National Inventors Hall of Fame®

THE BENEFITS OF STEM EDUCATION AT THE PRESCHOOL LEVEL

Innovation begins from a place of curiosity. Whether it be an engineer wondering how she can design a more reliable piece of machinery, or a scientist interested in the properties of a newly discovered material, the desire to improve the world around us is inspired by our curious nature and is at the heart of some of the most important STEM (science, technology, engineering and mathematics) advances and discoveries.

Children are especially curious – so much so that researchers estimate preschoolers ask an incredible 76 information-seeking questions per hour.[1] This innate sense of wonder and curiosity makes this age group uniquely suited to explore STEM topics. While some critics might argue that children in this age range have not developed enough to benefit from this type of specialized learning, research has shown the opposite. According to the Center for Childhood Creativity, "even before a child's first birthday, she is capable of making inferences, drawing conclusions about cause and effect, and reasoning about the probability of events."[2] If encouraged and developed correctly, these skills can act as a foundation for the growth of abstract reasoning crucial to excelling in any STEM-related field.

However, in order to provide the most effective STEM instruction for preschoolers, it's crucial that educators and administrators alike are aware of the most effective, research-backed techniques proven to engage children in this age group.

STEM LEARNING BEGINS WITH PLAY

Play is a universal activity essential to human development. In fact, during the first years of life, playing represents the primary method by which people explore the world. In a recent New York Times article, Catherine Tamis-LeMonda, professor of applied psychology at New York University, promotes this idea:

"I don't like it when scientists think children are playing only when they sit down with some toys," she said. "Almost all the learning that goes on in the first years of life is in the context of exploration of the environment."[3]

Though developmental psychologists have long echoed Tamis-LeMonda's praise of play, increasingly, teachers and administrators feel pressured to follow policies that place a far greater importance on academic readiness and standardized testing. Although this might sound like a pragmatic approach, Atlantic reporter Erika Christakis' article, "The New Preschool Is Crushing Kids" paints a far more troubling picture in line with what many preschool educators experience:

"Preschool classrooms have become increasingly fraught spaces, with teachers cajoling their charges to finish their 'work' before they can go play. And yet, even as preschoolers are learning more pre-academic skills at earlier ages, I've heard many teachers say that they seem somehow — is it possible? — less inquisitive and less engaged than the kids of earlier generations."[4]

In paradoxical fashion, this overemphasis on academic readiness has been shown by researchers at Vanderbilt University to cause children to become less academically prepared as they age.[5] Citing "an overreliance on direct instruction and repetitive, poorly structured pedagogy," the research found that the students in their study who attended preschool performed worse than those who had not.[6]

This study suggests that as children age, they are becoming less engaged and therefore more disinterested in school. To reverse this trend, educators can incorporate different types of play that will develop both STEM skills and excitement for learning.

A young innovator builds her invention prototype at Invention Playground

1. Frazier, Brandy N., Susan A. Gelman, and Henry M. Wellman. "Preschoolers' Search for Explanatory Information Within Adult-Child Conversation." Child Development 80, no. 6 (2009): 1592-611. doi:10.1111/j.1467-8624.2009.01356.x.
2. Hadani, Helen Shwe, Ph.D., Elizabeth Rood, Ed.D., Amy Elisenmann, Ruthe Foushee, Garrett Jaeger, Ph.D., Gina Jaeger, Ph.D., Joanna Kauffmann, Katie Kennedy, and Lisa Regalla. "The Roots of STEM Success: Changing Early Learning to Build Lifelong Thinking Skills." 2018. http://448bn62kp97s14oorg3xs7hn-wpengine.netdna-ssl.com/wp-content/uploads/sites/2/2018/02/CCC_The_Roots_of_STEM_Early_Learning.pdf
3. Klass, Perri. "Taking Playtime Seriously." January 29, 2018. https://www.nytimes.com/2018/01/29/well/family/taking-playtime-seriously.html
4. Christakis, Erica. "How the New Preschool Is Crushing Kids." December 28, 2015. https://www.theatlantic.com/magazine/archive/2016/01/the-new-preschool-is-crushing-kids/419139/

FOUR TYPES OF PLAY TO DEVELOP STEM LEARNING

According to the Center for Childhood Creativity, there are four different types of play that foster STEM learning:[7]

1 PRETEND PLAY

Children engaged in pretend play use their imaginations to create or enact stories. Often, objects around them represent other things (e.g., a stick becomes a sword, or the ground becomes lava) that help build their make-believe world.

2 EXPLORATORY PLAY

In exploratory play, children build, tinker and take things apart in order to better understand how the world works.

3 GUIDED PLAY

When participating in guided play, adults interact alongside children. During these sessions, they ask children questions, pose new challenges and lead them to specific learning outcomes.

4 FREE PLAY

Free play gives children control over how they want to play and does not involve adult collaboration. Here, an educator's job is to make sure students are safe and practicing acceptable behaviors.

Two Invention Playground participants explore foundational STEM concepts as they blow bubbles

Through these four different styles of play, preschoolers develop valuable causal reasoning skills – the ability to understand cause and effect. Not only is causal reasoning foundational for science learning, but research published in Frontiers in Psychology suggests that preschoolers actually prefer to learn using causal information.[8]

With all these findings in mind, it's clear that a hands-on approach to learning rooted in play is incredibly effective for preschool-aged children. For educators looking to introduce STEM topics in an engaging way, a curriculum that promotes active, self-directed learning is crucial.

USING ACTIVE LEARNING TO CULTIVATE A PASSION FOR STEM

The days of traditional mathematics and science learning are over. No longer can educators simply lecture or expect passive learning techniques to spark students' interest. Instead, according to the recently released Next Generation Science Standards (NGSS), the best way to learn science, "is by doing science."[9]

This revised approach aligns with what researchers have been saying for over a decade: students who participate in active learning are more engaged, retain more information and have a more positive attitude toward what they're learning.[10]

For children in preschool whose attention spans are limited[11], engagement is one of the primary challenges teachers must overcome. According to the Center for Childhood Creativity, incorporating hands-on learning is an ideal way to maintain a high level of excitement and interest in these classrooms.

"Encouraging children to use their hands; count on their fingers; and move, build, and tinker during learning experiences not only engages different neural networks relevant for problem solving (e.g., prefrontal and motor cortices), but also allows children to access and utilize conceptual understanding they cannot yet articulate."[12]

The importance of active learning for preschool-aged students was demonstrated in research published in Developmental Science that examined gesture training in preschool and school-aged students.[13] In the study, researchers monitored the different effects that observing versus producing gestures has on a child's performance of a special transformation task – combining two halves of a shape

5. Lipsey, Mark, Vanderbilt University, Kerry G. Hofer, and Abt Associates. "Effects of a State Prekindergarten Program on Children's Achievement and Behavior through Third Grade." 2016. https://peabody.vanderbilt.edu/research/pri/TNVPK_Grade_3_working_paper.pdf
6. Ibid., 3
7. Hadani, H.S., "The Roots of STEM Success" 12.
8. Alvarez, Aubry L., and Amy E. Booth. "Preschoolers Prefer to Learn Causal Information." Frontiers in Psychology. February 13, 2015. Accessed June 18, 2019. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4327508/
9. Understanding the Standards, Next Generation Science Standards. 2019. https://www.nextgenscience.org/understanding-standards/understanding-standards
10. Prince, Michael. "Does Active Learning Work? A Review of the Research." Journal of Engineering Education 93, no. 3 (2004): 223-31. doi:10.1002/j.2168-9830.2004.tb00809.x.

to make a whole. The researchers found that 6-year-olds who were encouraged to act out the required motions with their hands were more successful than those who were asked to simply point at the completion of the shape. In 2017, this study was repeated with preschool-aged children, and researchers found that performing the gestures provided an even greater benefit to these younger students.[14]

INVESTING IN A CHILD'S EARLY STEM SUCCESS

By the time a child turns 5 years old, their brain grows to 90% of its adult size.[15] Because of this, these years represent a valuable time for developing the type of creativity and curiosity needed to excel in a STEM career. Nobel Prize-winning economist James Heckman agrees with the importance of investing very early on in a child's education. According to his groundbreaking research, "the highest rate of return in early childhood development comes from investing as early as possible," and the greatest return on investment (ROI) for resources spent on educational development occurs during a child's first five years of life.[16]

The National Inventors Hall of Fame® (NIHF) believes in the importance of early STEM education, and considers it one of the best ways to inspire the next generation of innovators.

Because of this, we are especially proud of the PreK STEM curriculum offered in our Invention Playground® program. Not only do our activities incorporate the most effective and engaging teaching techniques, but they also introduce stories and lessons inspired by our world-changing NIHF Inductees. These units give preschoolers the opportunity to team up and build towers, launch rockets, create devices to keep animals safe, and explore buoyancy, circuitry and even the science of music.

By presenting children with problems and giving them open-ended time to explore their own solutions, Invention Playground provides an informal structure for enhancing established preschool curricula across the country.

To learn more about Invention Playground, we encourage you to watch the short video below:

https://www.youtube.com/watch?v=vNUpGNiCKKI

Monica Jarvis, Educator and Invention Playground customer

"These kids are so filled with enthusiasm and excitement because they are experiencing and seeing things for the first time. Having these kinds of exposures at such a young age builds for them great foundations that apply to all subjects."

Monica Jarvis, Educator and Invention Playground customer

11. Mahone, E. M., and H. E. Schneider. "Assessment of Attention in Preschoolers." Neuropsychology Review. December 2012. Accessed June 19, 2019. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3511648/#R122
12. Hadani, H.S., "The Roots of STEM Success" 22.
13. Goldin-Meadow, Susan, Susan C. Levine, Elena Zinchenko, Terina Kuangyi Yip, Naureen Hemani, and Laiah Factor. "Doing Gesture Promotes Learning a Mental Transformation Task Better than Seeing Gesture." Developmental Science 15, no. 6 (2012): 876-84. doi:10.1111/j.1467-7687.2012.01185.x. Jaeger, G.O., Jaeger, G. J., & Chen, Z. (2017). Helping hands: "Gesture facilitates problem-solving in early development." Manuscript submitted for publication.
14. Brown, Timothy T., and Terry L. Jernigan. "Brain Development during the Preschool Years." Neuropsychology Review. December 2012. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3511633/
15. Heckman, James. "Invest in Early Childhood Development: Reduce Deficits, Strengthen the Economy." The Heckman Equation. February 15, 2017. https://heckmanequation.org/resource/invest-in-early-childhood-development-reduce-deficits-strengthen-the-economy/