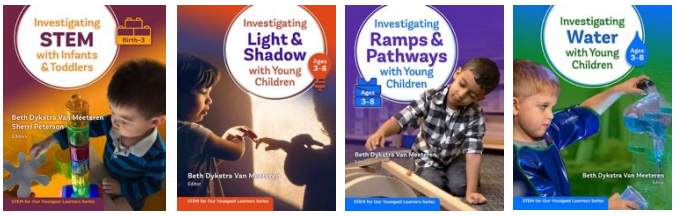
Research Based Professional Development on Ways to Design STEM Experiences for Children ages Birth to 8



What is STEM for young learners? Young learners often engage in STEM when they work with open-ended materials. They grapple with **science** concepts such as the properties of materials and physics, and the **mathematics** of spatial thinking as they **engineer** their **technology** of block structures, ramp and pathway systems, and systems to move water and air, images on a screen, and works of art using a variety of media. Engineering is unique in that to engineer is to also engage in science, technology, and mathematics. Engineering is the glue holding STEM together and the reason why we pay close attention to facilitating children's opportunities to engineer. Read on to learn about our approach to early STEM in our professional development for educators.

Our criteria for high quality STEM experiences: 1) the young learners need to be able to produce an action themselves; 2) the result of that action is immediate; 3) the result must be observable by the student; 4) there is something for the young learner to vary and try again (Counsell et al., 2015). Our experiences invite and encourage young learners to use the tools of literacy and mathematics in meaningful ways, and in the process, develop social skills. STEM can be the glue that unites all the subjects, enhances learning in all domains, and brings joyful and meaningful learning to the classroom.

Engineering Design Process or Engineering Habits of Mind? We advocate for focusing on engineering habits of mind. Professional engineers use their understanding of science to efficiently design and engineer technology for other people. In contrast, children's drive to design and engineer results in a growing understanding of science (VanMeeteren, 2018). Young learners have an intrinsic desire to design and engineer but do not yet have a robust understanding of science. In their process of designing and engineering they encounter problems of physics. Professional engineers do not follow a specific linear design process. It is much more complex. Young learners' approach to engineering is also complex and does not follow a linear design process (VanMeeteren & Zan, 2010; VanMeeteren, 2014). We find it more productive to focus on nurturing engineering habits of mind that includes systems thinking, creativity, optimism, collaboration, communication, and attention to ethical considerations (NAE & NRC, 2009).

Who selects the engineering design problems? The young learners do if we let them. While professional engineers solve other people's problems, young learners are most invested in solving their own problems. Rather than following a five-step engineering design process, they fluctuate among macro, meso, and micro design problems (VanMeeteren, 2022). Teachers can start this by providing an open-ended macro question such as "How can you move a marble in an interesting way? Young learners use open-ended materials to take on their own meso problem of designing such as a system to move a marble along a series of ramps and pathways. In the process of engineering their design, they encounter micro problems, or problems of physics that inform them that their design needs to change. They go through many iterations of meso and micro problems and persist until they have a successful system. Once they are successful, they are ready to find a more difficult design challenge using the same materials. They develop a growth mindset as they come to view errors as an opportunity to learn.

Teachers are engineers. When empowered by their administrators, teachers use their understanding of the science of child development, developmentally appropriate curriculum, and pedagogy to design and engineer the space of the classroom to optimize learning. They can continuously refine their expertise in engineering by focusing on four aspects of the environment: the physical, social-emotional, intellectual, and promotional environments within a classroom (VanMeeteren, 2022). 1) **the physical environment:** Young children come to school wanting to learn. The arrangement of the physical environment has clearly defined areas for learning that invite young learners to investigate, discuss, ponder, and create in **all** subjects. Moveable furniture that can be configured in multiple ways divides these areas, yet still allow the teacher to see all areas at all times. Buffers separate quiet and active spaces. 2) **the social-emotional environment:** An environment of inquiry demands an atmosphere where young learners are allowed to explore and investigate answers to their questions. We learn when we are challenged by our mistakes or misconceptions and investigate them. When young

learners expect to make mistakes and are given time to problem solve and fix them, they continue to challenge themselves and view this is the normal process of learning. They realize they may not be good at something… **yet.** 3) **the intellectual environment:** An environment with intellectual goals "addresses the life of the mind in its fullest sense, including a range of aesthetic and moral sensibilities." This environment facilitates "reasoning, hypothesizing, predicting, the quest for understanding and conjecturing, as well as the development and analysis of ideas." This environment encourages and motivates young learners to seek mastery of basic academic skills *in the service of their intellectual pursuits* (Katz, 2010). An intellectual environment "does not merely *furnish* the mind, but *forms the* mind" (Kohlberg & DeVries, 1987). 4) **the promotional environment**: Documentation of young learners' thinking and their artifacts are promoted when they are awarded high visibility space on the walls and shelving of a classroom. They are important resources for teaching and serve as evidence of the learning process. This documentation promotes and celebrates the learning experiences within that classroom and includes evidence of building upon young learner's prior knowledge, curiosity, and interest that leads to planning, investigation, and elaboration. These are not viewed as classroom decorations. They are tools in the classroom environment that support continuous learning (Evanshen & Faulk, 2011).

Teachers can engineer time to include STEM every day. Just as young learners need to read every day to develop as readers, they need to engage in STEM experiences every day to develop as innovators and capable scientists. The Iowa Regents' Center has developed a framework to assist teachers in providing time and space for their young learners to engage in **STEM investigations every day**. This framework dovetails nicely into the literacy small group instruction time and serves to elevate students' literacy learning (VanMeeteren, 2022).

Teacher Play Our professional development is active and hands-on. Educators work with the same materials they will offer to young learners. Join us and **b*ecome the learner you want your students to be.***

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For more information contact:
Iowa Regents' Center for Early Developmental Education
117 Schindler Education Center
University of Northern Iowa
Cedar Falls, Iowa 50614-0616
319-273-2101

UNI University of Northern Iowa · The University of Iowa · Iowa State University