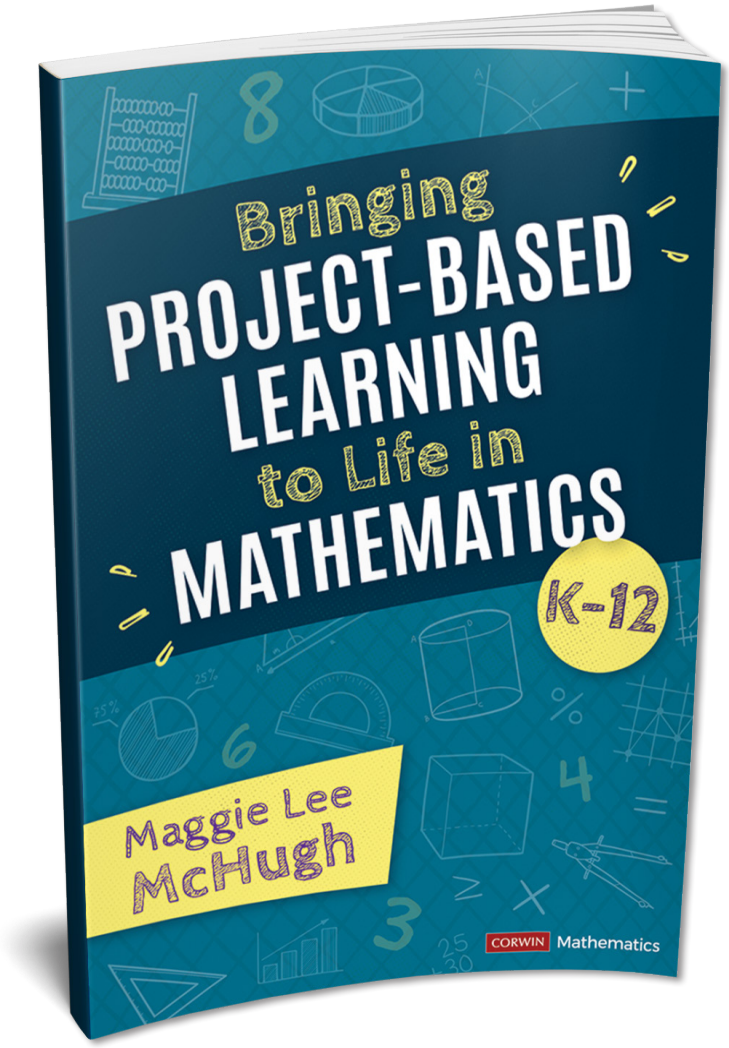

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FROM TASK TO PROJECT

Need to Knows

- How is project-based learning different from a problem-solving task or performance task?
- Why should I choose to engage students in project-based learning in addition to problem-solving and performance tasks?
- How do I turn a textbook problem into a problem-solving task, performance task, and/or project?

Diving into project-based learning (PBL) can seem like a gigantic jump for many mathematics educators. However, you can take smaller steps to ensure you and your students feel ready to tackle a project. One way is to begin implementing problem-solving tasks and performance tasks.

Most mathematics educators are familiar with problem-solving tasks, but let's clarify this idea. The National Council of Teachers of Mathematics (NCTM, 2010) recognizes the term *problem solving* in conjunction with tasks that "have the potential to provide intellectual challenges for enhancing students' mathematical understanding and development." These tasks help students view mathematics conceptually while furthering Mathematical Habits of Mind, especially Communicate Mathematically and Question & Persist in Problem Solving.

Problem-solving tasks have been likened to the phrase "low floor, high ceiling," meaning students can access the problem without much difficulty but room exists for exploration and growth. Problem-solving tasks ask students to determine a way to move from what is known to what is desired through multiple potential pathways that build upon prior knowledge and allow for creative risks. Liljedahl (2021) asserts that "good problem-solving tasks require students to get stuck and then to think, to experiment, to try and to fail, and to apply their knowledge in novel ways in order to get unstuck" (p. 20). I recommend further exploring the work of Liljedahl who examines what he calls "highly engaging thinking tasks" in his book *Building Thinking Classrooms in Mathematics*. Throughout the book, Liljedahl provides several examples of highly engaging problem-solving tasks for K–12 educators.

Additional Resources

Here's a list of other problem-solving tasks and mathematics educators I regularly consult:

- Open Middle Problems (Kaplinsky, 2019)
- 3-Act Math Tasks (Fletcher, n.d.; Lomax, n.d.; Meyer, n.d.; Pearce & Orr, n.d.; Wiernicki, n.d.)
- Visual Patterns (Nguyen, 2020)
- NRICH (University of Cambridge, 2022)

There is an option between a short problem-solving task and a full project, and that is what I'll call a performance task. According to Defined Learning (2015), a performance task is an open-ended application of knowledge and skills where students are asked to perform, create, or produce a tangible product to demonstrate their learning and proficiency. Performance tasks are similar to a shortened form of a project, where students grow in academic content and success skills through a transferable real-world application. Like a PBL experience, performance tasks emphasize cooperation, problem solving, and authentic, hands-on learning while de-emphasizing memorization or rote mathematics.

Figure 3.1 is a glimpse into the differences between a problem-solving task, a performance task, and a PBL experience. The similarities and differences between each level are on a continuum. The nuances between a performance task and a project are subtle, focused mainly on duration, depth of learning, and extent of resources.

Figure 3-1 • Comparison of Problem-Solving Task, Performance Task, and PBL Experience

	Problem-Solving Task	Performance Task	Project-Based Learning Experience
Time Frame	1 class period or less	2–5 days	6 days +
Number of Content Standards	1 content standard (one content area)	1–2 content standards (may include more than one content area)	3+ content standards (often includes multiple content areas)
Strategies and Solution	Open-ended strategies toward one or limited solutions	Open-ended strategies and multiple solutions	Open-ended strategies and multiple solutions
Real-World Context	Authentic connection possible	Authentic connection likely	Authentic connection required
Student Collaboration	Independent or collaborative	Independent or collaborative	Collaborative
Potential Role(s) Played by Student	Problem Solver, Materials Manager, Time Keeper	Researcher, Designer, Presenter	Engineer, Architect, Sports Statistician, Environmentalist, Advertising Agent, Software Designer
Outcome	Mathematical explanation	Presentation, model, prototype, diagram, sketches, public service announcement, infographic	3D-printed item, video, artwork, scaled map, fundraiser/ event, business, community presentation
Resources	Limited: Written or digital problem-solving task and solution	General: Technology for research (optional), classroom supplies	Extensive: Technology for research, experts, physical product supplies, technology for creation

WHEN PROBLEM-SOLVING TASKS AREN'T ENOUGH

Using high-quality problem-solving tasks with multiple entry points in the mathematics classroom is an effective and engaging teaching strategy. Like all quality teaching strategies, problem-solving tasks have their place in the classroom. Where problem-solving tasks often fall short is in their ability to deeply and authentically engage students in the mathematics of our world. Take, for example, the classic locker task, where students open and close lockers in a unique pattern.

I have given this engaging task with a unique solution to my middle school students; however, to what purpose? Who actually opens and closes lockers in such a pattern?

> Imagine there is an endless string of lockers in your school.
>
> Person 1 starts at locker 1 and opens every locker.
>
> Person 2 starts at locker 2 and closes every 2nd locker.
>
> Person 3 starts at locker 3 and closes every 3rd locker.
>
> Person 4 starts at locker 4 and closes every 4th locker.
>
> Person x starts at locker x and closes every xth locker.
>
> Which locker doors will be open when the process is complete?

If my purpose is for students to explore Mathematical Habits of Mind like Search for Patterns or Communicate Mathematically, then this is a quality task. It invites dialogue, helping students establish the mindset of a mathematician. However, if my goal is for students to see mathematics as a skill applied in their own lives—whether that is to create something or critique society—then a problem-solving task in and of itself may not go far enough.

This is where PBL comes into play. Through projects, students apply their mathematical skills and abilities to authentic contexts, embodying the role of a professional who uses mathematics. For example, students may assume the role of an engineer when designing a spacecraft or an architect when creating scale blueprints. Students may act as a sports statistician analyzing data to determine the peak performance levels of an athlete or an environmentalist using mathematics to persuade politicians to tackle tough issues. Moving from problem solver in a mathematics classroom to problem solver as an engineer, architect, statistician, or environmentalist elevates the dynamics of the classroom environment.

ALIGNMENT TO EQUITY-BASED TEACHING PRACTICES

Another reason I ensure PBL plays a central role in my classroom centers on my commitment to equity-based mathematics teaching practices. When using a problem-solving task or even a performance task, students may or may not experience all five equity-based mathematics teaching practices as well as the PBL equity levers described in Chapter 2. However, in a PBL experience, students almost always engage in these practices. Figure 3.2 highlights whether each equity-based mathematics teaching practice and equity lever is met on the scale of Rarely–Sometimes–Often–Always.

Figure 3-2 • Examination of Meeting Equity Levers

Equity-Based Teaching Practice *[PBLWorks Equity Lever]*	Problem-Solving Task	Performance Task	Project-Based Learning
Going Deep With Mathematics *[Cognitive Demand]*	Always A problem-solving task of high cognitive demand provides students with multiple solution pathways and representations. Problem-solving tasks support students in analyzing, comparing, justifying, and proving solutions.	Always A performance task of high cognitive demand is open-ended, allowing for multiple solution pathways and representations. Students work collaboratively in teams to analyze, compare, justify, and prove solutions.	Always A PBL experience of high cognitive demand is naturally open-ended, allowing for multiple solution pathways and representations. Students work collaboratively in teams to analyze, compare, justify, and prove solutions. Especially leveraged in a project is the opportunity for presentation and critique, leading to greater opportunities for comparison, justification, and communication of solution pathways.
Leveraging Multiple Mathematical Competencies *[Knowledge of Students* and *Cognitive Demand]*	Sometimes A problem-solving task may or may not allow for effective structured collaboration where students with varying content and success skills can contribute to complex problems. Due to the short-term nature of a problem-solving task, student collaboration is limited, perhaps not allowing all students to contribute meaningfully.	Always A performance task by its nature is collaborative. Effective structuring of a task allows students with varying content and success skills to contribute to complex problems.	Always A PBL experience by its nature is collaborative. Effective structuring of a PBL experience allows students with varying content and success skills to contribute to complex problems. In a PBL experience, our knowledge of students is heightened as we intentionally team students for long-term collaboration, allowing each student to effectively contribute through application of content knowledge or success skill.

(*Continued*)

(*Continued*)

Equity-Based Teaching Practice *[PBLWorks Equity Lever]*	Problem-Solving Task	Performance Task	Project-Based Learning
Affirming Mathematics Learners' Identities *[Knowledge of Students]*	Sometimes Problem-solving tasks promote student persistence and reasoning, leading to a growth mindset where mistakes are seen as opportunities for growth. Problem-solving tasks in and of themselves often do not recognize or lift up the multifaceted nature of mathematical identities. Reflection sometimes occurs on mathematical identity after a problem-solving task.	Often Performance tasks promote student persistence and reasoning, leading to a growth mindset where mistakes are seen as opportunities for growth. Because students have a longer amount of time in a performance task, opportunities for iteration to learn from mistakes are more prevalent. A performance task centered on an authentic context often allows for exploration of students' multifaceted mathematical identity. Reflection often occurs on mathematical identity at the conclusion of a performance task.	Always A PBL experience promotes student persistence and reasoning, leading to a growth mindset where mistakes are seen as opportunities for growth. An essential part of the project process is to critique and revise products, meaning opportunities for iteration to learn from mistakes are inherent in PBL. A PBL experience centered on an authentic context always allows for deep exploration of students' multifaceted mathematical identity. Reflection always occurs on mathematical identity both throughout and at the conclusion of a project.

Equity-Based Teaching Practice *[PBLWorks Equity Lever]*	Problem-Solving Task	Performance Task	Project-Based Learning
Challenging Spaces of Marginality *[Shared Power]*	Rarely Problem-solving tasks rarely center on students' lived experiences with racism or discrimination. In a problem-solving task, students rarely use mathematics to address societal injustices within the school or community. Problem-solving tasks sometimes are structured to leverage students as a source of expertise. Problem-solving tasks rarely allow students to generate math-based questions to explore an unjust situation. Note: Ongoing work in this area is directly addressed in *Engaging in Culturally Relevant Math Tasks* (Matthews et al., 2022a, 2022b).	Sometimes Performance tasks sometimes center on students' lived experiences with racism or discrimination. In a performance task, students sometimes use mathematics to address societal injustices within the school or community. Performance tasks often are structured to leverage students as a source of expertise. Performance tasks sometimes allow students to generate mathematics-based questions to explore an unjust situation.	Often A PBL experience often has a connection to students' lived experiences with racism or discrimination, whether that connection is at the center of a project or a part of the project. In a project, students often use mathematics to address societal injustices within the school or community. Projects are always structured to leverage students as a source of expertise, whether that expertise is content knowledge or a success skill, especially during peer-to-peer critique and revision opportunities. Projects often allow students to generate mathematics-based questions to explore an unjust situation. Projects always lift up mathematics-based questions based in authentic contexts during the gathering of Need to Know questions.

(*Continued*)

(*Continued*)

Equity-Based Teaching Practice *[PBLWorks Equity Lever]*	Problem-Solving Task	Performance Task	Project-Based Learning
Drawing on Multiple Resources of Knowledge *[Literacy]*	Rarely Problem-solving tasks rarely make connections to multiple resources outside of the task itself. Problem-solving tasks pose limited opportunities to connect school mathematics with the mathematics of the home and community. Problem-solving tasks sometimes allow students to reexamine their historical identity as a mathematics student, if students engage in targeted reflection on that topic.	Sometimes Performance tasks sometimes make connections to resources and research outside of the task. A performance task often connects school mathematics with the mathematics of the home and community. Performance tasks sometimes allow students to reexamine their historical identity as a mathematics student, if students embrace a mathematical role in the performance task and engage in reflection on that role.	Always A PBL experience always makes connections to resources and research, often leveraging experts in the field and primary sources to enhance learning. A PBL experience always connects school mathematics with the mathematics of the home and community. By embracing a role throughout the course of the project, students continually reexamine their historical identity as a mathematics student as they build a new, positive identity. This reexamination is especially lifted up during opportunities for reflection both throughout and at the conclusion of a project.