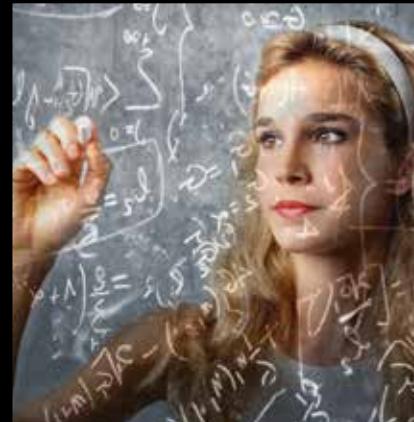




Collaborations in Math & Science Education

College of Arts and Sciences
College of Education and Human Sciences
College of Agricultural Sciences and Natural Resources

University of Nebraska-Lincoln





College of
Education and
Human Sciences

College of
Agricultural Sciences
and Natural Resources

College of
Arts and Sciences

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Helen Keller's words serve as a simple but fitting introduction to frame a discourse about math and science education at the University of Nebraska-Lincoln (UNL). Specifically, and with great purpose, the colleges of Agricultural and Natural Sciences; Arts and Sciences; and Education and Human Sciences have been re-imagining their efforts in mathematics and science education. This initiative is not only impacting students in UNL classrooms, but extending beyond the boundaries of campus to reach younger students and their teachers in classrooms across Nebraska.

enroll in college don't make it past the second year. One of the goals of this collaborative effort is to retool how key concepts and ideas are delivered, using proven instructional strategies that will result in more success for students, and, hopefully, more students who complete a degree and go on to apply math and science in successful careers.

"We're working to help every single UNL student have a great math and science experience, regardless of their major," said Marjorie Kostelnik, dean of the College of Education and Human Sciences. "There are great discoveries and translations of math and science

"Alone we can do so little; together we can do so much."

"Our university administration has recognized that we need to work together and break down historical silos," said Joseph Francisco, dean of the College of Arts and Sciences. "We are now reaching across the disciplines and overcoming differences to meet our students' foundational needs."

In these pages you will find examples of how faculty members in all three colleges have collaborated to enhance math and science learning for UNL students. The classroom experience of first- and second-year students has received special scrutiny. National data shows that half of the students who

that our students must experience, so we are bringing together people that are passionate about that to refine how we inspire that learning."

These purposeful strategies to elevate math and science are in part a response to the national need for more professionals in the STEM fields of science, technology, engineering and mathematics. Whether it's exposing school children to the ecology of the soybean, applying discipline-based educational research to the math and science classroom, giving high school and middle school teachers



Joseph Francisco
Dean, College of Arts and Sciences



Marjorie Kostelnik
Dean, College of Education and
Human Sciences



Steve Waller
Dean, College of Agricultural Sciences
and Natural Resources

new tools to teach math and science, or researching effective math concepts at the preschool level, UNL's interdisciplinary partnerships are making a bigger impact.

"The fact we're one of the few institutions where we're working together on math and science across disciplines is reflective of the Nebraska way," notes Steve Waller, dean of the College of Agricultural Sciences and Natural Resources. "By nature the colleges are cooperative. It's a wonderful opportunity to serve our students and faculty, and it's a credit to

Nebraska that we can accomplish this, because our collaborative nature is not all that common."

This booklet provides glimpses into this unique Nebraska approach. It doesn't capture every effort at UNL, but will give you a snapshot of our vision. The stories are divided into four themes:

- Science and math lifespan (PK-16)
- Science and math literacy
- Underrepresented STEM fields
- Teacher preparation and professional development

We hope you enjoy learning more about how Nebraska is responding to the math and science needs of its students. As you read, we hope that you will discover the many ways that UNL has embraced the principle that "together we can do so much."

Soybeans in the classroom

The humble soybean produces more protein per acre than most other uses of land. Already one of the most versatile plants around, the soybean fields in Nebraska today are yielding more than a bumper crop of the power-packed legume. They are playing a role in the professional development of science teachers.

The idea sprouted four years ago in a meeting between Jon Pedersen, associate dean for research at the College of Education and Human Sciences, Tiffany Heng-Moss, associate dean in the College of Agricultural Sciences and Natural Resources, and local and national soybean stakeholders. Their colleges had mutual interest in developing future scientists and responding to the higher expectations for science instruction, particularly at the elementary level. That meant bringing the real world of science to elementary school teachers and, perhaps, to their own work at the college level.



The ubiquitous soybean was the “model organism,” in Pedersen’s words.

Elementary teachers, expected to be capable instructing in a wide range of topics, are given little hands-on experience with science, particularly involving the active side of the scientific process.

“If elementary teachers only have a very limited opportunity to actually engage in the process of science,” Pedersen asks,

“how can we expect them to engage their students in science in a meaningful way?”

For three weeks each summer, 20 teachers are brought together under the auspices of the Summer Science Soybean Project—supported by the Nebraska Soybean Board and the United Soybean Board. Both organizations, Pedersen says, have opened their doors to the project.

Teachers study alongside soybean breeders, entomologists, molecular biologists, plant pathologists, agronomists and other experts. They examine crop “stressors.” They study end-product uses of the bean and nutritional issues. They engage in authentic research. They have access to soybean fields, greenhouses and laboratories. Time is split between engagements with scientists and working on how their science experiences can be translated into student learning in their own classrooms.

“It’s the holistic viewpoint,” says Heng-Moss. “It’s systems thinking and problem solving—exactly what we want them to teach in schools.”

“Systems thinking is actually the way the world works,” adds Pedersen. So instead of teaching weather, soil and life cycles separately, he says, a teacher can cover all three in the context of this one organism, the soybean, and find ways to draw in math and social studies and other disciplines along the way.

The summer soybean institute for teachers aligns with the Next Generation Science Standards, which call for connecting classrooms with real-world science work. Pedersen says the institute makes a major point of saying that they are not trying to change any individual teachers’ preferred curriculum, just to encourage that they “think differently” about how they approach the subject matter.

The “systems thinking” has come full circle. Pedersen says the university’s approach to teacher training is shifting as a result of the institute, too, and must now look in the mirror at its own approach to working with teachers-in-training. “When we started this relationship,” Pedersen confides, “that was the long-term goal that we had, to impact how science was taught pre-K through 16, the entire spectrum of science instruction.”

The humble soybean—it’s what’s for learning.



Science & Math Literacy

Cultivating

With a goal of enhancing science instruction in Nebraska schools, educators turn to the soybean.



Teacher Prep & Development

Innovation

Rising to a national challenge, an innovative approach is preparing STEM professionals to teach in secondary classrooms.

Noyce grants and UNL opening doors for non-traditional math and science teachers

In early 2012, President Barack Obama set a goal of preparing more than 100,000 math and science teachers over the next decade.

"The belief that we belong on the cutting edge of innovation, that's an idea as old as America itself," said the president. He called for training 1 million graduate students in STEM (science, technology, engineering and mathematics) at the same time—to develop what he called "future thinkers, dreamers and believers."

Even before the president's challenge, the Center for Science, Mathematics and Computer Education (CSMCE) at UNL was collaborating with the Department of Teaching, Learning and Teacher Education to find a more efficient way of preparing math and science professionals interested in classroom teaching.

Two programs were born in 2011: MAst and MAmt. The Master of Arts with an emphasis in science teaching (MAst) and Master of Arts with an emphasis in mathematics teaching (MAmt) offer pathways to secondary-level (grades 7-12) teaching for those who have earned degrees in their fields but who do not yet own a teaching credential.

"Our particular innovation with the M^Ast program is to get people certified in a year's time to be science teachers and not sacrifice quality," said Elizabeth Lewis, assistant professor of science education and M^Ast program coordinator. She is also principal investigator of a \$1.2 million Robert Noyce Teacher Scholarship grant for science teachers from the National Science Foundation.

Mathematics Professor Jim Lewis, director of the CSMCE, is the principal investigator for UNL's \$3 million Noyce scholarship for math teachers, which ends in 2016.

Both programs recognize that while many undergraduates will emerge as effective science and mathematics teachers, "real world" experience as working professionals yields a meaningful dimension.

MAst and MAmt participants start their intensive 14-month cycles of learning in May. They are ready to be hired as teachers, if they



Image credit: Lindsay Augustyn, Center for Science, Mathematics and Computer Education.

complete the requirements, in August of the following year. The schedule varies between the math and science strands, but includes teaching methods, educational technology and curriculum theory course work, practicums, student teaching in nearby public schools, and a master's seminar that culminates in a capstone project.

"We really need to have teachers who are highly qualified in their subject matter and who understand the nuances of curriculum development that meet state standards," said Elizabeth Lewis. In addition to state-required courses in special education and human development, UNL also requires M^Ast students to learn how to teach students who are English Language Learners. For many years Lincoln, Nebraska has been home to a large refugee resettlement population and the student-aged population in the U.S. is becoming increasingly diverse.

The NSF Noyce scholarship has supported more than 50 science teachers with scholarships of \$12,000 each. Graduates of the UNL M^Ast program have been employed as middle and high school science teachers across Nebraska and in many other states, including Colorado, Missouri, Arizona and as far away as Alaska. Thirteen Noyce graduates from the mathematics grant have become teachers in high-need districts in Nebraska.



Teacher Prep & Development

Web coaching

Through the use of technology, rural educators are helping researchers improve science instruction.

Science coaching helps rural educators while research provides insights

The need to improve the quality of science instruction and science achievement among students in rural schools is being met in Nebraska with two powerful 21st Century tools—digital video and the World Wide Web.

The University of Nebraska-Lincoln's Center for Research on Children, Youth, Families and Schools (CYFS) is leveraging technology to bring one-on-one professional development to science educators in rural Nebraska communities, where it's not uncommon to have one science teacher for all students from grades seven through 12.

The research on science coaching is one of several projects within a \$10 million, five-year grant from the U.S. Department of Education's Institute of Education Sciences. A detailed study is taking place at the National Center for Research on Rural Education (R²Ed), which is housed within CYFS.

The “heart and soul” of the work is studying how science teachers perform in the classroom, says Gwen Nugent, research professor with CYFS. Knowing science content is not enough. Teachers must also know how to develop science skills in students. The Next Generation Science Standards call for developing science skills through inquiry practices. They encourage students to think and question the world in a new way.

The research randomly splits rural teachers into two groups. One group receives instructional coaching over an “intervention period” that lasts six to eight weeks. For the other group, business as usual—no coaching.

In the summer, those science teachers receiving intervention are also given in-person professional development. During an eight-day institute, they work with coaches to plan and practice lessons for use during the school year and strengthen the inquiry-based approach to instruction.

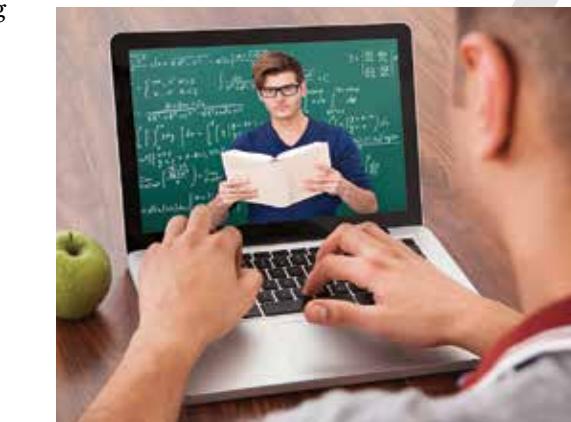
Tiny GoPro cameras record classes from both groups of teacher participants. Videos are saved in the “cloud” and are reviewed by

coders who watch each lesson and make detailed assessments of specific instructional moments. The data coders have no idea if they are watching a teacher who received “treatment” (ongoing coaching) or not.

“On one instrument there are 31 individual teacher behaviors we are looking for,” says Nugent, “and they are all key to teachers facilitating student understanding of inquiry as reflected in the standards.” Another instrument gauges student focus—are students on task, off task or engaged in inquiry? A coder picks a student at random, watches and records for one minute, and moves at random to the next.

Online video conferencing allows master science teachers, who provide the instructional coaching, to connect with rural educators and make suggestions based on what they've observed on the video. Three coaches make the virtual rounds via the Web.

Teacher networking also helps. Many of these teachers work solo yet embody the entire “science department” for multiple grade levels. Science teachers recognize that the presence of coaches means it's a new day in science instruction, but there's no switch you can flip that will change the habits and routines of a teacher. Like the math and literacy instructors before them, translating instructional strategies to meet student needs might best be achieved by a coach on the sideline, making suggestions as the work continues.



NSF grant programs revitalizing math instruction

Gaileo was known for his knowledge in a multitude of realms, but he advocated the importance of learning one topic first. "If I were again beginning my studies, I would follow the advice of Plato and start with mathematics," he said.



Image credit: Lindsay Augustyn, Center for Science, Mathematics and Computer Education.

state of math and science education in 2006. The group called for attracting 10,000 new math and science teachers into the profession every year for the foreseeable future.

Jim Lewis, mathematics professor in the College of Arts and Sciences as well as director of the Center for Science, Mathematics and Computer Education, says the cry for improvement requires a transformation.

The old paradigm, in which elementary school teachers were required to take only one math course prior to certification, is of no use. The new paradigm requires "teacher-leaders" immersed and committed to math education. Lewis advocates for teacher-leaders who can change the whole conversation about mathematics school-wide.

Professors who developed Math in the Middle and Primarily Math at the University of Nebraska-Lincoln agree.

Various reports have suggested the nation's economic status is at risk without improved math instruction. The National Academies, the leading advisory group on science and technology, decried the dismal

At the turn of this century, the Center for Science, Mathematics and Computer Education at UNL helped initiate a major change in how mathematics was taught to elementary education majors. A "Math Semester" makes the university's program unique in training teachers in both mathematics and education at the same time, increasing the intensity with math content.

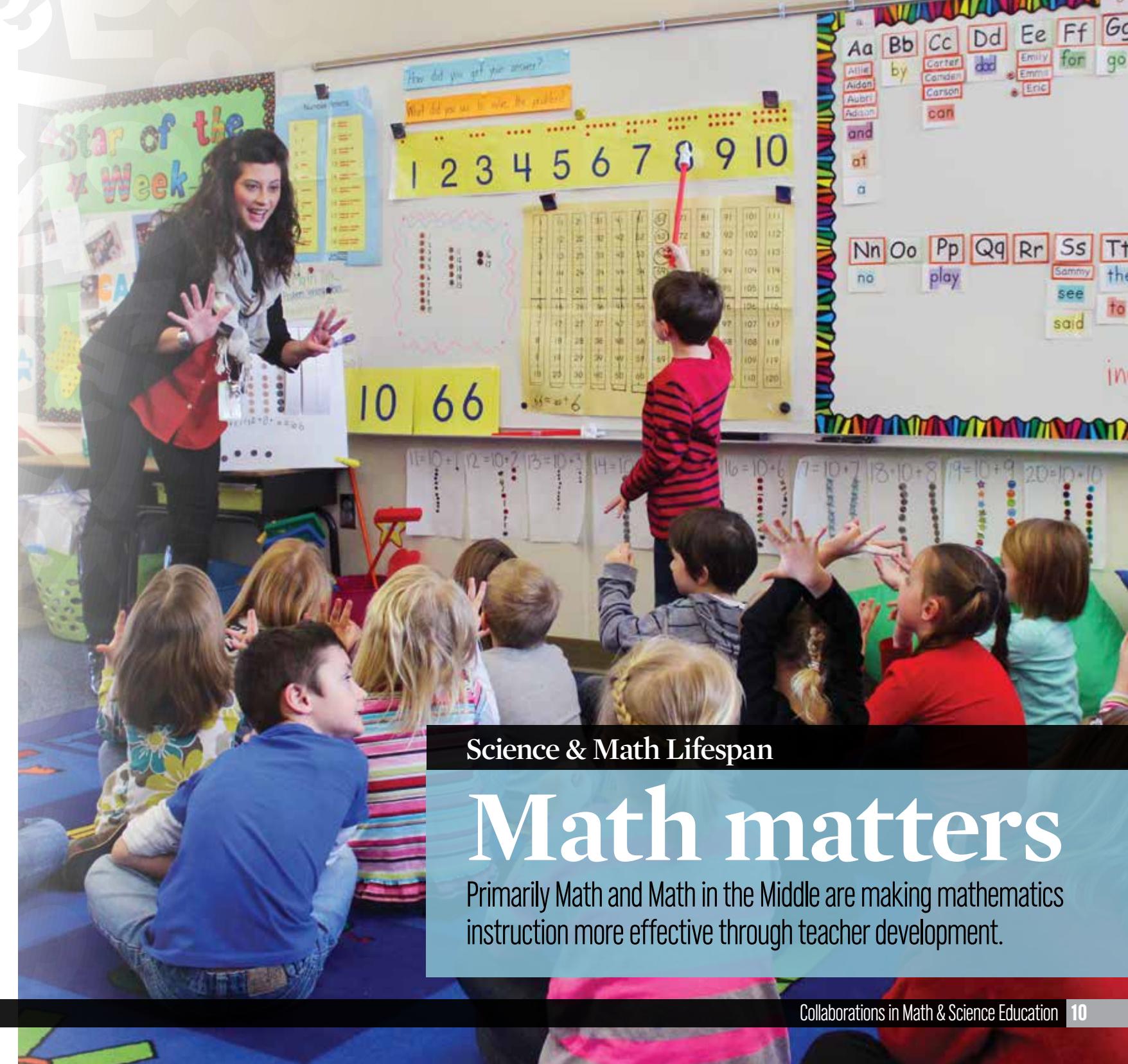
Over the last decade, two additional initiatives have upped the ante. In 2004, the center started strengthening teacher talent at the middle school level. With a \$5.9 million grant from the National Science Foundation, 156 teachers have earned a master's degree through the Math in the Middle program and are now established in schools across Nebraska, championing math and its relationship to other subject areas. Lewis calls the crop a "remarkable community of intellectual leaders." Graduates of Math in the Middle lead the various state organizations focused on math instruction.

Primarily Math, part of the \$9.3 million NebraskaMATH grant from the National Science Foundation, arrived five years later, in 2009. In Primarily Math, teachers earn a K-3 Mathematics Specialist Certificate from UNL upon completion of an 18-hour graduate program. So far, Primarily Math has produced 223 teachers who, Lewis says, are having an "enormous impact on the primary grades."

Lewis credits colleague Ruth Heaton, a professor of teaching, learning and teacher education in the College of Education and Human Sciences, for leading changes in how pre-service teachers in her department learn to teach math to elementary students. It's a direct outcome of Primarily Math as was her creation of the associated pedagogy courses and a robust initiative to research effective math instruction.

"Things are happening the way we wanted them to happen," says Lewis. "As teachers learn more about math and they learn more about teaching math, their attitude toward teaching becomes much more positive and confident. And then they affect their peers so they help the whole school improve."

To Lewis' way of thinking, "this is what a university is supposed to be doing—it's supposed to be working in partnership with K-12 schools to strengthen education. It's also supposed to be doing research to find out if it makes a difference."



Science & Math Lifespan

Math matters

Primarily Math and Math in the Middle are making mathematics instruction more effective through teacher development.



Science & Math Literacy

Math studio

Making the work of math teaching “visible in real time.”

Teaching math in one Omaha area school is no longer a solo adventure. It's a group expedition.

The Math Studio is a journey far removed from the old days of a teacher closing the classroom door and doing his or her “own thing.”

The Math Studio project in Nebraska grew out of the National Science Foundation grant, NebraskaMATH and is currently funded by the Sherwood and Lozier foundations.

Principal investigators include Jim Lewis, Aaron Douglas Professor of mathematics and director of the Center for Science, Mathematics and Computer Education in the College of Arts and Sciences, and Ruth Heaton, professor in the College of Education and Human Sciences’ Department of Teaching, Learning and Teacher Education.

The NebraskaMATH grant also included a substantial research and professional development program for K-3 teachers (Primarily Math) and an elementary math coach project. But something was missing from this equation.

Teachers emerging from those programs had completed the course work but then came the challenge—translating what they learned to their own schools and classrooms. Study groups and cohort meetings weren’t enough.

The Math Studio project was developed based on a presentation Heaton saw at a conference with principal investigators from other projects funded by the National Science Foundation.

An idea clicked. What if she could deliver professional development on the spot and in the moment, with class in session? The Math Studio “is a way to make the work of teaching visible in real time,” says Heaton.

“Visible” might be putting it mildly. If you are a math teacher and the subject of a Math Studio, you could host anywhere from a dozen to 18 observers in your classroom. First the team huddles before a class to discuss the teacher’s plans. What are the mathematical goals of the lesson? How will students engage, react?

Next, in the classroom, each of the observers is given specific aspects of the classroom work and interactions to monitor. Some confer with students as the lesson progresses. Occasionally, a lead observer might stop the class and ask the teacher about the choices being made. The teacher, on the spot, turns learner. After the class, the team huddles again and de-briefs. What worked? What didn’t? The conversations can be “pretty intense,” Heaton acknowledges.

Heaton promotes four “big ideas” of teaching—that it should be intentional, planful, observant and reflective. Every teaching moment represents a choice.

“The underlying idea about teaching here is that it’s a really uncertain endeavor,” says Heaton. “My goal isn’t to point out what’s going wrong, but to help teachers understand that there are choices with consequences in every moment of a class.”

Math ‘community’ engages to improve instruction



The Math Studio is now being run in two Omaha elementary schools with teachers, math coaches and principals from nearby schools and districts regularly participating.

The concept calls for teachers, math coaches and school administrators to work together as a professional and trusting community to study teaching—and support each other’s learning. If it’s working well, observers (fellow teachers, coaches and administrators) are gaining new insights into children’s understanding and learning as much from practice as the teacher in the spotlight. It is all “really difficult work,” Heaton admits.

The goal is improved teaching practice and all involved must understand, advises Heaton, that there is no one right way. “Teaching is a practice to be studied,” she says. “Continually.”



Science & Math Lifespan

Active learning

"The lecture hall gets really loud, and you can really tell that interactions are going on."



Larry the Clicker Guy" may be extra busy in the next few years at the University of Nebraska-Lincoln. The affectionate nickname belongs to the information technology staffer, Larry Weixelman, who helps faculty set up and use student response systems in UNL classrooms. Use of the "clickers" is one of many instructional strategies helping professors discern if their students are truly understanding key math and science concepts.

"The first two years of college are critical for retention of students, especially in STEM fields," says Marilyn Stains, assistant professor of chemistry in the College of Arts and Sciences, and a co-principal investigator on a \$2 million National Science Foundation WIDER (Widening Implementation and Demonstration of Evidence-based Reforms) grant. "There is evidence that infusing active learning in the classrooms helps retain students past the first and second year."

The WIDER grant will provide over 100 faculty members in 14 STEM-related departments with the opportunity to learn and practice proven instructional strategies and course design. Over the course of the three-year NSF grant, which begins in the fall of 2014, the project is expected to reach more than 5,000 UNL students in the colleges of Agricultural Sciences and Natural Resources, Arts and Sciences, and Engineering. It builds on the UNL Scientific Teaching workshop series that was supported by a previous NSF WIDER grant led by Stains.

Instead of students adapting to the instructional style of the professor, evidence-based instructional strategies turn that around and suggest that students will learn better if instructors seek what will work best to meet the learning needs of their students. Using the clicker technology to introduce peer instruction is an example. To assess student comprehension, a question is posed about recently presented material. Each student in the class responds anonymously on a remote device (clicker). Results are provided to the instructor immediately. If students fail to grasp the concept, the instructor asks students to pair off and discuss the question. Often, after "re-voting," the response rate for correct answers will increase 40-80 percent.

"Sometimes when it's instructor driven, students turn off," said Roberto Cortinas, assistant professor of practice in UNL's School of Veterinary and Biomedical Sciences, who participated in the UNL Scientific Teaching workshop series. "When they interact with their peers, they are much more critical

and aware. They have to explain, think it through and are more likely to develop a logical argument. When we do peer instruction, they really get into it. The lecture hall gets really loud, and you can really tell that interactions are going on."

The purpose of the grant's professional development is to improve the instructional practices of STEM faculty resulting in improved student learning outcomes. Additionally, the grant

Teaching and learning clicks with aid of WIDER grant

research team, which is composed of discipline-based education researchers, will study factors that influence faculty and departmental adoption of effective pedagogies.



Image credit: Travis Lund, College of Arts and Sciences.

"It's training we lack as scientists," notes Cortinas. "You get to practice strategies, and you see evidence that these approaches work. These workshops are extremely beneficial."

Ultimately, it is hoped that students will be more engaged, will successfully complete courses and will complete their degrees and move into a variety of careers with a better understanding of critical STEM concepts. For an increasing number of UNL students, that reality may be just a "click" away.



Underrepresented STEM Fields

Empowerment

"There is nothing quite like being in a room full of people like you for the first time. It's a powerful experience."

Helping women lead and succeed in math and science

The data are powerful—women remain, for the most part, outside the professions of science and mathematics.

Consider that only one-fifth of physics Ph.D.s in the country are awarded to women. Or consider that of all the physics professors in the United States, only 14 percent are women (*New York Times*, Oct. 3, 2013). Study after study have demonstrated the bias against women in both math and science.

Boys and girls take math and science courses in equal numbers from elementary school through high school, but they take different paths when it's time for college. By graduation, men outnumber women in nearly every science and engineering field. And at the graduate level, women's representation in science and engineering declines even further.

Reversing course on this trend is paramount to the College of Arts and Sciences and the Center for Science, Mathematics and Computer Education. Changing female access to both professions is critical. "When we exclude this group from the field—or exclude any group—we systematically exclude a large percentage of the population and you never know where the next great idea is going to come from," says Judy Walker, Aaron Douglas Professor and chair of the mathematics department.

The issue is longstanding. It was 1999 when Walker visited the White House and received a \$10,000 award from President Bill Clinton in recognition of the university's success with female graduate students. The department was required to use the prize to enhance or expand the mission of improving female access to math programs—and that grant is still paying dividends today.

Using the money, Walker's team developed a conference designed specifically to encourage undergraduate women to pursue graduate school with an eye on studies in mathematics. Each winter, the Nebraska Conference for Undergraduate Women in Mathematics gives undergraduate students a chance to exhibit their current research—and engage in feedback from graduate students and professors. The conference has drawn participants from all over the country and around the world. "A lot of them are coming from very small schools," says Walker, "where there aren't

a lot of math majors. There is nothing quite like being in a room full of people like you for the first time. It's a powerful experience."

At the high school level, UNL's Women in Science Conference, started by the Center for Science, Mathematics and Computer Education, shows future women mathematicians, scientists and engineers that their dreams of careers in these fields are valid. And possible. The conference annually exposes about 100 high school sophomores and juniors from Nebraska and Kansas



to positive role models and provides an opportunity to learn about future studies from the perspective of current women at the college—undergraduate, graduate and professional. The conference also takes students on a field trip to a local hospital to see the profession in action.

Lindsay Augustyn, director of communications at the Center for Science, Mathematics and Computer Education, says, "I think we definitely have opened the students' eyes to different careers in the sciences. They always comment that they are now considering majors or jobs that they did not consider before."

Stereotypes dismantled at girls' math camp

There was a stereotype-busting incident at math camp a few years ago that still makes Judy Walker smile. A group of cheerleaders, involved in their own camp, were sharing the same dorm. The math girls, the cheerleaders complained, were up late, having too much fun and making too much noise. The cheerleaders wanted to get some sleep.

"One of my all-time proudest moments," recalls Walker, chair of the Department of Mathematics, while acknowledging that she did ask the math students to tone it down.



Image credit: Stephanie Vendetti, Center for Science, Mathematics and Computer Education.

More role reversals are needed, argues Walker. Ample messages exist in society that discourage women from pursuing mathematics, down to the Barbie doll that complains math is hard.

"It's kind of pervasive that math isn't cool and that girls don't do math but cool girls, in particular, don't do math," she says. "The message is you can be pretty or you can do math. A lot of men are intimidated by smart girls and we have to find a way as a society to get past this."

Enter the All Girls/All Math Summer Mathematics Camp for Girls. For 17 years and running, the week-long camp invites 56 high school girls (half from Nebraska, half from around the United States) to spend some quality time with mathematics and learn about the possibilities for further study of math in college and beyond.

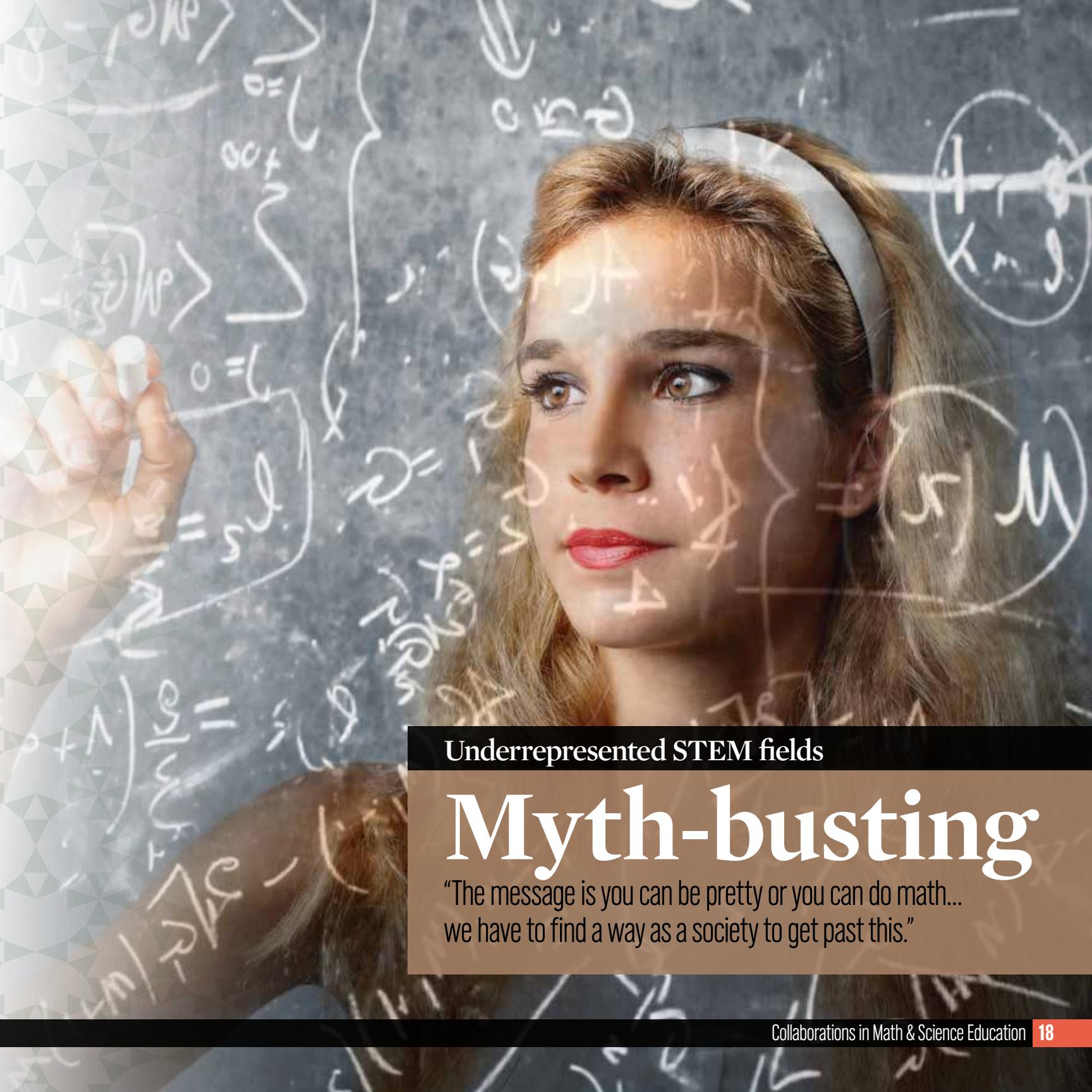
Candidates for the camp must have completed high school geometry. Special consideration is given to those who will enter their sophomore or junior year in the fall but have not yet taken calculus. Applicants abound. There are always more applications than spots available. Every high school in Nebraska receives a brochure and the girls who score in the top 500 on American Mathematical Competitions receive an invitation, too. Students have attended from Belgium and South Korea.

"It is for girls with a strong interest in the field," says Walker. "When you're a high school girl interested in math, sometimes you're the only one. We want to keep them in there with math at that time when they are very vulnerable to the peer pressures of high school."

Participants spend mornings in a week-long course focused on cryptography, the mathematics of codes. In the afternoons, mini-courses are offered on such topics as aerodynamics, graph theory and learning a math game called SET. Camp goers work with mathematics professors and graduate students and interact with their peers. Faculty from other universities attend as instructors.

Grants from the National Security Agency and the American Mathematical Society's Epsilon program underwrite some of the costs for transportation, room and board and registration.

Math isn't tied to gender, Walker says. She wants to encourage more women to remain engaged with math through high school and all the way through college. She wants to encourage more women to enter fields that require a mathematics degree. The change starts with smashing the notion that "geek" is a pejorative, especially for women, and then providing the space and time to gather and work together. Says Walker: "Sharing interests can be incredibly powerful."



Underrepresented STEM fields

Myth-busting

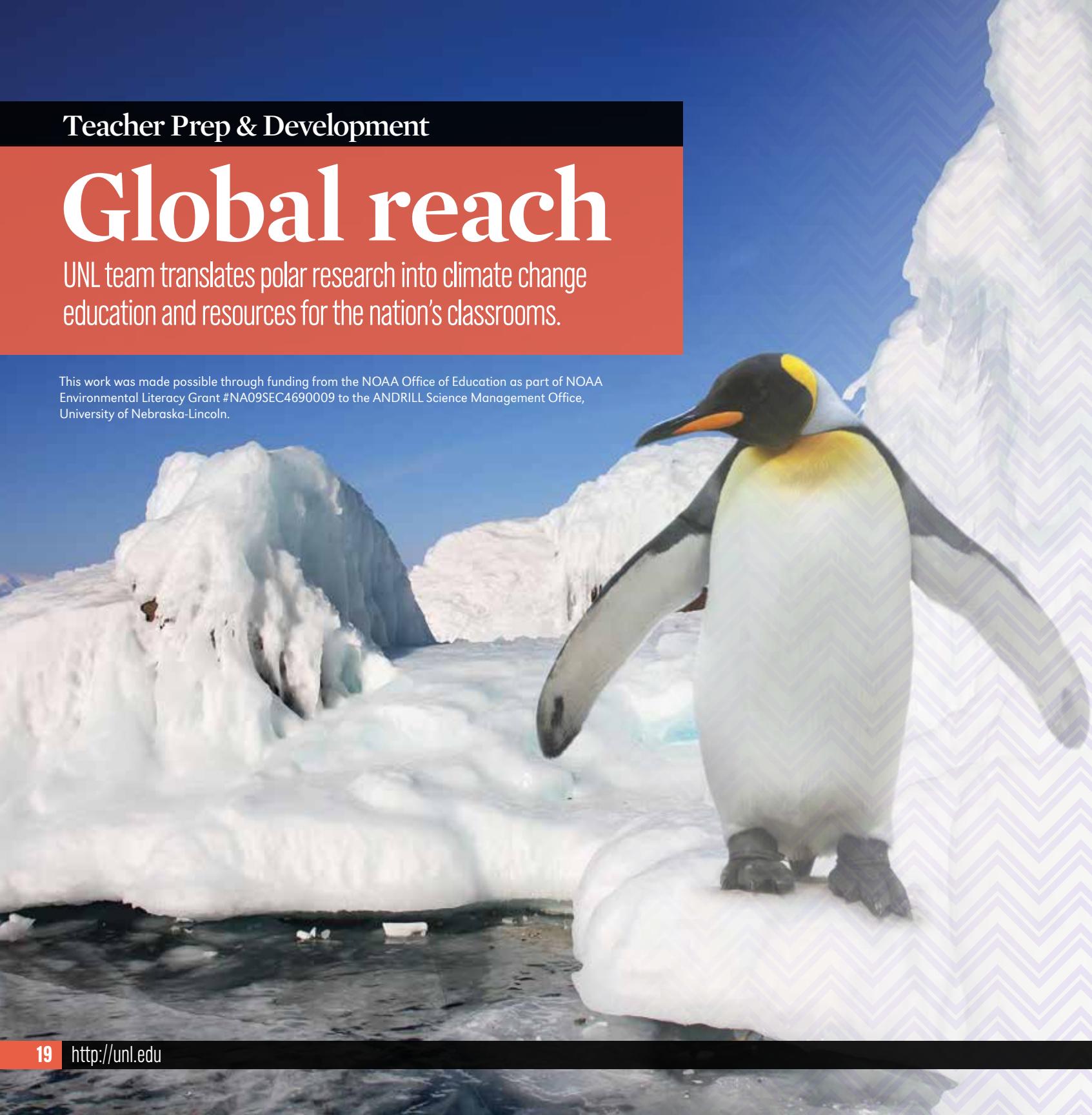
"The message is you can be pretty or you can do math... we have to find a way as a society to get past this."

Teacher Prep & Development

Global reach

UNL team translates polar research into climate change education and resources for the nation's classrooms.

This work was made possible through funding from the NOAA Office of Education as part of NOAA Environmental Literacy Grant #NA09SEC4690009 to the ANDRILL Science Management Office, University of Nebraska-Lincoln.



At the far reaches of the planet, where penguins are much more at home than UNL researchers, a team of scientists, educators and students have bored through the McMurdo ice shelf and below the sea floor to study earth's history for clues about historic climate change. ANDRILL (ANtarctic geological DRILLing) is a multinational collaboration with more than 200 people from five nations participating in each of the two drilling projects to date.

Thanks to grant funding from the National Science Foundation and the National Oceanic and Atmospheric Administration (NOAA), the UNL-based ANDRILL Science Management Office (SMO) assembled an education team to share the science of ANDRILL and facts about climate change with middle and high school teachers and students in Nebraska and across the country.

The initial educational project, funded by NSF, was a formal collaboration between the ANDRILL SMO and the Nebraska State Museum of Natural History at UNL on a project called "Antarctica's Climate Secrets." It produced a series of museum quality banners and hands-on learning modules designed for middle school students culminating in groups of students developing and presenting public science events or "flexibits." Flexibits included hands-on activities, posters and video podcasts to help share the science of ANDRILL and climate change.

Building on that success, the SMO was awarded NOAA funding to develop the Environmental Literacy Framework (ELF) with a focus on climate change. This series of educational modules covers the earth's major systems: atmosphere, hydrosphere, geosphere and biosphere and a fifth unit, energy, to link them. Together they provide resources that teachers can use in grades 5-10 to teach climate change concepts and principles.

To introduce the ELF and build a cadre of science educators who could champion climate change education, the SMO team organized and hosted two in-depth professional development workshops for teachers in multiple states in each of four years. Each group of educators committed to using the ELF in their classrooms and to prepare their students for a climate change student summit. Training and summits were held from California to North Carolina. In 2012, summits were held at 10 sites with all sites connected by videoconference links to allow the students to communicate what they had learned through discussions with their peers.

"We wanted to get the science of ANDRILL and climate change out there," said Frank Rack, director of the ANDRILL SMO. "The goal was to build capacity among practicing educators by providing them resources to teach the science and to make it as easy as possible for adoption [of the materials into classroom instruction]."

ANDRILL's SMO is housed in the College of Arts and Sciences. Rack noted that the educational projects reached out to other

Antarctic ice leads to lessons in Nebraska classrooms

UNL units for development help and support. Judy Diamond at the University of Nebraska State Museum was the principal investigator of the Antarctica's Climate Secrets project, and faculty in the College of Education and Human Sciences' Department of Teaching,

Learning and Teacher Education helped connect the project to schools in Lincoln. Rack also connected with faculty in the College of Agricultural Sciences and Natural Resources about interagency funding opportunities.



Image Credit: ANDRILL Science Management Office

While the NSF and NOAA grants have expired, the educational projects live on through the dozens of teachers who participated and continue to teach their students about climate change using the resources developed by the SMO, which are still available at andrill.org. More than 800 students participated in the Climate Change Student Summits, and 5,000 students in 10 states are currently using the ELF modules in their classrooms.

"Hopefully we have inspired some of them," says Rack about the students. "We know some participants have adopted a science career path and have gone on to college."

Foundations build on partnerships to improve math instruction and achievement

Helping students improve their math skills by investing in outstanding math teachers is behind the logic of a \$5.5 million grant made by two Omaha foundations.

The Sherwood Foundation® and the Lozier Foundation have partnered to provide the grant to the University of Nebraska Foundation to support a partnership between Omaha Public Schools (OPS) and UNL's Center for Science, Mathematics and Computer Education.

The funding supports the NebraskaMATH Omaha Public Schools Teacher Leader Academy, a community of OPS K-12 mathematics teachers dedicated to strengthening mathematics teaching and learning in Omaha, from 2013 to 2016.

Through the program, teachers have access to continuing education and graduate coursework centered on math education. Since courses began in 2013, nearly 150 OPS teachers have participated.

The OPS Teacher Leader Academy builds on a foundation laid by three National Science Foundation grants to UNL: NebraskaMATH, Math in the Middle and NebraskaNOYCE. Nearly 75 OPS teachers have participated in those programs, forming a base of teacher leaders for the new program.

Jim Lewis, UNL mathematics professor and director of the Center for Science, Mathematics and Computer Education, said the goals of the OPS initiative are to strengthen mathematics learning in Omaha classrooms, narrow student achievement gaps between different populations and conduct research that continues to inform school improvement efforts.

The academy offers various programs for teachers, including Primarily Math, a program for K-3 teachers; Math in the



Middle, a master's degree program for grades 4-8 teachers; and fellowships to enable OPS K-12 math teachers to take math courses at no cost to the teacher. Courses are offered in Omaha at the OPS Teacher Administrative Center (TAC). The grant also supports six K-3 and two middle-grade math coaches for OPS.

In addition, university faculty will study the impact of professional development on teachers' beliefs and knowledge, student outcomes and the impact school culture has on student achievement. They also will establish a studio classroom as a model for implementing instructional change in K-3 classrooms. This project and its research results will provide a national model for effective mathematics teacher education, Lewis said.

In July 2013, the first cohort of 24 K-3 teachers began the Primarily Math program, and 29 teachers of grades 4-8 began the Math in the Middle program. In addition, three other courses for teachers were offered at TAC in 2013 and seven in 2014. The second cohorts of Math in the Middle and Primarily Math, each with 28 teachers, began in the summer of 2014, along with a cohort of 10 New Teacher Network teachers.

As part of a strategy to build the capacity of OPS teachers to provide professional development for their peers, the program makes heavy use of teachers as part of instructional teams for the courses, and also collaborates with other universities for instruction. Collaborating with Lewis at UNL are co-principal investigators Ruth Heaton, professor in the department of Teaching, Learning and Teacher Education in the College of Education and Human Sciences, and Wendy Smith, research assistant professor and assistant director of the Center for Science, Mathematics and Computer Education.

More information about the OPS Teacher Leader Academy is available at <http://scimath.unl.edu/opstla>.



Teacher Prep & Development

Partnership

The Sherwood Foundation® and the Lozier Foundation, both based in Omaha, are providing major funding to extend the reach of promising programs.

Image credit: Lindsay Augustyn, Center for Science, Mathematics and Computer Education.



Teacher Prep & Development

Inspire to inquire

UNL professors use inquiry-based strategies to enhance student learning.

The University of Nebraska-Lincoln has employed what looks a lot like scientific method to train top-notch P-12 science teachers across the state. Any good scientist begins, of course, with an observation of phenomena, then forms a hypothesis about those phenomena, tests the hypothesis, and arrives at a conclusion that either validates or modifies the hypothesis. In UNL's case, the hypothesis (see below) is undeniably true. Here's proof.

Observations: Most science education programs among Nebraska's colleges and universities focus on meeting state mandates for teacher certification. Inquiry opportunities are important to improving science education.

It's all about the students

Hypothesis: Increasing inquiry opportunities and focus on student needs in the UNL curriculum has improved how science is taught and improved the effectiveness of teachers.

Test: The university has introduced courses that focus on inquiry-based learning, a critical component in developing the most effective teachers of science. UNL also promotes collaboration among its colleges of Education and Human Sciences, Arts and Sciences, and Agricultural Sciences and Natural Resources to elevate science education across the institution.

Participating in the effort is Associate Professor of Practice Eric Malina who teaches general chemistry in the College of Arts and Sciences, and whose research emphasis is "learning in the laboratory." With a grant from the NU-Teach program, Malina's task has been to develop inquiry-based laboratory activities in the general chemistry sequence.

"I have combined the benefits of the traditional laboratory curriculum with inquiry-based approaches to help students improve their science reasoning skills," Malina explains. "It has taken me the better part of five years to develop completely novel laboratory activities for the first semester course."

Malina points to research showing that traditional laboratory activities have been effectively employed for decades to teach scientific methods and techniques. But research also confirms that problem-solving skills are improved when students engage in an inquiry-based approach.

"So, that is my combination," Malina says. "Teach students techniques and methods from a very traditional approach – then

move into problem solving using those newly learned techniques and methods."

David Gosselin concurs. He is a professor of earth science in the School of Natural Resources and director of the Environmental Studies Program, a joint program between the College of Agricultural Sciences and Natural Resources and the College of Arts and Sciences.

"Students need to be engaged in the process of investigating their world," he states. "Inquiry is driven by the ability to question and be curious about how things work, why they work, and how people know what they know."

Gosselin oversees the Science for Educators (S4E) specialization in the Master of Applied Science program offered by the College of Agricultural Sciences and Natural Resources. Students in this online program not only gain greater content knowledge, but also learn via integration, inquiry and application.

"The ability to question drives problem solving and is at the foundation of inquiry-based learning," Gosselin asserts. "In the courses I teach, I provide students the opportunity to develop questioning skills – skills that are at the foundation of inquiry and are transferable across all disciplines."



The evidence is compelling. UNL's inquiry-based approach to science instruction is better preparing Nebraska's next generation of science teachers. But there is one more factor critical to the university's success.

"Teaching is not about the teacher, it's about the students," offers Professor of Life Science Don Lee. Lee credits predecessor David McGill, former instructor of genetics in the College of Agricultural Sciences and Natural Resources, as the inspiration for his student-centered perspective. "David was 'all in' as a teacher, creating a legacy of teaching success. Nebraska has a long history of investing in teachers who love to teach, like their students, and are passionate to help them discover how science can make an impact on their personal and professional lives."

The conclusion? Hypothesis strongly supported.

“What does a million look like?” It’s the kind of question that the very best teachers might choose not to ask. Why? Because the very best teachers inspire their students to be the ones asking such questions—and seeking the answers. It’s about reviving that sense of wonder too many people lose as they become “worldly wise.” And it’s among the purposes of the Nebraska Math and Science Summer Institutes (NMSSI).

The NMSSI’s mission is “to offer Nebraska teachers of math and science intellectually rich graduate course work that will enhance

their ability to offer their students challenging courses and curricula.” One of several programs born of a \$5.9 million Math and Science Partnership grant from the National Science Foundation, NMSSI was launched in 2007 to further the University of Nebraska–Lincoln’s long-term commitment to strengthen K-12 mathematics and science teaching and learning. The program has grown from three courses the first year to more than 30 offered each summer.

“Teachers like our program for two very important reasons,” observes principal grant investigator Jim Lewis, Aaron Douglas Professor of mathematics and director of UNL’s Center for Science, Mathematics and Computer Education. “First, we offer our courses using an intense format. Teachers might attend class for four hours a day with homework every night for two weeks. They learn a lot, and they protect much of their summer for other work or activities. Second, we pair pedagogy courses with math and science courses.”

Image credit: Lindsay Augustyn, Center for Science, Mathematics and Computer Education.



Teachers also appreciate the program’s affordability. Recognizing that most K-12 teachers live on limited budgets, NMSSI offers them a 20% tuition discount. “More teachers are earning master’s degrees, and still more are in the pipeline because they’re finding out we exist,” Lewis says. “Local school districts are even beginning to pay the tuition and fees so that their teachers can take our courses.”

Courses include offerings from the College of Education and Human Sciences, the College of Arts and Sciences, and the

Reviving a sense of wonder

Institute of Agriculture and Natural Resources. There’s even a 14-day, inquiry-based field course, Methods in Geoscience Field Instruction. “I think this is one of the most fantastic courses we offer,” Lewis enthuses. Participants make entries in personal field journals as they camp across Nebraska, South Dakota and Wyoming. “I have had one of the most memorable trips of my life,” writes one adventurer. “I do not want to go back!”

Notes another: “It turns out that geology is so massive and at the same time so small in scale. ... Imagine systems and processes that create inland oceans and mountain ranges, then check out a piece of sandstone and identify the particle size. Which is it – big or small?”

So what *does* a million look like? One field course explorer suggests using grains of sand to find out. “Why is a particular kind of sandstone red?” There are at least four correct answers. “What is the cause of all causes?” Wow. Search for clues to these and other questions in actual field journal entries at NMSSI’s website: scimath.unl.edu/nmssi.

But beware. An inspired teacher’s sense of wonder is infectious.

The Center for Science, Mathematics and Computer Education, housed in the College of Arts and Sciences and directed by professor Jim Lewis, is the model partnership between the three colleges. Among its projects are NebraskaMATH and NebraskaSCIENCE, devoted to improving achievement in Nebraska’s K-12 schools. The varied programs of NebraskaMATH and NebraskaSCIENCE have been fueled by nearly \$20 million in National Science Foundation funding since 2004. Please visit scimath.unl.edu for more information.

Teacher Prep & Development

Summer institutes

K-12 teachers relish opportunity to help their students through UNL summer institutes.



Image credit: Stephanie Vendetti, Center for Science, Mathematics and Computer Education

Michael Jackson had it almost right. "A B C, it's easy as 1 2 3 ..." goes the 1970 pop hit, implying that math and literacy are of equal importance in education. But math, easy? Instructors in Nebraska's Educare schools, which serve at-risk children from birth to five years old, might beg to differ. "It's particularly challenging because teachers are often anxious about math—they were intimidated by it when they were in school," says Ruth Heaton, professor in Teaching, Learning, and Teacher Education at the University of Nebraska-Lincoln. "The Educare schools have defined it as a real area of need."

More than just counting

Enter "Math Early On," brainchild of Heaton and colleagues Carolyn Pope Edwards, professor of psychology and child, youth and family studies, and Tori Molfese, professor of child, youth and family studies. With a grant from the Buffett Early Childhood Fund, the trio is partnering with the Educares of Omaha and Lincoln to plan and conduct up to eight professional development sessions in math content and pedagogy (learning about teaching) for Educare staff.

"We want preschool teachers to be more intentional, planful, observant and reflective about math education," Heaton says. "Carolyn and Tori know where young children are developmentally and are grounded in preschool educational practice. I know what these children need to know as they enter elementary school. We are all versed in teacher professional



understand what it takes to provide a rich and rigorous environment for math teaching and learning."

development. It's important to begin as early as possible to give children the right start in terms of learning mathematics."

The 18-month pilot project targets Educare teachers of children 3 to 4 years old, and covers key concepts like sets, number sense, counting, number operations (addition, subtraction, etc.), patterns, measurement, data analysis and spatial relationships (shapes). Projected outcomes include:

- Better understanding of mathematical ideas among young children
- Improved motivation toward teaching mathematics among teachers
- More intentionality in the way teachers plan mathematics lessons, design their environment and interface with families
- Increased recognition and utilization of opportunities throughout the day to help children think about math

"Over time, we hope math becomes as important in the children's realm as literacy," Heaton says. "We want math to get the same kind of attention as literacy. And we want preschool teachers to see that they are capable of understanding mathematics in comprehensive ways—just like they do literacy."

It's oddly apropos that the Jacksons' "ABC" climbed the Billboard Hot 100 to knock "Let It Be" by the Beatles out of the number one spot. Heaton, Edwards and Molfese, not content to let the status quo be, are optimistic about the success of "Math Early On."

"Math is more than just counting," Heaton concludes. "Our goal is to help children build a solid foundation from which to develop mathematical understanding as they move into the early years. And to help teachers



Science & Math Lifespan

Smart start

Teaching math to preschoolers starts with strengthening teachers' mathematical confidence and understanding.



Science & Math Literacy

Retooling LIFE

"The importance of the life sciences to UNL's future demands an innovative, interdisciplinary, multi-college approach."

Steven Harris was having too much fun in the lab. Originally bound for medical school, he found himself so taken by the lab experience that he decided instead to become a scientist. Today he is professor of plant pathology in the Center for Plant Science Innovation at the University of Nebraska-Lincoln. And he is an instructor of LIFE 120, the first segment of a two-semester sequence that lies at the heart of UNL's Life Sciences Undergraduate Curriculum Initiative.

"The purpose of the initiative is to streamline the life sciences curriculum across multiple UNL campuses, colleges and majors," Harris explains, "so that no matter what specialties students pursue later in their college careers, they'll draw from the same basic fundamentals of biology they will have gained by the end of their freshman year."

Prior to the initiative's launch in the fall of 2013, UNL faculty had identified the life sciences as an academic and research priority. But there was a problem. "The academic programs that contribute to the current life sciences curriculum are

The thrill of discovery

often independent and operating without coordination across departments and among colleges," wrote initiative co-planners John Osterman, associate professor of biology in the College of Arts and Sciences, and Tiffany Heng-Moss, professor of entomology and associate dean in the College of Agricultural Sciences and Natural Resources. "The importance of the life sciences to UNL's future demands an innovative, interdisciplinary, multi-college approach to maximize our efforts in undergraduate education in the life sciences."

The answer? LIFE 120/120L and LIFE 121/121L, a two-semester series of courses and associated laboratories covering the fundamentals of biology for freshmen planning to tackle more advanced biology courses down the road. One week, "dry labs" unite UNL's campuses with a co-teaching model of instruction employing student-centered, interactive learning. Instructors represent UNL's colleges of Arts and Sciences, Agricultural Sciences and Natural Resources, and Education and Human Sciences. The next week, lead faculty facilitate guided inquiry "wet labs" during which students conduct self-designed experiments and embark on personal journeys of scientific discovery.

"We want students to think like a scientist and act like a scientist," says Harris, who coordinates the LIFE 120 labs. "We want to improve their overall scientific acumen."

"Response has been overwhelming," Osterman notes. "Last fall we expected an enrollment of maybe 500 at the most, but the final count shot up to nearly 700. The initiative has stimulated a lot of excitement among faculty and students alike."

It may take a few years before the initiative's success can fully be measured. Ultimately, UNL hopes to see increasing numbers of well-prepared, aspiring scientists enroll in upper-level life sciences courses as they anticipate the completion of their degrees.



"Practicing scientists often can trace back to an 'aha moment' when they said, 'Wow – I'm the first one to know something!'" Harris muses. "My dream is that students encounter that 'aha moment' their very first year at UNL. It's the thrill of discovery. And it's addicting. Perhaps then they'll decide to pursue a career in science. That's what happened to me."



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