Starting early on science

UC researcher Heidi Kloos works to keep children ahead in the global science race by reaching out to our youngest learners.

By Dawn Fuller

Photos by Lisa Ventre

Four-year-old Sophie **Gervais was so excited she could barely sit still in her chair.**

Earlier that morning, while planning for her visit to the University of Cincinnati's Children's Cognitive Research Lab, she insisted that her mommy fix her hair just like Princess Leia's in "Star Wars." Shortly after her arrival at UC, her mouth and her big, brown eyes were wide open with wonder, excitement and anticipation.

Heidi Kloos, PhD, UC assistant professor of psychology, captured Sophie's unwavering attention when she seated her in front of a large water tank, showed her two weights and said, "Guess what? These are submarines. These are the same weight, but one is bigger than the other. Which one will sink the fastest?"

Sophie pointed out her choice. "You told me this one would sink the fastest, right?" Kloos said to Sophie, as she held the weights over the tank. Sophie nodded eagerly. "Are you ready? Get set…"

HOW DO YOUNG CHILDREN COME TO KNOW something that hasn't been explicitly taught to them? And how can it be changed?

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"*Go!*" Sophie exclaimed, containing her excitement no longer. In this scenario, the smaller submarine sped to the bottom of the water tank in a game that lasted less than 3 seconds. Kloos, however, had more submarines to sink, and this was far more than just a game.

"This is pioneering research that could position us nationally, because I investigate how young children can learn about science," she says. "The NSF (National

Science Foundation) emphasizes that more study needs to be done on this topic."

For her work, Kloos received more than $700,000 from the NSF's Research and Evaluation on Education in Science and Engineering program, which is dedicated to advancing research at the frontiers of science, technology, engineering and mathematics (STEM) learning.

Kloos demonstrates in her research that in order for children to learn science, they must have coherent structure, and the younger they are when they're first exposed to it, the better.

"Children cannot be sure of the world unless it's structured properly. When the appropriate organization is hidden, they'll form coherent but mistaken beliefs about what they experience," she says. "They will latch onto the simplest coherent order that they can come up with, and then they'll hold onto their beliefs like a blanket.

"Young children love order and structure more than being correct," says Kloos. "So, to learn scientific concepts, we have to get them into an environment that's highly structured. If they're going to learn about density, we need to create an environment where density is super-salient. We have to provide them with the appropriate conceptual framework, even when they are only 4 years old. Letting them explore a cluttered domain on their own is not enough. And in fact, it leads children to form

Photo: Dottie Stover

In 2006, Heidi Kloos hired her first group of psychology students to design the rooms for the Children's Cognitive Research Lab, carpeting the floors and designing the spaces to look more welcoming to young children. The lab has been growing ever since, with more than a half-dozen undergrads and two graduate students conducting their studies. Now there are six separate research projects under way that are exploring the question of how young children can profit from coherent structure in learning.

Children's Cognitive Research Lab

One of the projects in the Children's Cognitive Research Lab is the "**Door Study**," led by first-year graduate student, Lori Gersham. Mother of little Sophie Gervais and her 6-year-old brother, Luc, another lab visitor, Gresham is examining the behavior of children who take part in the "Door Study." It's a game of hide-and-seek, as a ball rolls behind doors and stops at a wall behind one of those doors. Even 2-year-olds can see the wall above the screen, and they are told the ball is by the wall, but surprisingly, they do not use this information to open the correct door.

"Young children look surprised when a ball seemingly passes through a solid wall, but they can't seem to locate the ball when you ask them to find it behind the door," Gresham explains. "In some sense, children know the ball will not pass through the wall, but they can't find it. We're exploring how to help them connect the dots and look for the ball in the right location."

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mistaken beliefs that are hard to change later on."

Through that ordered environment, the long-term goal of the research, Kloos says, is to improve teaching approaches by taking advantage of children's bias toward consistency and congruence, rather than working against it.

In the Children's Cognitive Research Lab on UC's campus, Kloos is investigating how 4- to 5-year-olds are developing their ideas about physics. The submarine sinking game is one example of how she's exploring how they form these ideas.

"They have all these beliefs about physics that nobody has told them about. That's why we call it naïve physics. No one has instructed them about physics, they just make ideas up on their own. If anybody asks them about what might sink faster, they come up with a consistent answer on the spot—just not always the right answer."

Children differ in this from adults, Kloos believes, because adults are more flexible. "If we [adults] see something at odds, we have the extra energy to explore further. Rather than exploring something surprising further, children will try to confirm their beliefs. And if that's not possible, then they'll move on and find another thing to play with.

"I'm interested in where children develop these ideas," Kloos adds. "How did this naïve knowledge develop? And of course how does it link

Door Study

Children's Cognitive Research Lab

Graduate student Daniel Bullard is following the performance of children who take part in the "**Balance Study**," which examines how children learn to balance blocks that weigh more on one end than the other. Children are asked to place the block on a narrow beam to create a "see-saw" that balances. However, children typically ignore the unequal weight distribution of the blocks and focus on the middle of the block as their balancing point. "Their performance goes down as they get older," notes Bullard. "This shows that they create their own structure of what they experience."

Balance Study

to knowledge development in general? How do young children come to know something that hasn't been explicitly taught to them? And how can it be changed? Answering these questions will be supported by this grant."

THIS PIONEERING RESEARCH investigating how young children can learn about science could position UC nationally.

Kloos became interested in learning and knowledge development from her own world experience as a high school student. She believes her interest in math and science was fueled as a young student living in Romania. When she moved to Germany, she discovered she was a standout student in math and science while other students struggled.

"When I started studying psychology, I wanted to find out what made math and science easier to understand for some people and harder for others, and I think it was because of how we were taught."

Kloos eventually came to the U.S. to pursue her graduate degree at Arizona State University. She also worked as a researcher at the University of Massachusetts and as a postdoctoral student at Ohio State University. She has been a faculty member in the UC psychology department for nearly three years.

A mother of two—Nik, 10, and daughter Tanaja, 7—Kloos says she finds preschoolers the most delightful age group to study. They are an age group that often has more answers than questions, she says, even though the answers are not always right.

"They're naïve, but still so sophisticated in their way of understanding the world and putting things together. I love that—that wide-eyed look and that excitement that says, 'Tell me more about the world, because I think I get it.'"

Child scientists from outside the Children's Cognitive Research Lab are also being recruited. In 2007, Kloos formed a partnership with the Duke Energy Children's Museum at the Cincinnati Museum Center at Union Terminal. She first joined a museum exhibit "Women and Science" that invited research presentations at the center. Also in a joint venture with the Children's Museum, Kloos developed a UC undergraduate capstone course last fall. The museum's young visitors participated in various tasks as UC students examined how the children learned. Kloos says that partnership is ongoing, with a conference presentation in the planning stage.

Photo: Lisa Britton

With separate National Science Foundation funding from the Human and Social Dynamics program, the Kloos lab is collaborating to explore how children manage to coordinate separate activities, such as walking and thinking at the same time. These results will add important answers to basic-level questions of development, helping to piece together the puzzle on learning and knowledge development.