Curiously, they do not realize these subjects are vital in forming the foundation of their engineering and technical skills.

However, a cutting-edge interactive curriculum called "Active Physics" — brought to TVET hubs across the country by Chevron, Kenan Foundation Asia, and their technical partners — is inspiring students in vocational training classrooms to acquire the skills and knowledge necessary for the era of technology known as Industry 4.0.

"It is widely understood that vocational students possess great technical skills, but they can lack a clear thought process," says Mr. Adisak Jitphusa, Assistant Professor at Rajamangala University of Technology Srivijaya in Songkhla province. "When we support them with STEM education through the Active Physics curriculum, which promotes learning by doing, students can clearly see the relationship between their studies and future employment and get excited about it."

At the TVET Hub in Srivijaya, Asst.Prof. Adisak introduced teachers to the Active Physics curriculum, which uses learning materials developed by education experts from the United States to pioneer a new way of comprehending physics through both Project-Based Learning and Inquiry-Based Learning.

In this curriculum, technical teachers begin each lesson with an experiment and encourage students to discuss and reflect on the outcome under their guidance and direction. The physics concept underlying the experiment is then introduced to explain and elaborate on the phenomena students have just witnessed.

In this method, teachers instruct each student to create at least one invention, using their knowledge in physics, science, and mathematics, as well as their creative inspiration. This approach has helped to revolutionize science teaching in approximately one quarter of all vocational schools across Thailand and has set a new standard for connecting science learning to daily life and the world of work.

"Generally, vocational students hate maths and science," Asst.Prof. Adisak adds. "But when we introduce them to Active Physics, they have so much fun!"

He points out that one of the typical weaknesses of vocational students is that they are too shy to present to the class. "But with Active Physics, they discuss and actively answer questions, which brings a good measure of liveliness to the classroom. More importantly, it creates learning by solving problems, which triggers reasoning and logic. They can then apply this higher-order learning to solving problems in daily life or in workplace, thereby achieving the entire aim of vocational technical training."

Meet Your New Coworkers

Robots

Thai people working alongside robots may sound like science fiction, but it's happening right now, and given the pace of technological development, it will become the norm sooner than we think. By the year 2025, humans and robots could work in tandem to mobilize Thailand toward greater competitiveness through the coming era of technology called Industry 4.0.

The Enjoy Science project saw the necessity of preparing Thai workers for the fourth industrial revolution by enhancing teaching methodologies and training technical students in industry-relevant skills.

During the five years of Enjoy Science, the project provided teacher professional development trainings, teaching packages, and 28 industrial robots (ABB IRB 120 model) to technical colleges across Thailand, a mammoth undertaking. A six-axis robotic arm, commonly used in S-curve industries, was installed in schools for industrial robotics classes so that students could develop hands-on experience with intelligent automation. This was the first time an industrial robot and supporting software and materials were systematically rolled out in the technical vocational college system.

Mr. Somphob Chantra, an industrial robotics teacher at Surin Technical College, was eager to join the project. *"Before the arrival of the project's industrial robot arm, my students learned the fundamentals of industrial robots from a mockup that couldn't even move,"* says Mr. Somphob. His college only had obsolete models that were in bad shape or not functional. Sometimes students had to learn solely from YouTube tutorials. What's more, many teachers lacked experience with modern industrial robots, leaving students without essential knowledge.

"A real robot in the industrial robotics class was an enormous upgrade. It served as a springboard for our class in terms of instruction. The students are now very enthusiastic and eager to learn," says Mr. Somphob. *"Enjoy Science also helped me enrich my industrial robotics lesson plans."*

The Enjoy Science curriculum emphasized project-based learning, where students discovered how to control industrial robots through group work and self-motivated instructional approaches. Students learned by questioning, trying to find answers, practicing robot control skills, and using simulation programs.

"Knowing that a robot arm is best at doing repetitive tasks, some students had fun designing a program to make it pick up several pieces of coconut rice cake," Mr. Somphob informs. *"They first had to learn how the robot works: What type of grippers do they need? How do you commission robot arm motion with accuracy to optimize its effectiveness?"*

According to Mr. Somphob, the knowledge, skills, and experience students gained from working with industrial robots in class boosted their confidence. *"Now, they'll be fully prepared to work with their robot 'colleagues' in the not-too-distant future."*



Somphob Chantra
Industrial Robotics Teacher
Surin Technical College

A real robot in the industrial robotics class was an enormous upgrade. It served as a springboard for instruction. The students are now very enthusiastic and eager to learn.

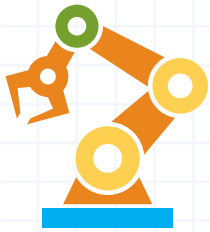


Dr. Chatkaew Hartrawung
Managing Director
Thai Summit Automotive Co., Ltd.

Thailand will continue to need highly skilled personnel in robotics system integration. Technical and Vocational Education and Training (TVET) is the key to helping them reach their full potential in designing efficient industrial robots.

Transforming

Technical Students into Innovators



Many Thai people worry that factory workers may soon be replaced by industrial robots. Indeed, manufacturing plants in the automotive, electronics, and medical industries have brought more and more artificial intelligence (AI) and automation into their workplaces, sparking fears of job losses.

Dr. Chatkaew Hartrawung, Managing Director of Thai Summit Automotive Co., Ltd., thinks differently. Acting as an advisor for Enjoy Science's Technical and Vocational Education and Training (TVET) Automotive Hub, Dr. Chatkaew sees the adoption of automation as a great leap toward the new economy.

"I am not at all worried that people will be replaced by industrial robots. Any repetitive jobs should be done by robots! Thailand cannot escape the middle-income trap by cultivating only wage labor in the industrial sector. We should be innovators and technology inventors who create efficient and reliable automation systems," Dr. Chatkaew says. Indeed, this concept is at the heart of the industrial component of Thailand's 4.0 strategy.

An expert on industrial robots and automation, Dr. Chatkaew adds that this technology is designed for hazardous, unhealthy, or monotonous jobs few people would want. *"Humans, on the other hand, should focus on developing knowledge and high-level technical skills to master the systems that control the robots or inspect products to ensure quality."*

Dr. Chatkaew knows as well as anyone that TVET institutes are in need of a curricular makeover to catch up with the next wave of industries. He firmly believes a STEM-educated workforce with high-level technical skills is necessary to drive Thailand toward the fourth industrial revolution, otherwise known as Industry 4.0.

In the next five to ten years, the robotics industry is projected to grow considerably in Thailand. Krungsri Research, under the Bank of Ayudhya, found that Thailand, as a manufacturer and exporter of robotic parts, generated an export value of over US$9.2 billion in 2018.

"It's evident that Thailand will continue to need plenty of highly skilled personnel in robotics system integration. Technical and Vocational Education and Training (TVET) is the key to helping them reach their full potential in designing efficient industrial robots," says Dr. Chatkaew.

Enjoy Science's TVET initiative made important strides toward meeting the needs of the knowledge-intensive economy, according to Dr. Chatkaew. The project developed programs — such as Active Physics, Interactive Maths, and an industrial robotics curriculum — that equipped students with knowledge, skills, and much-needed hands-on experience. Academic concepts, especially maths and science, were augmented by systematic thinking and teamwork skills in lesson activities.

"Learning maths and science in this way is vital to enabling students to transition from being a user to being an innovator," says Dr. Chatkaew. *"We thank Enjoy Science for introducing its cutting-edge training programs in technical colleges. They help ensure the smooth development of the industrial sector. After the Enjoy Science project, I would like this platform to continue expanding its scale to impart high-level skills and knowledge for technical students."*

Project Evaluation

The Enjoy Science project evaluation report is the largest, most comprehensive monitoring and evaluation effort conducted for a Thai education project. Through a competitive selection process involving applications from more than 16 organizations, Kenan Foundation Asia engaged an international team of evaluators and researchers to rigorously and quantitatively measure the Enjoy Science project's impact on the development of STEM and TVET education in Thailand. Data were collected over three points in time, comprising a baseline, midline and endline evaluation that measured changes over the project's five-year period.

Key findings from the study indicate that student participation and confidence in studying science and mathematics have increased significantly in participating schools. Technical students feel more confident about entering the industrial workplace. Teachers were able to better manage student learning, and students reported having more fun in class.

The evaluation's success was achieved with the help of international partners, including the project evaluation experts from Management Systems International (MSI), a leading U.S. evaluation firm. MSI was chosen from 16 organizations worldwide that submitted proposals to serve as the project's third-party evaluator. Additionally, the contributions of the National Research Team (NRT),



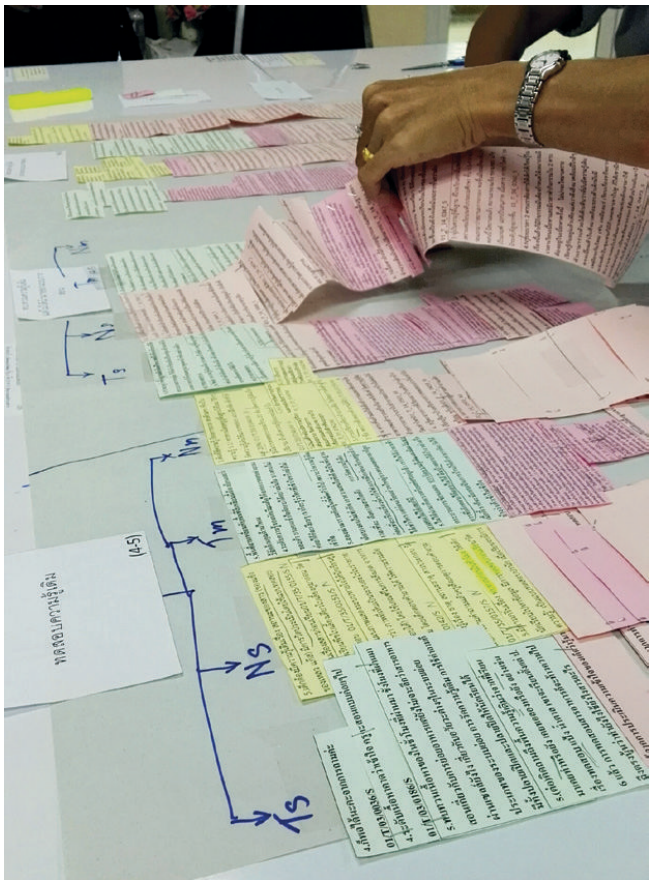


comprised of STEM and TVET education experts from 16 universities across Thailand, proved invaluable.

The evaluation compares “intervention schools/colleges” (secondary schools and vocutional colleges that received Enjoy Science support) with “comparison schools/colleges” (secondary schools and vocational colleges without Enjoy Science support) that are of similar size, location, and range of O-NET and V-NET scores, to ensure the fairest comparison.

The evaluation also benefited from the input of Thai educational institutions, including Thailand Science Research and Innovation (TSRI) and other national experts.

The training and development of the professors and researchers comprising the NRT will prove an invaluable resource for Thailand, as the NRT expertise now represents the leading group of education research experts in the country. Kenan Foundation Asia encourages policymakers and private sector stakeholders to use this project evaluation and the NRT to continue developing the Thai educational system to prepare students for the modern workplace and a brighter future.

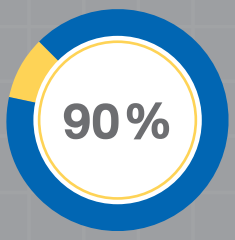


Study Results and Conclusion

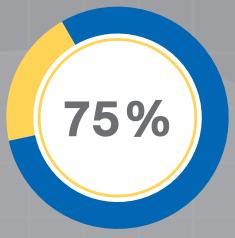
The endline report reveals significant improvements in both secondary schools and technical and vocational colleges since the project's initiation in 2015. STEM teachers have adopted active-learning techniques and problem-based lesson plans and increasingly urge students to independently solve problems with their own initiative. Enjoy Science was successful in implementing its objectives with STEM and TVET education, helping the nation of Thailand prepare for the Industry 4.0 era.

STEM

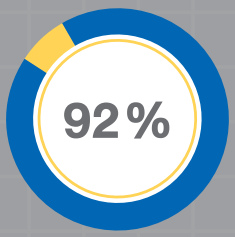
Students



enjoy learning mathematics

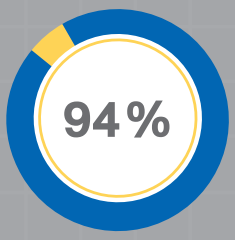


perceive the importance of learning science and maths

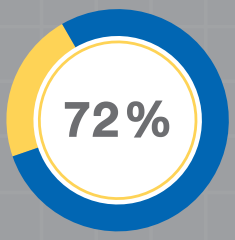


on task and engaged throughout the class

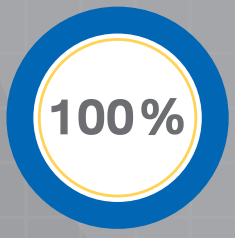
Teachers



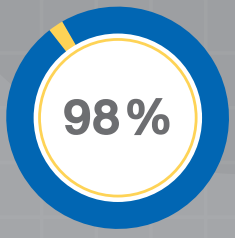
implemented inquiry-based lessons



implemented inquiry-based lessons and adopted teaching methods focused on group participatory learning



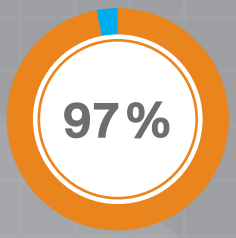
connected lessons to students' daily lives



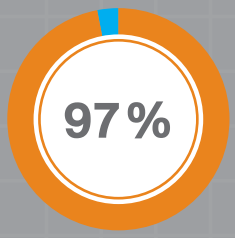
applied knowledge and experience acquired from Professional Learning Communities (PLCs) to improve teaching methods

TVET

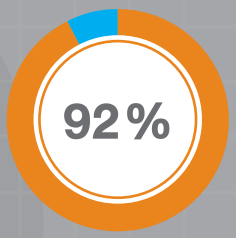
Students



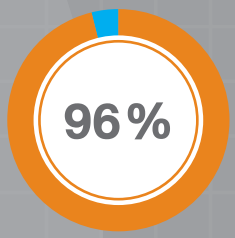
enjoy learning science



intend to apply scientific concepts to daily life, future careers, and higher education



improved problem-solving skills

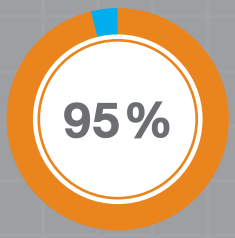


gained technical skills in software simulation, robot arm operation, and resolving problems with industrial robots

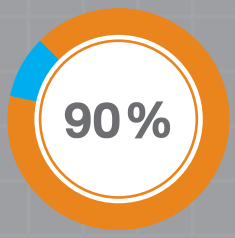


confident in applying teamwork and problem-solving skills in the workplace

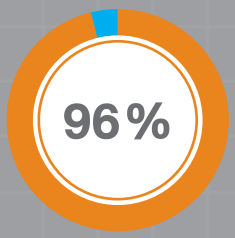
Teachers



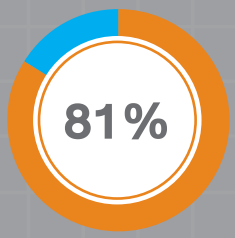
observed that students enjoy learning science



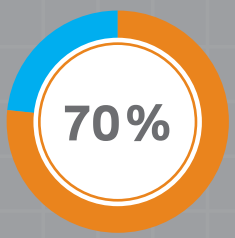
connected scientific concepts to students' daily lives, workplace, higher education, and/or future profession



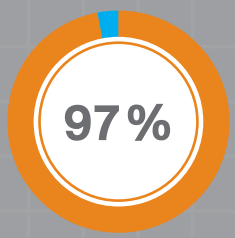
facilitated participatory learning in groups and encouraged group brainstorming



of maths teachers adopted Active Learning techniques such as problem-solving and inquiry-based lessons



of technical teachers focused lessons on programming and controlling industrial robots in the workplace to ensure students' readiness to work in the industry



of technical teachers included hands-on practices utilizing industrial robot simulation software and robot arms in lessons to prepare students for the work in the industry



Inspiring a Society of Lifelong Learning

The Enjoy Science project, in collaboration with a diverse network of partners, developed engaging STEM activities and programs for broader society to enjoy. Informal education allows people to gain a wider appreciation for how STEM helps us navigate daily life in the 21st century.



Chevron, Kenan Foundation Asia and all Enjoy Science partners firmly believe that learning should not be confined to a classroom — rather, learning has the potential to move Thailand toward a more knowledgeable and innovative society, one based on science, technology, engineering, and mathematics. Therefore, one of the main objectives of the Enjoy Science project was to raise awareness of STEM and its far-reaching importance in all corners of Thai society.

In addition to promoting the public profile of STEM education among youth, parents, teachers, and students in both secondary and vocational schools, the project also created extensive STEM learning spaces outside the classroom, including activities designed for people of all ages, with an aim to instill the love and understanding of science in every Thai citizen. That kind of passion is important for fostering the lifelong learning that inspires young people to pursue STEM education and consider STEM careers, as well as to nurture the growth of a "maker culture" in Thai society.

Indeed, the Enjoy Science project created a learning ecosystem that engaged educational stakeholders, from students, parents, and teachers, to the institutions of schools, government, and business. It called forth an unprecedented level of government investment in the country's educational and technological infrastructure. To form an open, inquisitive, educated, and capable society for all, people must be willing to cooperate in creating learning spaces and activities wherefrom everyone can benefit, and wherein all can take part.

Over the past five years, the Enjoy Science project engendered programs across the nation to bolster STEM education for all. With a focus on inspiring students to pursue STEM careers, and building a broader culture of innovation, activities opened STEM learning to all age groups and every walk of life.



Igniting Thailand's "Maker Culture"

The Enjoy Science project teamed up with world-renowned institutions to inspire Thais to apply their ingenuity and pursue their own inventions as a part of a "maker culture."

For example, the project teamed up with the internationally acclaimed New York Hall of Science to design Enjoy Maker Space, an exhibit that promotes engineering activities for elementary school youth. Correspondingly, the program collaborated with the Museum of Science in Boston to implement Enjoy Design Challenge, another festival event.

Across Thailand, the project partnered with the National Science and Technology Development Agency (NSTDA), the National Science Museum (NSM), and the Office of the Vocational Education Commission (OVEC) to launch four generations of the Young Makers Contest, innovation competitions for both general education track and vocational track students. Contest themes ranged from "inventions for the elderly and physically impaired" to "inventions for community safety" and "innovation for a sustainable society."

Finalists of the Young Makers Contest were invited to Maker Faire Bangkok, Southeast Asia's largest exhibition of maker culture, drawing more than 36,000 participants. Maker Faire Bangkok showcased over 100 inventions from Thai and foreign makers. Winners of the Young Makers Contest received a scholarship and chance to attend Maker Faire Bay Area in San Francisco, Maker Faire London, and other notable global maker faires.

Pursuing
“Enjoy Science Careers”

The “Enjoy Science Careers” traveling exhibition was designed in collaboration with National Science Museum (NSM) to encourage interest among youth toward STEM careers. By showcasing various STEM professions that have brought exciting innovation and advancement to Thai society, exhibition activities gave participants a glimpse of what experts do in such fields.

The traveling exhibition had three editions, showcasing 24 careers over the years, including petroleum geologist, drug analyst, food scientist, biomedical engineer, cosmetic scientist, software developer, data scientist, satellite engineer, robotics and automation engineer, and investment analyst. The exhibition also highlighted a hugely popular inventor who turns garbage into products, and modern farmers who use technology to cut costs, reduce labor, and increase income. The exhibition was part of the NSM’s traveling “science caravan” that reached over 700,000 students in provinces with less educational resources across the country.







Never Too Young for Science at the “Children’s University”

During HRH Princess Maha Chakri Sirindhorn’s visit to Shanghai in 2010, she learned of a highly successful “Children’s University” program at the Shanghai Institutes for Biological Sciences. Inspired, HRH Princess Sirindhorn resolved to launch a Children’s University in Thailand.

In 2011, the Thailand Children’s University (TCU) was born. Within this learning initiative, Enjoy Science developed projects for elementary and junior high school students that enable them to participate in challenging scientific experiments under the guidance of university student mentors. These projects were only possible through the collaboration of such partners as the Institute for the Promotion of Teaching Science and Technology (IPST), National Science and Technology Development Agency (NSTDA), Office of the Basic Education Commission (OBEC), Thai universities, and the German Academic Exchange Service (DAAD).

Guided experiments in an informal learning setting allow students to ask questions and find answers independently, igniting a passion for learning that may inspire them to pursue STEM careers that will help propel Thailand’s industries into the future.



Asst.Prof.
Dr. Rawin Rawiwong
President
National Science Museum

We worked as one team to create these activities together from the beginning. I believe the collaboration will have a positive impact on every sector of our society.

Sowing the Seeds of STEM Education

Even as Thai schools have begun to adopt STEM modules into their classroom environments, STEM isn't necessarily confined within a four-walled classroom. The Enjoy Science project teamed up with various sectors of Thai society to bring awareness of STEM education to the public. These initiatives give everyday people and policymakers alike a chance to experience a new approach to learning STEM that raises understanding to a new level.

The National Science Museum (NSM), a major partner of the project, helped sow the seeds of the future by creating maker spaces for innovation and inspiration. Specifically, NSM's Enjoy Maker Space is a platform for young people to awaken the inventor within, encouraging them to bring their own ideas to life. Such spaces can kindle a lifelong love of learning and promote a shift from a Consumer Society to an Inventor Society.

"All children have a maker spirit within them," says Assistant Professor Rawin Rawiwong, President, National Science Museum. *"They only need a space to create and showcase their works, with a mentor to guide and challenge them."*

Meanwhile, the Enjoy Science Careers mobile exhibitions have given youth a chance to experience over 24 interesting STEM careers of the 21st century. Careers include petroleum geologists, sound engineers, and smart farmers who employ STEM knowledge and scientific analytical thinking in their pursuits.

Over the past five years, Assistant Professor Rawin has witnessed a positive impact among the project's beneficiaries.

"I have seen a series of fascinating changes. Children have expressed interest in and gained better understanding of science and technology, as well as the career opportunities that come out of them," Assistant Professor Rawin informs.

"Meanwhile, teachers are enthusiastic to adopt our Enjoy Maker Space activities into their classrooms. Parents see Enjoy Science Careers as informative guides for their children's potential futures, and they are grateful to know how to support their children."

According to Assistant Professor Rawin, the partnership between NSM and Enjoy Science was highly beneficial. It was considered a unique and innovative public-private partnership that went a long way toward raising awareness of STEM education among the people of Thailand.

"We created these activities together from the beginning," adds Assistant Professor Dr. Rawin. *"We worked as one team with Chevron and Kenan Foundation Asia. I believe the collaboration will have a positive impact on every sector of our society. It will empower us to continue to implement these kinds of educational STEM projects in the future."*

A University for the Younger Set

Thailand Children's University is a royal project of HRH Princess Maha Chakri Sirindhorn. After HRH Princess visited a children's university project at Shanghai Institutes for Biological Sciences in Shanghai, China in July 2010, she decided that Thailand should implement such a project to inspire Thai children to enjoy learning and experimenting with science.

Ms. Ruetai Chongsrid, Senior Director of Academic Affairs and Youth Science Development Division at the National Science and Technology Development Agency (NSTDA), which oversees Thailand Children's University, explains that the guiding concept of the project is making sure all children can access scientific knowledge.

"Science is for everyone. The heart of Thailand Children's University is to make science more enjoyable, meaningful, and useful for children who want to learn," Ms. Ruetai says.

Thailand Children's University brings together the country's leading universities and research organizations to encourage children to practice experimentation and invention. They learn under the direct guidance of experts and scientists from the NSTDA, the Institute for the Promotion of Teaching Science and Technology (IPST), and 19 partner universities.

Each year, Thailand Children's University engages over 6,000 children with activities that connect their communities to national and global issues. Such activities allow children to explore the universe of technology that is shaping the world around them.

"Thanks to the project, over 30,000 Thai children have had a chance to walk into a laboratory or research room, and learn from experts in a friendly environment," informs Ms. Ruetai. *"We have inspired children, enhanced their experiences, nurtured their skills, and created a powerful academic network."*

Over the last five years, the Enjoy Science project has created a network of professional instructors who specialize in developing learning activities for children, and whose fruitful cooperation will continue into the future. Ms. Ruetai adds that the impact is particularly felt among students with less access to scientific resources.

"For children living in faraway rural areas, it is almost impossible to participate in learning activities with experts from universities and research institutes," Ms. Ruetai says. *"But this project made it possible."*

At the core of Thailand Children's University is the concept of improving society.

"We are building young researchers who possess powerful and creative ideas. The idea of 'research and development' is to make things work better. Children who have been through Thailand Children's University, no matter what career they pursue, can apply this mindset," Ms. Ruetai adds.

"If they want to be a teacher, they can develop their teaching techniques to be more efficient and fun. Or if they want to be a doctor, they can research a better cure for patients. Even if they want to sell noodles, they can develop new, tastier, better quality noodles to cater to their clients!"

Ms. Ruetai explained that researchers and experts in Thailand Children's University wish to inspire children to think like a scientist, with the spirit of an innovator.



Ruetai Chongsrid

Senior Director of Academic Affairs and Youth Science Development Division

National Science and Technology Development Agency (NSTDA)

The idea of 'research and development' is to make things work better. Children who have been through Thailand Children's University, no matter what career they pursue, can apply this mindset.



Dr. Supara Kamolpattana
Director of Education
Program Division and
Project Manager of
NSM Science Square
National Science Museum

When a child creates something innovative, their parents can wonder why they think differently from others. I am happy to reassure them. 'Your child is actually showing intelligence and creativity.

Making Innovation
with Maker Spaces

As Thailand develops into an innovative society, Maker Spaces are an indispensable resource for nurturing future inventors, whose unconventional ways of solving problems will push the country forward.

The National Science Museum (NSM) is at the forefront of promoting STEM education through the development of informal STEM learning activities like Maker Spaces. **Dr. Supara Kamolpattana, Director of the Education Program Division and Project Manager of NSM Science Square**, believes in Maker Spaces as a way of inspiring creativity, analytical thinking, and other life skills in children. *"It's all part of creating an Innovation Society,"* she says. *"Developing the capacity of the next generation is a crucial step toward unlocking Thailand 4.0."*

Interestingly, Dr. Supara notes that innovation from children can sometimes be misinterpreted.

"When a child creates something innovative, their parents can wonder why they think differently from others. They may be concerned something's wrong with their child," Dr. Supara suggests. *"I am happy to reassure them by saying, 'Don't worry. Your child is actually showing intelligence and creativity by developing an idea of their own.' When a child thinks differently like this, that new idea is an innovation."*

NSM Science Square collaborated with the Enjoy Science project, Kenan Foundation Asia, and the New York Hall of Science to create the Enjoy Maker Space in NSM Science Square, a place where children can develop their problem-solving skills for themselves, their family, their community, and their country.

Here, children gain a foundation for the 21st century: they learn to analyze a problem, propose a solution, choose materials, plan a procedure, test and adjust their model, and present their work to their friends — all STEM concepts.

According to Dr. Supara, Enjoy Science was instrumental in bringing the Maker Space in NSM Science Square to life, as well as the Maker Space concept to NSM itself and its traveling science caravan.

"Enjoy Science powered maker activities and expanded innovative programming through their initiatives," Dr. Supara adds. These included interactive "Train the Trainers" programs for NSM personnel and a project-sponsored trip to the U.S., where the NSM management team joined a weeklong training with specialists at the New York Hall of Science's Maker Space.

Dr. Supara explains that when teachers teach students, they often expect them to think in certain ways. *"But in reality, there are many approaches to solving problems. This is called 'innovative thinking,' in which there is no one right way of doing things. It opens a world of possibility for all of us."*

Maker Spaces have the power to spark joy in children's eyes and leave deep impressions on young minds. Dr. Supara believes this is the first step in developing future scientists and innovators who will become a great asset to our country.



“Enjoy Science is helping Thailand create education in the new age to reduce social disparities and improve overall quality of life. This cooperation between government, private organizations, and educational institutions is producing the highly skilled workforce we need to reach the goals of Thailand 4.0.”

Air Chief Marshal Prajin Juntong
Deputy Prime Minister cum Minister of Justice

“Hands-on learning enables students to use real equipment to explore and analyze the world of science, and then present their thoughts and exchange ideas with their peers. I’ve used this knowledge to design my class in ways that is more interesting and fun for my students.”

Ms. Wiphada Phiratham
science teacher
Ban Phan Saharat Bamrung School



“Installing the first robotic arm at our school has raised the quality of our instruction many times over. When you can adapt coursework to real-world applications like that, students begin to really see the effects of what they’re learning.”

Mr. Vatanyoo Howhan
teacher
Prachinburi Technical College