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Early STEM Exposure Through Career-Focused PBL



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Project-based learning can help educators link STEM concepts to careers. Here's why this matters—along with three keys to success.

Science, technology, engineering, and mathematics (STEM) education is most effective when students understand how these concepts apply in the real world. Learning how actual scientists, engineers, and other professionals use STEM concepts to solve complex problems helps bring these ideas to life and answers the age-old question, "Why do we have to learn this?"

What's more, connecting STEM concepts and careers should begin in elementary school, when students' natural curiosity is greatest. Not only does this make STEM education more concrete for students; it also exposes them to possible career paths at a young age, which expands their vision for what is possible in life.

For these and other reasons, creating a career-focused STEM program in the early grades can reap huge benefits, positioning students well for future success. And project-based learning (PBL) is a highly effective technique for creating such a program.

By assuming the roles of a professional as they look to solve authentic problems, students learn more about STEM subjects and the roles they play in various careers. They also make deep connections between the content and how these concepts are applied within various careers.

This white paper explores how a career-focused STEM program can benefit students in the early grades, and how PBL aptly supports this goal. It looks at how some high-performing school systems are using PBL to link STEM concepts and careers—and it reveals the keys to doing this successfully.

Why Teach STEM in the Early Grades?

According to the report *STEM Starts Early,* co-published by the Joan Ganz Cooney Center and New America, research shows that children can—and should—engage in STEM learning at a very young age.[1]

"We now know that very young children are much more capable of learning about STEM concepts and practices than originally thought, resulting in missed opportunities for early learning when we wait to start STEM education until later," the report states. "In fact, a growing number of studies show a correlation between early experiences with STEM subjects and later success in those subjects or in school generally."

For instance, children who engage in scientific inquiry from an early age "develop positive attitudes toward science, which also correlate with later science achievement—and they are more likely to pursue STEM expertise and careers later on."

But early STEM learning experiences also support a child's development across a wide range of areas, including literacy and problem solving. When children have opportunities to collect evidence and solve scientific problems, the report says, they build foundational skills that can be used in many ways throughout their lives.

To Caroline Gordon Messenger, director of curriculum for the Naugatuck Public Schools in Connecticut, it makes sense that educators should leverage young students' curiosity about the world to teach STEM concepts at an early age.

"Exposure to STEM learning in the early grades is critical," she says. "It's probably what is most intriguing to students. They are always asking, 'Why?' They're inquisitive about how the world works by nature."

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[1] McClure, E., et al. *STEM Starts Early: Grounding science, technology, engineering, and math education in early childhood.* The Joan Ganz Cooney Center at Sesame Workshop and New America (2017). Retrieved from http://joanganzcooneycenter.org/publication/stem-starts-early.

Why Focus on Careers Within STEM Instruction?

Introducing students to STEM careers (and the people who do this work) helps them make valuable connections between what they are learning in school and how it applies outside the classroom. For example, seeing how a creative designer uses her knowledge of math, science, engineering, and technology to design backpacks that will appeal to consumers makes these concepts more relatable for students.

Learning about various STEM careers can also spark students' interest in STEM education by giving them something to aspire to. Meeting exploration geologists who serve as modern-day treasure hunters, traveling the globe testing the earth's surface for possible mineral or oil deposits … or animal behaviorists who are important to global conservation efforts … or digital forensics experts who help solve crimes … can open new worlds of possibility to students. In turn, students may be inspired to follow in the footsteps of these STEM professionals.

"The transition to adulthood starts in preschool," says Dr. Genevra Walters, superintendent of the Kankakee School District in Kankakee, Illinois. "From the moment students walk through our doors to the time they walk across the stage to receive their high-school diplomas, it's our job as educators to do everything we can to prepare them for life outside the classroom and for the jobs of the future."



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She continues: "Ask a third-grader what they want to be when they grow up, and you'll likely get answers like a teacher, a police officer, or a doctor. To a child, the idea of what those careers entail is narrow. When we take the time to dig deeper into specific fields, we open our students' minds to new career paths they may never have thought of: engineer, builder, or scientist."[2]

Fueling students' interest in the STEM disciplines at an early age could be critical to meeting the need for STEM professionals. For instance, global management consulting firm McKinsey & Co. estimates there will be 50 million new technology jobs created by 2030.[3]

"At least 20 percent of U.S. jobs require a high level of knowledge in any one STEM field," according to *STEM 2026: A Vision for Innovation in STEM Education*, a 2016 report from the U.S. Department of Education. But even outside the traditional STEM job sector, there is a need for STEM competencies and skills.

"Data show that the set of core cognitive knowledge, skills, and abilities that are associated with a STEM education are in demand in nearly all job sectors and occupations," the *STEM 2026* report says.[4]

How Project-Based Learning Can Help

Project-based learning is an effective way to link STEM concepts and careers. With PBL, students are given the kinds of authentic performance tasks to complete that actual STEM professionals work on solving in the field.

Returning to an earlier example, after meeting a creative designer who designs backpacks and learning how she uses STEM principles to accomplish this task, students might be challenged to design their own ideal backpack. By applying these principles for themselves in a hands-on manner, students develop a deeper understanding of the concepts involved. And by taking on the role of STEM professionals as they complete this work, not only do they learn more about STEM careers—but they begin to feel like actual scientists and engineers.

When implemented well, PBL can be a highly engaging and effective instructional strategy. In a study involving a large suburban school system, independent research firm MIDA Learning Technologies compared the attitudes and achievement of second- and fifth-graders in classrooms using PBL with those of students in more traditional classrooms.

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[2] Walters, G. "Why College and Career Readiness Belongs in Preschool." *Tech & Learning*, June 21, 2016. Retrieved from https://www.techlearning.com/resources/why-college-and-career-readiness-begins-in-preschool.

[3] Bughin, J., et al. *Skill Shift: Automation and the Future of the Workforce.* McKinsey & Co. (2018). Retrieved from https://www.mckinsey.com/featured-insights/future-of-work/skill-shift-automation-and-the-future-of-the-workforce.

[4] *STEM 2026: A Vision for Innovation in STEM Education.* U.S. Department of Education, Office of Innovation and Improvement (2016). Retrieved from https://innovation.ed.gov/files/2016/09/AIR-STEM2026_Report_2016.pdf.

The researchers found that students in the PBL classrooms "significantly outperformed their peers in the corresponding control groups," their report says. "In addition, teacher reflections in interviews and focus groups indicated that student enthusiasm, motivation, and engagement in the (PBL) classes were very high."[5]



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These findings are consistent with a growing body of research that suggests PBL provides a deeper, more meaningful understanding of content—while engaging students in a highly motivating learning environment.

In light of this growing body of research, the STEM 2026 report from the U.S. Department of Education recommends that STEM concepts be taught using real-world situations or problems, which the report refers to as "grand challenges."

"Tasking students with tackling a grand challenge provides them with the opportunity to understand the relevance of STEM to their lives and to see the value of STEM in addressing issues that are important to their communities," the report says. "Undertaking a grand challenge also gives students an accessible entry point (into STEM learning)—as well as the freedom to tinker with ideas because there is no one right answer to solving these issues."

Examples of PBL in Action

In the Kankakee School District, conversations about STEM careers begin as early as kindergarten. Each grade level from K-6 focuses on a different set of career pathways. As students move through elementary school, they have a chance to explore a variety of fields and decide where their interests lie. For example, first-graders focus on careers in agriculture, food, and natural resources, while third-graders focus on engineering, outer space, and plant life.

[5] Speziale, M., et al. A Comparison of Student Application of Mathematical Practices in Traditional Vs. Project-Based Classrooms. MIDA Learning Technologies LLC (2016). Retrieved from http://www.academia.edu/34623259/A_Comparison_of_Student_Application_of_Mathematical_Practices_in_Traditional_Versus_Project-Based_Classrooms.

"The idea is for students' knowledge of, and curiosity about, different career fields to evolve as they progress through elementary school," Walters says.

During the school year, students undertake four large-scale projects that align with their grade-level career focus and appropriate state standards. For instance, first-graders might be tasked with creating a garden that can feed a local community center, and they have to think about what foods they should grow to provide healthy menu options.

These hands-on projects "make the careers come alive," Walters says, "because students can apply their classroom knowledge in a real-world setting. The students are engaged, because they're using creativity and critical-thinking skills to solve a problem and play a role."

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Felice Hybert, assistant superintendent for curriculum and instruction in Kankakee, says framing instruction in terms of solving actual problems explodes teachers' preconceptions of what students can do.

"We have teachers saying: 'The kids have blown us away by what they can do at such a young age,'" she observes. "And the students are developing a passion for possible career paths they didn't know existed before."

Anthony Johnson, a fifth-grade science and social studies teacher at H.D. Isenberg Elementary School in Salisbury, North Carolina, has seen test scores soar by having students engage in career-focused PBL. "Just like in the real world, my students show what they can do through projects, teamwork, and research," he says.[6]

Johnson's students take on various roles as they complete projects. For instance, his students might assume the role of energy consultants as they research alternative energy sources and try to convince their principal and the school board that wind energy is better for the environment.

"The products the kids create, and the models they get to build, help bring science to life," he says. "The learning is hands-on—and the kids take it very seriously. They're not just doing this work for me; they're doing it for a global audience. And they take more pride in their work as a result. They become really engaged, and they work all night. I have seen them working on their projects at 10 o'clock on a Saturday night because they are so invested in the work."

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[6] Johnson, A. "I made my classroom look like the real world—and test scores soared." *eSchool News*, Oct. 7, 2016. Retrieved from https://www.eschoolnews.com/2016/10/07/i-made-my-classroom-look-like-the-real-world-and-test-scores-soared/?all.

Messenger, from the Naugatuck schools, has seen the same level of engagement from her district's problem-based model of instruction.

"All of our lessons and tasks are designed around four major components: making meaning, investigation, creating and producing, and communicating and presenting," she says. "Woven throughout this model is actionable feedback that students can use to improve their performance."

In one recent project, third-graders had to design an irrigation system using motors and tubing that would keep flowers alive for a week without human intervention.

"When I went in to observe on the second day," Messenger recalls, "one girl ran up to me and said, 'We did this yesterday, and we're just like real scientists. We failed!' The students asked their teacher if they could try it again, and he said, yes, of course. He went out and bought more supplies, and the kids were trying it again. They were excited that they had failed, because they were able to learn from that experience and redesign the system to achieve their goal."



For PBL to be successful, "teachers have to learn to let go and allow students to take control of their own learning."

Keys to Success

Linking STEM concepts and careers using a project-based approach to learning might be a radical departure from what educators are used to. Here are three keys to making this transition successfully.

Break down the walls that separate various disciplines.

"Research suggests that an interdisciplinary approach can enhance students' learning and better model STEM processes in the real world," says the STEM 2026 report. Real-life problems aren't confined to a single domain, and so project-based learning works best when the performance tasks are interdisciplinary, cutting across several different subject areas simultaneously.

If students in the upper elementary grades have different teachers for each academic subject, having these teachers get together to co-plan lessons and performance tasks that involve all these disciplines makes students' learning richer.

Help teachers learn to shift control to their students.

For PBL to be successful, "teachers have to learn to let go and allow students to take control of their own learning," Johnson says. He describes his role this way: "I'm a facilitator. I work beside them as they complete their projects. I help them when they get stuck, but they are responsible for their own learning."

This is a big adjustment for many teachers. Not only do they have to learn a new instructional strategy, but they also have to change their mindset about their role in the classroom. Having teachers experience professional development through performance-based tasks can help them make this shift effectively.

Give teachers resources to help them succeed.

Teachers need models for what high-quality, career-focused PBL looks like, and they need support in designing projects and leading students through performance tasks successfully.

Defined STEM, a PBL solution that provides an online library of engaging, authentic lessons built around careers, is one such resource. Defined STEM's cross-curricular projects provide opportunities for students to deepen their understanding of STEM-related concepts and apply their knowledge in real-world scenarios.

"What I like about Defined STEM is that the tasks are already designed for teachers," Hybert says. "If they don't have a lot of experience in designing project-based learning experiences, this helps them get there faster."

About Defined STEM

Defined STEM creates excitement about STEM career opportunities and encourages students to be more proficient in these subjects, providing a pathway to a promising future. Each project puts students in the role of a specific STEM career and asks them to conduct an authentic performance task to apply their knowledge and skills.

Defined STEM provides teachers with all the essential project design elements they need to implement and assess high-quality, project-based learning: interdisciplinary performance tasks, engaging videos, research resources, an assessment manager, and more. Video clips set the stage for each lesson by showing the practical application of STEM concepts within a company or industry, and performance tasks built around a specific job ask students to apply their knowledge to a real-world scenario.

To learn more, visit www.DefinedSTEM.com.