Professors in Teacher Education and Leadership Boost STEM Knowledge with Hands-on Learning

Professor Max Longhurst and students use a magnifying glass to closely examine the changes
mealworms undergo during their brief lifecycle.

Apparently, Harvard graduates aren't always smarter than a fifth grader. In a documentary produced by the Harvard-Smithsonian Center for Astrophysics, 21 of the 23 Ivy League students or graduates interviewed struggled to explain what causes the changing of the seasons on our planet and why the phases of the moon happen.

Many people erroneously believe Earth's seasonal changes are due to the planet's changing distance from the sun as it orbits that hot glowing orb in the center of our solar system. But Earth's distance from the sun is relatively unchanging. The seasonal changes are, in fact, due to the angle of Earth's axis in relation to its orbit around the sun.

Similarly, many people incorrectly believe the phases of the moon are caused by Earth's shadow, or from Earth's or the moon's rotation on their respective axis. One of the most prevalent beliefs is the phases occur when the moon enters Earth's shadow.

In reality, the moon doesn't give off its own light. The light we see is the reflection of the sun on the surface of the moon as it orbits Earth.

To that end, the pair dedicate much of their time and energy teaching future teachers the fundamental concepts of science. Their methods prioritize hands-on discovery and inquisitiveness.

One example is the miniature rollercoasters they task their students with building each semester. It is an experience that is designed to help them better understand the complex concepts of gravity and forces of motion.

Using a six-foot piece of foam pipe insulation cut lengthwise, their students connect the pieces together to fashion a flexible, grooved, 12-foot track. Marbles speeding through the grooves of the pipe mimic the movement of cars to which would-be thrill-seekers are strapped.

The first step of the project is to create a rollercoaster with three hills. The students must consider where they will put their hills to keep the marble moving. Then they must incorporate loops. The trick is finding the sweet spot where the marbles have enough speed to navigate the track without falling off the loops, but not so much speed that they go flying off the track.

"That's exactly the way orbits work," Lott explains as the students successfully (and sometimes not so successfully) complete their tracks. "Earth is going around the sun every year. The sun is so huge, and Earth is so small that it is pulled toward the sun with gravitational force, but we aren't being pulled into the sun because we're moving just fast enough to stay in orbit. It's the same with the moon. Our moon doesn't get pulled into Earth because it's moving at an optimal speed to stay in orbit."

The Early Years

Both Longhurst's and Lott's love of science began at home when they were young. Although they both had educator parents, it was small but simple experiences like learning the constellations and the traditional lore that went along with them (for Longhurst) and hunting for snakes and bugs (for Lott) that instilled in them their lifelong love of science.

"Those experiences were magical to me," Longhurst recalls. "I had the luxury of learning science outside of the classroom. Doing things beyond the walls of the classroom enables students to have experiences with the real world."

Lott grew up in Madison, Alabama—a small town near NASA's Marshall Space Flight Center—where she developed an avid interest in science during time spent outside. In the seventh grade, she became an aide for her science teacher and the two years she spent helping in the classroom clinched it for her.

"From that moment on, I knew I was going to be a science teacher," Lott remembers.

Lott taught middle school and high school science classes for eight years while she completed her higher education degrees. When she came to Utah State in 2007, instead of aiming to publish her research in scholarly journals that schoolteachers wouldn't read, she opted to submit her ideas to publications like "Science and Children," a magazine for elementary school teachers produced by the National Science Teachers Association. When the publication rejected her first article, requesting anecdotal evidence from inside a classroom from teacher and student perspectives, Lott began partnering with teachers at Edith Bowen Laboratory School, a K-6 charter school on USU's Logan campus.

"I moved my office over to Edith Bowen where I worked directly with the teachers and students. I would reach out to the teachers to get my ideas in front of their students, then I would say in my articles and to my pre-service students at USU, 'This is what we should do with first graders,'" Lott says. "For me, it was a win-win. And that was when I came to love elementary education."

She has now published nearly two dozen articles in various teachers' magazines across the country.

Similarly, Longhurst spent six years teaching elementary school in Mesa, Arizona, and Millville, Utah, but his ultimate goal was to make an impact on both teachers and kids. In 1999, he came to USU as a professional learning provider where his work led to the development of the Elementary Core Academy.

"My skillset is in the delivery and methodology of how you get students excited about science, so we focused on the science core curriculum and the intended learning outcomes," Longhurst explains. "Elementary education is about helping students discover concrete explanations."

Longhurst recalls a moment during one of the teacher development courses when he was discussing characteristics of water with a group of elementary school teachers. Stretching a length of string between two cups of water held at differing heights, he demonstrated that a steady stream of water would run down the string while it made its way toward the lower cup. He asked the teachers why the water didn't drip off the string.

"The teachers were using vocabulary terms like cohesion and adhesion as memorized terms but without clear understanding," Longhurst recalls. "They kept coming back to the vocabulary words, but the explanation of what was happening with the string and water was limited."

When a group of second-grade boys walked by their room, Longhurst called them in and asked why the water wouldn't fall from the string.

"They said, 'Well, the water's sticking to the string.' 'The water's grabbing hold of itself,'" Longhurst remembers. "The science principle was clear to the boys. The teachers were trying to come up with this really sophisticated way of explaining a simple principle. In science, understanding and explaining the principle should be paramount to instruction focusing only on vocabulary."

Demystifying Concepts of Space Science

One of Lott and Longhurst's most important roles is teaching science methods to cohorts of elementary education students. The course, which is required for all elementary education majors, comprises nine weeks in the classroom followed by a practicum during which the students apply their learning in local elementary school classrooms under the guidance of mentor teachers.

With limited time to explore all the potential science topics elementary school teachers might introduce to their students, Longhurst and Lott mix it up each semester. Concepts they focus on range from energy and ecosystems to geology and biomes. They've found, though, that it's important to target space concepts every semester.

"In 16 years of teaching the class, we never touch space concepts because there are so many misconceptions about space," says Lott.

But once the students are aware of the extent of the misconceptions, and how they can hinder learning in a child's early years, Lott and Longhurst get down to the business of teaching space concepts correctly, so these misconceptions won't be passed down to the next generation.

To demonstrate the moon phases, they give each student a stick with a Styrofoam ball glued to it and turn on a bright light from an old overhead projector. As they all stand in the "sunlight" and hold the ball on the stick directly in front of their faces, they begin to turn their bodies — and the ball — in a counterclockwise direction to match the direction the moon turns. Treating their heads as Earth, the light as the sun, and the foam balls as the moon, the students begin to very clearly see the different moon phases.

Lott says that her former students will visit her years later and mention that lesson specifically, saying things like:

“Every time I look at the moon in the sky, I think about that Styrofoam ball on a stick.”

The teachers employ a similar method to teach the reason for Earth’s changing seasons. Using small wooden models that represent Earth and a flashlight that represents the sun, the students move the model around the light so they can distinctly see where heat directly and indirectly hits Earth as it orbits the sun. The more direct the light (and heat) the warmer that particular area of Earth, and vice versa.

“The direct light is changing,” Lott explains to her students. “That’s what causes the temperature changes. As Earth goes around the sun, because of Earth’s tilt on its axis, different parts are illuminated more intensely, or more directly.”

“It’s a simple but dramatic lesson. The students start moving the model around, and all of a sudden, they start to see what’s causing the seasons. It’s just like seeing a lightbulb go on.”

Engaging the Next Generation

Brittny Amott, a 2016 graduate of USU’s elementary education program, took the lessons she learned from her professors and has thrived in her own classroom. She has been teaching elementary students for the past nine years in Cache Valley, seeking daily to find ways to keep her students actively engaged in the learning process through investigation. She recalls how Longhurst—who taught her core science content block—exemplified the innovative science teaching practices Amott now applies in her second-grade classroom.

“Dr. Longhurst was great at putting questions into place,” she recalls. “He wouldn’t just give us the answers, he would make sure we understood the concepts through our own investigation and observations and problem solving.”

Following that method has served Amott well.

“As a science teacher, you can’t just lecture,” she explains. “Science is something that has to be taught through investigation and figuring out the problems and wondering. It’s not about being told the answers.”

For maximum success, Longhurst also advises his pre-service teachers to teach what they love.

“Their love of a topic will land well with students because they see their teachers enjoying it,” he says. “I think that’s true with any content area, but it’s especially true with science.”

Because Amott loves exploring plant science, she brings that passion into her classroom. In 2022, she applied for and was awarded a grant for a school-wide hydroponic system. Every teacher in the school, regardless of grade level, received a small hydroponic system for their classrooms that fits 12 plants. The school science room also received a large commercial system that fits about 300 plants.

“We continue to grow tomatoes and peppers using the hydroponic systems in the school,” Amott says. “The students love to see something that they start from a seed turn into a big plant. Every time they pass by, they check to see what’s going on with it. They love to see the growth happen over time. The entire school’s doing it, so it’s fun for all the kids to watch.”

Because the students are required to learn principles of botany in second grade to follow the state core standards, this project is a natural fit for second-grade teachers. But Amott says, regardless of the core requirements for the grade level, teachers can easily find ways to engage student imagination and investigative skills on concepts like space, which are required in first, third, and sixth grades.

“For me, I do a lot of work with hydroponics, but that is something that can be easily connected to space,” she says.

Recently, Amott’s students participated in Tomatosphere, a Space Station Explorers partner program created by the ISS National Laboratory. The program enables K-12 students to investigate how the unique environment in space affects tomato germination and growth. To get started, the class received two small bags of tomato seeds. One bag had been in the International Space Station, potentially orbiting the earth 500 times and travelling some 10 million miles. The other bag had regular, garden-variety tomato seeds. Students observed, tracked, and compared how the two sets of seeds germinated and grew.

Hands-on lessons like this help students gain greater understanding about things such as microgravity (or weightlessness), space exploration, and the potential impacts of growing food in space.

“Letting kids explore and ask questions is key,” Amott says. “It makes them wonder and dive deeper into learning. By giving them phenomena to observe, we can ignite a true love for learning. It is also important to integrate science into reading, writing, and math, so students can see the scientific connections in the world around them.”

Amott’s passion for helping science concepts come alive for her students has been rewarding in many ways, one of which is statewide recognition for her efforts in teaching science. She received the Outstanding Elementary Educator of the Year Award from the Utah Science Teaching Association in 2023 and is the recipient of the Utah and National Excellence in Teaching about Agriculture Award for 2025 from Utah Agriculture in the Classroom, a Utah State Extension program.

A Lasting Impact

Longhurst and Lott are passionate about the lasting impact good science teaching can have on children.

“It isn’t enough for students to see science from a distance or to simply read about it in a textbook,” Longhurst exhorts. “As students ask questions and wonder about a particular phenomenon, they build personal understanding that fuels their desire to know even more about their world.

“It is our belief these students will become the scientists of the future, capable of solving questions that haven’t even been asked yet. And our teachers are the individuals who can inspire children to ask those questions.”

Lott and Longhurst have worked to instill their love of teaching to many hundreds of USU elementary education graduates, most of whom, like Amott, are now thriving in their own classrooms. In addition, their multi-decade outreach efforts to impact educators via publications and professional training have extended well into the tens of thousands.

Note: This article was originally published in the Spring 2025 issue of Utah State Magazine.