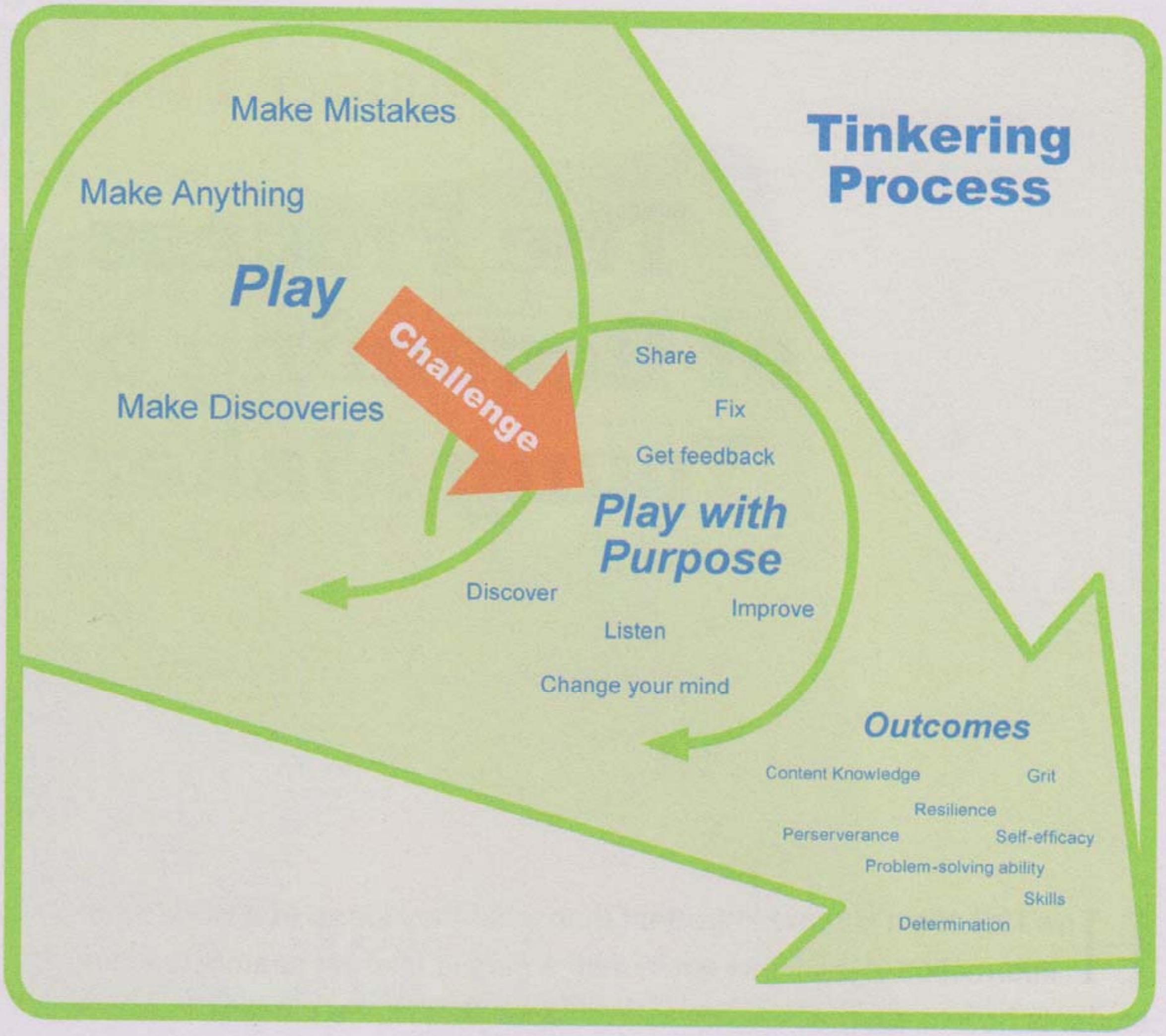
Chapter Four

The Process of Becoming a Young Maker

How kids learn is more important than what they learn. In a world where information is available easily with a simple Internet search, teaching students how to approach complex problems (that is, the process to use to solve complex problems) trumps learning facts and figures. When educators elevate process over product, we have an opportunity to embrace a purposeful, well-reasoned learning path in which all the stops along the way provide benefits to students.

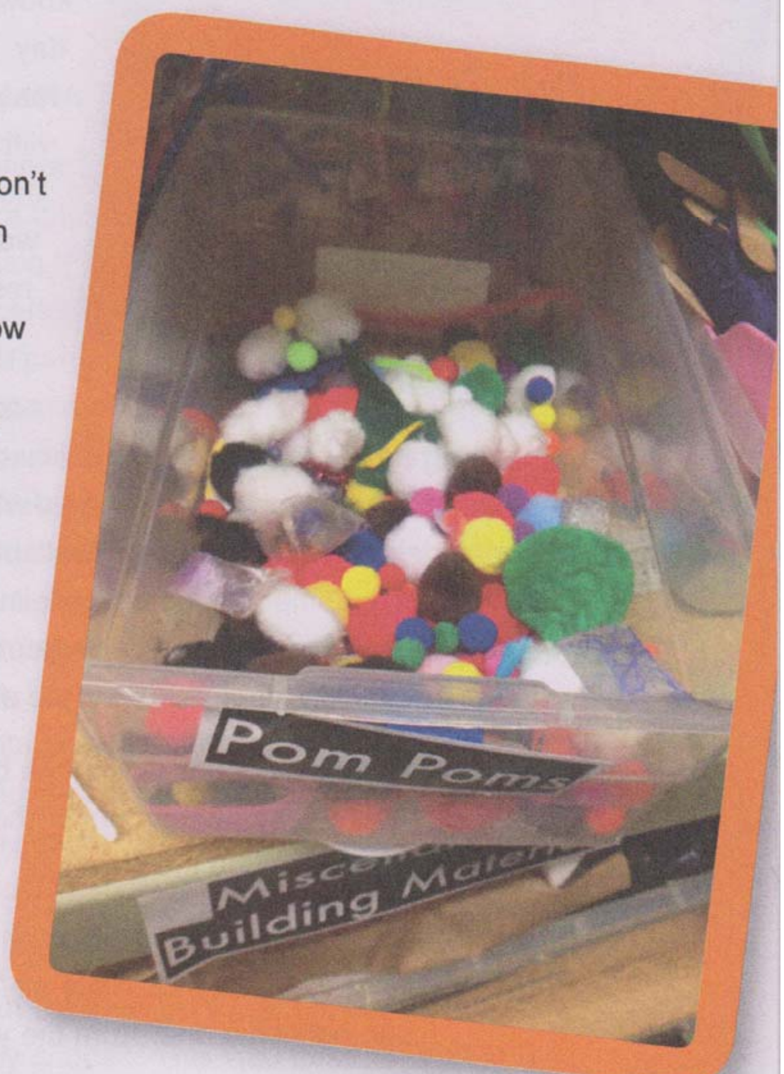
This infographic details the process I like to use. Each part of the process is explained on the following pages.



Step 1: Play

Teaching young makers works best if the very first step in the process is pure play. Maker activities involve materials, and materials are extremely fun for kids. Kids need to play with materials before you can expect them to do anything else. For example, a bin of pom-pom balls can turn an otherwise self-possessed second grader into a raving lunatic who is unable to focus on anything else because, well, A BIN OF POM-POM BALLS! Similarly, if you eventually want kids to build with LEGO bricks or toilet-paper rolls or Scratch or littleBits, they will most definitely do better if you give them a chance to play with the materials on their own terms before beginning any official activities. Playing with materials on their own terms does not mean they have license to chuck LEGO bricks at each other's faces or use every last pom-pom ball to create the world's largest caterpillar. You're still in charge and you should explain some fundamental guidelines during this stage. Do this as quickly as possible without long lectures. You will have to repeat and enforce these guidelines, but if you are consistent, students will internalize these guidelines as time goes on.

Guideline 1: Responsibly and respectfully care for nonconsumable materials



Show kids how to hold materials so they won't drop them. Show kids how to turn things on and off. Explain how to store items when kids are done. Explain and demonstrate how to be safe when using the materials. Don't underestimate kids' abilities to find ways to be unsafe! The first time I let first graders play with motors one of my students was enjoying how the spinning axle tickled against her skin. She thought it would be especially ticklish on her face, and when she held the motor up to her face, it grabbed some strands of her long hair, winding them tautly around the axle with no chance of untangling the mess. I had to give her an impromptu haircut to get the motor out of her hair. Thank goodness her parents were very understanding and suggested I open a barber shop on the side to earn extra cash.

Guideline 2: Responsibly consider use of consumable materials

Kids do not naturally practice moderation. Their tendency is much more toward excess. This can present some challenges if you want to offer a wide variety of consumable materials for kids' use for your maker activities. I am a huge fan of having tons of different materials available for kids to use when building. After all, you never know what will inspire an inventor on any given day. Helping kids learn to think about what materials they want to use for specific tasks with a goal of using consumable resources thoughtfully and responsibly without wasting is vital for creating environmentally responsible inventors for the future.

There are lots of ways to help kids be mindful of their resource consumption during maker projects. A good place to begin is a general conversation about caring for our world by using only what we need. Having lots of recycled materials and/or trash items available for building is another good idea. Often, however, kids need specific guidelines and restrictions to help them make responsible choices about using consumable resources. Depending on the age of the kids and the project we are working on, I use these approaches:

- Have kids check in with me before using a consumable resource. This allows me to monitor their use without putting too many restrictions on the kids.
- Use different storage bins or different physical space as an indicator of what they can use. Have an "unlimited" bin or shelf, or a rule that "you can only take one" from the yellow box.
- Limit their total number of consumable resources. Telling young

makers they can use up to ten items per day and/or project can be a nice limit.

- Limit the materials available for a particular day and/or project. For instance, set the googly eyes, pom-pom balls, and pipe cleaners aside, but let them use as many toothpicks and toilet paper rolls as they want.
- Assign a price to all the consumable items and give the kids a fixed budget to use. This works well for bigger, longer-term projects and for kids who can add.

Guideline 3: Safely and responsibly use tools

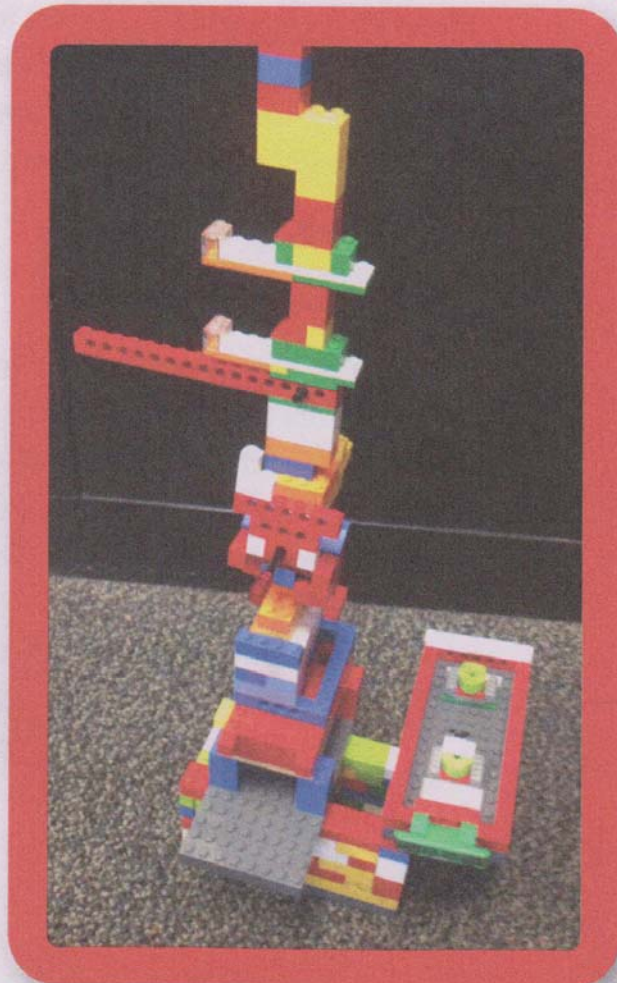
Kids take the most ownership in projects where they can do the work themselves without teacher intervention. For this reason, I try to set up learning experiences for my students in which they can do the work by themselves using age-appropriate tools. I carefully train my students to use tools safely and appropriately, and I let their parents know what their children are learning so they are not surprised if mishaps occur. And mishaps DO occur—almost all of them, fortunately, minor. Kids as young as kindergartners learn to use hand tools like screwdrivers, pliers, and hammers. We practice using the tools properly, and kids always wear safety goggles when using hand tools in my lab. I introduce the hot glue gun in the second half of second grade, and kids earn the right to use it after passing a short safety quiz. Even so, kids inevitably make mistakes with hot glue guns, so be prepared to administer lots of love when kids get minor burns. Third graders can use the hand saw and miter box to cut wood and PVC pipe. Kids love to saw, and most kids have never had the chance, in my experience. It might take forty-five minutes to get through a board, but the look of sheer delight on the successful sawer's face makes it all worth it!

Once you have reviewed the guidelines with the kids, give them some time to play with the materials in whatever way they choose. This vital unstructured time may not seem important, but it is essential. By playing with the materials in an unstructured way, kids have the chance to make all kinds of discoveries. They develop a tinkerer's mindset. The freedom to play lets kids become engaged at whatever level best suits them. Playing in this kind of flow state is enormously satisfying for the students, which helps build positive associations with the materials and the process of tinkering. A final benefit is that when you give the students a more specific challenge later, the time they will have spent playing will enable them to be more focused and productive.

Typically I allow two to three class sessions of play when introducing a new big idea. The first session starts with a very brief introduction from me—just enough information for the kids to get started. I typically begin the second play session by asking the kids to share the discoveries they had made in the first play session with each other, allowing the kids to pool their collective knowledge for the entire group's benefit. If the kids continue to be engaged and curious and making new discoveries, I sometimes add a third (and even, rarely, a fourth) day for play. I want the students to be comfortable enough with the materials and/or software that they can move forward without frustration but not so comfortable that they're bored or uninspired.

Step 2: The play-with-purpose loop

Once the kids have had a chance to play with materials or software for a sufficient amount of time, it's time to move on to the next step. In this phase, students continue to play but this time with varying levels of purpose. The goal of this step is to challenge students to make even more discoveries by issuing challenges that allow them to realize, through their own experiences, valuable concepts about the materials. For instance, if I ask kindergartners to build the tallest tower possible with LEGO bricks, they will eventually realize through trial and error that towers with sturdier bases can support more height. It may take multiple iterations; it may take sneaking a peek at what a peer is building; it may even take hints from a teacher (which I typically give out in the form of lots of questions that help kids come to realizations on their own), but all the kids will figure out what I want them to discover if I set up the challenge in exactly the right way. (Frankly, they will also figure out lots of stuff I don't expect them to discover, and that is great!)



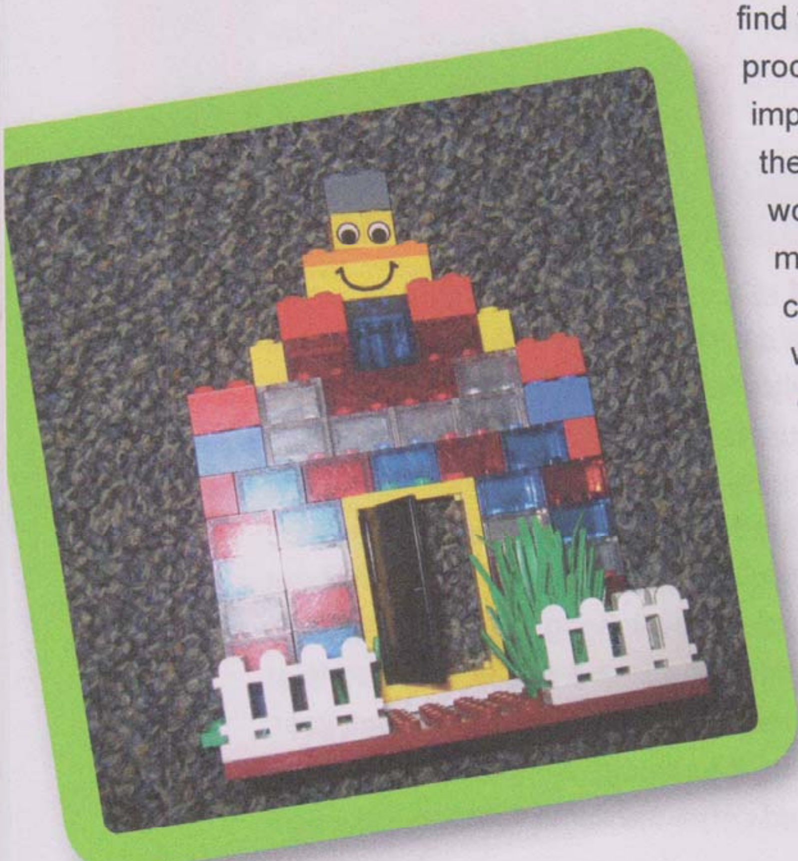
This step is very messy and cyclical. Towers fall over dramatically and must be rebuilt. Kids sometimes cry. Sometimes they become so engrossed they refuse to go to recess. Sometimes they "accidentally" build a magical fairy castle instead of a tower. Always, however, they have to try more than once to achieve a solution to the challenge I have set forth, and that is what I am aiming for at this step. I want them to fail, take risks, and make mistakes that propel their learning process forward so that their next iteration can be more successful.

Rarely you might encounter a student who is paralyzed by the idea of trying something so open-ended. In this case, I recommend that you proceed slowly and sensitively. Talk with the child to see if you can determine what is going on. Is she worried because she has never built with toothpicks? Does he wish he were in a different group? Did something unpleasant just happen at recess? If you can find out what is actually going on by talking with the student, you can craft a perfect solution. If the problem is that the child is simply scared of trying something new, you can, depending on the personality of the child, use humor, rewards, hand-holding, and/or clever partnering to help. If none of these ideas work, try modifying the challenge. One time a student refused to build a dragon that could transport its medieval entourage on its back but was perfectly delighted to build an alicorn (which, it turns out, is a creature with a unicorn horn and Pegasus wings) that could serve the same function.

As a last resort, ask the student to take a camera and document the work of other students. She will have an important job, and the vicarious academic risk-taking she documents on camera may just make it possible for her to participate the next time around.

Feedback and sharing

Students benefit enormously from having the chance to share their work in progress with their peers. Sharing work in progress can feel vulnerable and risky, but I find that when kids talk about the problems they're having, or the successes they're experiencing, everyone in the class benefits. Peers often provide suggestions for addressing various problems, and often they're useful and thoughtful. (And if you do this part of the process regularly, the feedback-giving kids get better and better at being helpful and constructive.) Of course the students sharing their work in progress find this process useful. But this part of the process also has a vital role in conveying the importance of process over product. Even the kids who are not sharing their current work in progress are collaboratively mulling over other people's work and considering how to improve it (and, I would argue, gaining so much from being on this end of the process).



The metacognitive message inherent in this step of the process is that all of us makers are part of a messy, gorgeous process that has lots of highs and lows, lots of moments when we know exactly what we're doing, and lots of moments when we have no idea what we're doing—and times when we need to ask for help and times when we don't. And all of this is okay! It's just part of the normal, natural cycle of making.

Jump back in—or don't

Once students make something and get some feedback about it, they may be gung ho to launch another iterative cycle . . . and they may not be. The idea that there is one perfect iteration of whatever a student is making can be great, but it can also cause trouble. It's great to challenge kids to fix glaring problems. On the flip side, making tons of iterations (or sometimes even just two!), can stop a student's enthusiasm cold. Just as you help your students take on the level of challenge that is appropriate, help students know when to push forward on another iteration and when to be satisfied with what they have already made. Remember, this process is all about the *process*, and too much emphasis on the final product can undo all the vital learning that occurred around understanding and being enmeshed in process.

The amount of time this part of step 2 takes can vary widely. Kindergartners building tall towers may only need two class sessions, while second graders making robots that interact with coding on their computer screens may take sixteen class sessions. Be prepared to be flexible. You will get better at predicting how long a project will take over time. The projects in chapter 9 give you a sense of how long things will take.

Outcomes

Students who do projects using this process learn about coding, electronics, 3D modeling, and who knows what else depending on the emphasis of your project. And that alone makes the work important and worthy. But in addition to all that juicy content, students who learn this way emerge with essential life skills that will help them throughout their entire lives. These noncognitive skills of grit, determination, resilience, and perseverance apply across academic and nonacademic areas of life in equal measure, empowering students' problem-solving abilities and their abilities to thrive in a complex world.

Another really important part of the making process is reflection and evaluation. Because the most effective reflection and evaluation occurs alongside every step of the process outlined in this chapter, I thought it would be useful to isolate this step in another chapter. You will find this information in chapter 6.

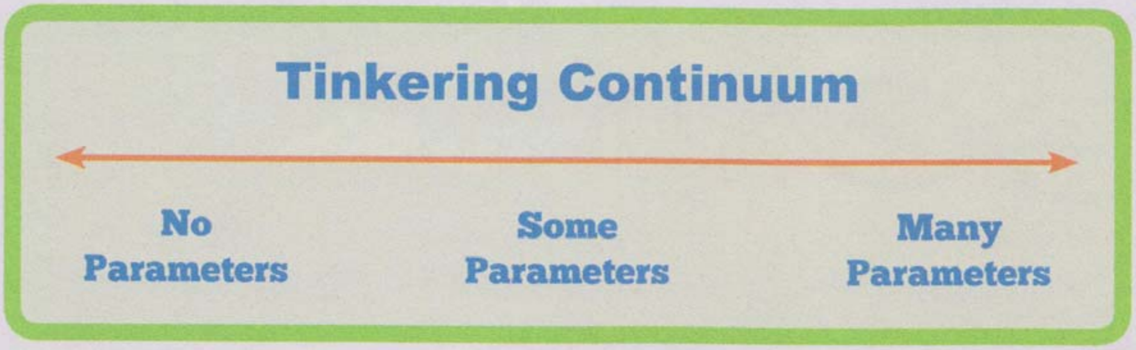
Takeaway

Giving young makers access to this process is a lovely gift. Setting up learning experiences that rely on process-based, child-centered learning allows you to give your students so many important life messages. For instance, mistakes are normal and we learn from them. It's okay to try something even when you're not sure exactly how to do it. You can make lots of discoveries just by messing around. You are responsible for some of your own learning. Giving students these messages (and so many more) from a young age sets them up to be the real problem solvers of the future. That alone makes it worth diving into this messy, gorgeous process.

them to go in a new direction. Once I've started my initial contemplation of these questions, I move on to other considerations.

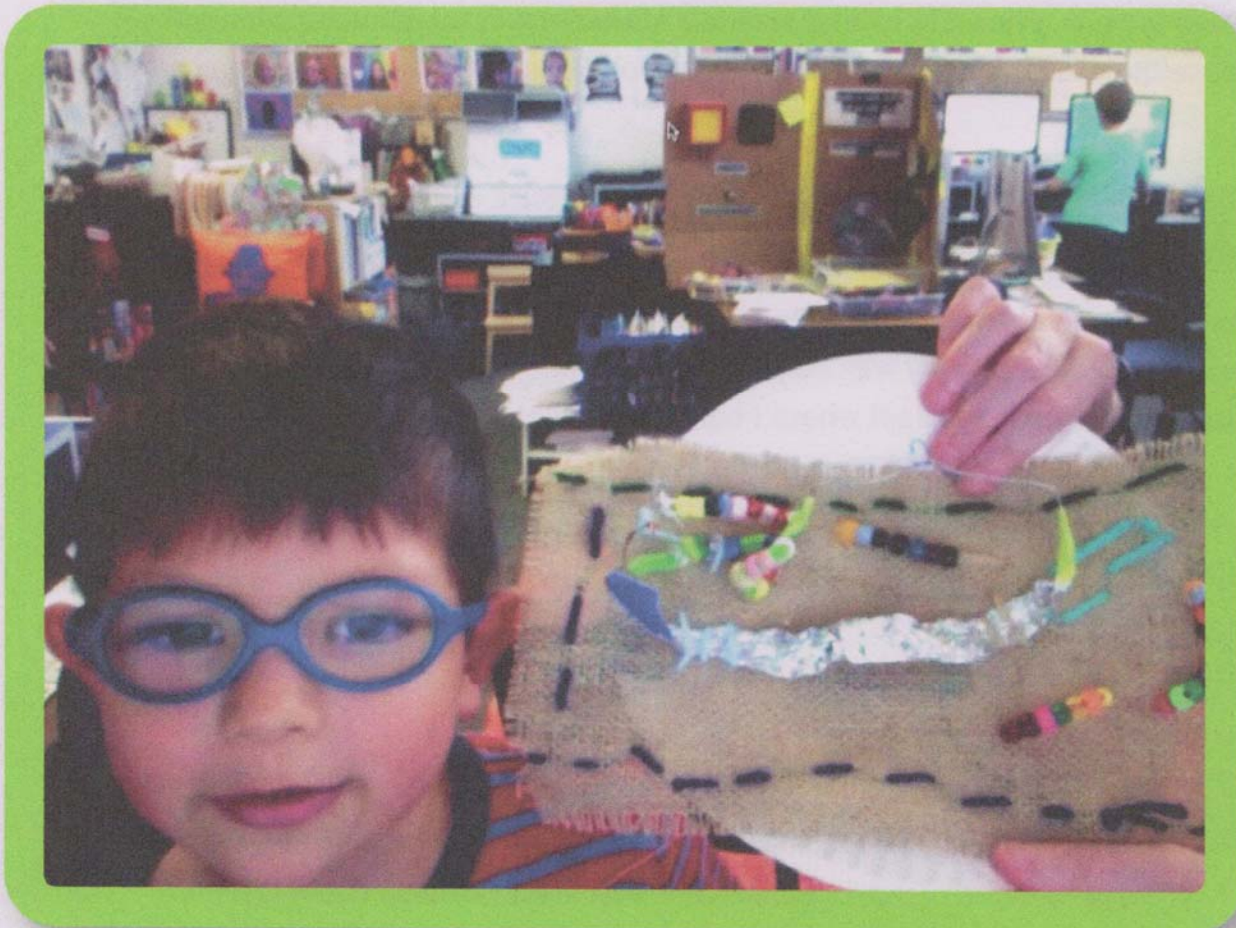
The tinkering continuum

As outlined in chapter 4, the process I advocate begins with pure, unadulterated play. Play with no parameters is at one end of the tinkering continuum. That's the spot where I believe everything should begin.



Starting with play holds true regardless of what the project is. For instance, if I am introducing a coding challenge to kindergartners, we begin by just messing around with software for a few class sessions. Kids try all kinds of things on their own without consequences or direction. I do give the kids enough information to get started, but it's truly just the basics, which includes things like *Here is how this software is organized.* and *Here is how you can make the character on the screen do things.* It's just enough information so that kids are intrigued and empowered. I also make sure to leave tons of things unexplained so kids have to figure things out on their own.

At the play stage, I do not issue any miniature challenges at all. I do, however, encourage kids to share their discoveries with each other, which is enormously empowering to them and which expands the whole group's understanding of how things work.



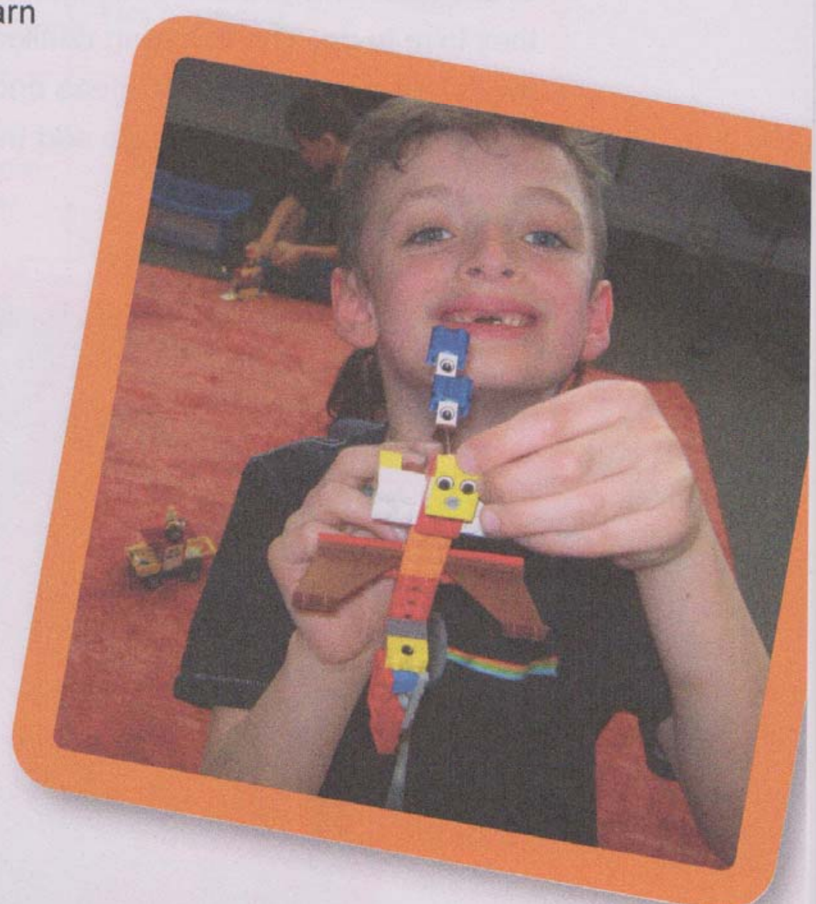
Once the kids have had a chance to play (with software, robotic components, art materials, building materials, tools, etc.), it's time to think about the kind of parameters to place on the project. I am a firm believer in the idea that parameters (or limitations or constraints if you prefer) allow students to unleash their bountiful creativity much more than a lack of parameters. Kids need something to push up against in order to fully test themselves and their problem-solving ability. And that is the function that parameters serve.

The question of what is the precise amount of limitations for a given project is a great challenge. It takes lots of trial and error on the part of the teacher to figure out what will work best for a group of students, a teacher's personality, and all the other variables that may sway the choice.

When I first started teaching robotics, I was very anxious because I had never done it before and I had no idea what I was doing. That first year my students took the LEGO kits and built the projects exactly the way the manual suggested. And we programmed the robots just as the manual suggested. The kids were pretty bored. It was okay, but I was very conscious of the fact that I hadn't really tapped into the giant well of creativity that my students possessed.

The next year I decided to let the students build whatever they wanted. I was not going to make the same mistake again! Look at me, learning from my past mistakes! Honestly, it wasn't any better. This time the kids were completely overwhelmed. They had no idea how to approach the project since it was too big. I hadn't unleashed their creativity—I had overwhelmed them and made them feel ill equipped.

The next year (you may be surprised to learn I still had a job, what with my track record the previous two years!) I decided to aim somewhere between the two ends of the continuum. I asked the students to build a robot that in some way improved the world and that included at least one motor and one light. The experience was so much better for the kids. Having a few restrictions seemed to focus the students AND empower them to try new things and take risks. Parameters! The best! Who knew?



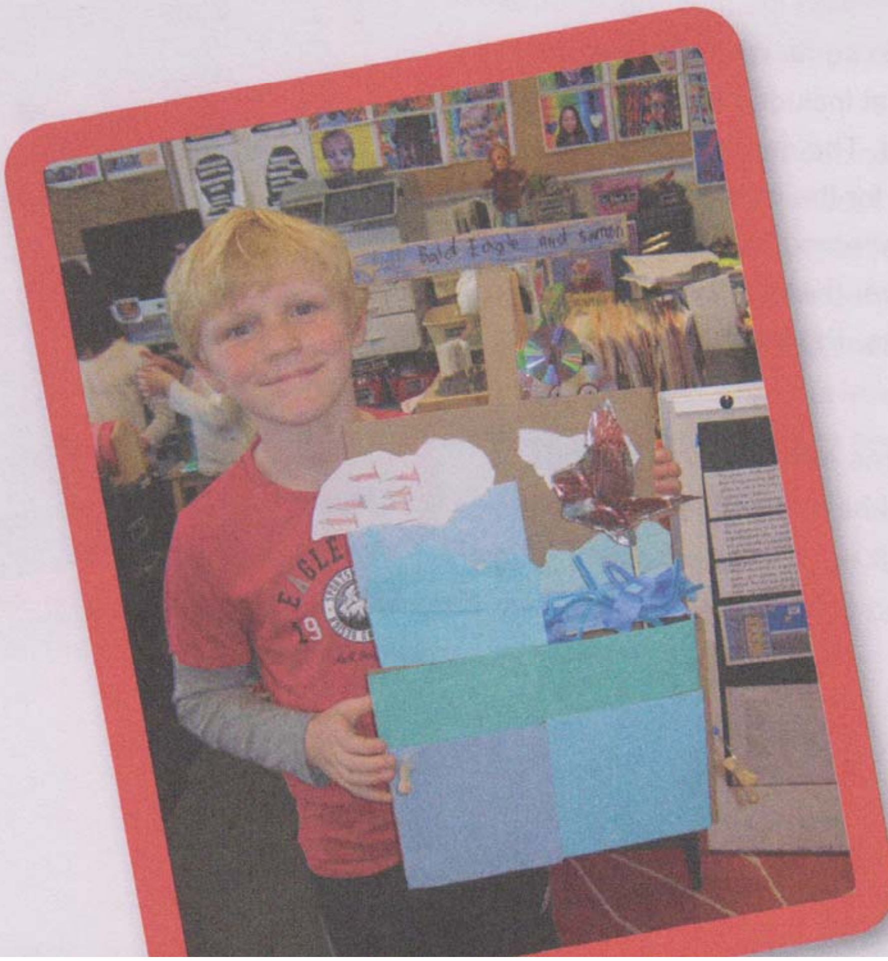
Here are some examples of the kinds of parameters I have found to work really well with kids.

Functionality challenges. Build something that launches a ball. Build something that beautifies a playground.
Create something that carries stones. Invent something that can hold up a library book. Make something that solves a real-world problem.

Imagination challenges. Build something that could be sold in a toy store. Create something that a character from a book could use to solve her problem.

Materials challenges. Build something that incorporates the use of a motor and a light. Build something that requires you to use a screwdriver. Create something in which you use cardboard in an unexpected way. Build something from all this debris I have collected from the floor of our materials closet (one of the most requested challenges, honestly!).

Of course, you can combine parameters of different types to make challenges of all sorts. And you can even let kids make up their own challenges, which they love to do. The following challenge-generating matrix is one tool you might use to come up with ideas once you have carefully considered all the above questions. Kids love to add their own ideas to this matrix.

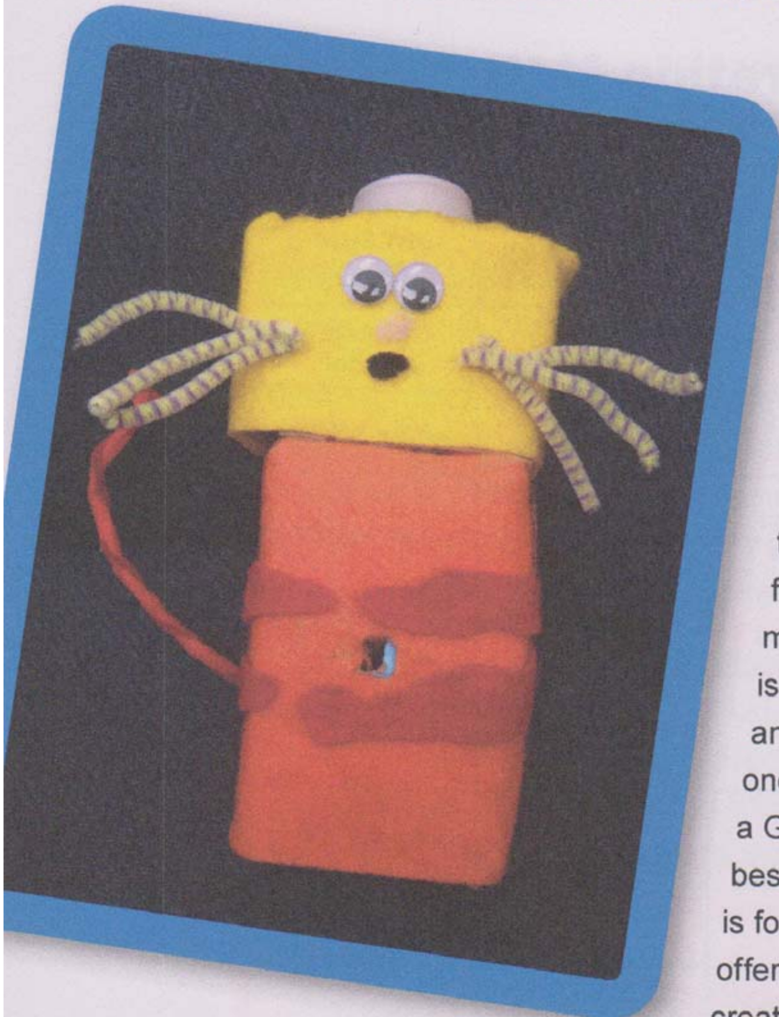


Challenge-Generating Matrix

Pick one or more in each column to generate a challenge.

Using these raw materials	Make a(n)	That will	In this place	And/or in this situation
Robotic components	Vehicle	Spin	Space	Clean a floor
Coding software	Ball launcher	Travel in the air	Our playground	Pour water
Graphic design software	Toy	Transport marbles	The grocery store	Feed a pet
3D modeling software	Tower	Say words	The basement	Help a hungry person
LEGO pieces and/or build-ing blocks	Bridge	Dance	The barnyard	Build a home
Motors, lights, switches, and other conductive materials	Object of beauty	Inspire emotion from the viewer	The human brain	Write words
Recycled materials	Piece of playground equipment	Make music	On top of the Space Needle (or other local landmark)	Create a poem
Art materials	Game	Teach a kindergartner	Underground	Turn on a light

The question of what kinds of challenges to give young makers can inspire hearty debate. Some schools employ specific learning philosophies in their makerspaces, philosophies that dictate the types of projects kids should do and the methods they should use to do them. On the other end of the continuum are schools without particular philosophical ideas dictating the use of the space. What ends up working best for you will depend on your school's mission and your philosophy as a teacher.



Whatever kinds of challenges you end up crafting, consider the role of deliberate ambiguity. Deliberate ambiguity describes the art of making a challenge that has lots of room for student interpretation. There are many advantages to crafting your challenges with plenty of room for interpretation, especially for your students. When students are not told exactly which path to follow to solve a problem, they're forced to engage with the challenge in a meaningful way, and I believe their learning is far deeper. It may seem easier to create an ambiguous challenge than a specific one, but it takes time and practice to create a GOOD ambiguous challenge. But the best advantage to these kinds of challenges is for the students. Ambiguous challenges offer students the chance to bring their own creativity and curiosity to a challenge in a way that you may not have anticipated.

However, being ambiguous shouldn't mean complicated or complex. Challenges should be easy to understand. Use words that need no explanation but are open to interpretation. "Make a toy," "make a zoo," or "make music" are clear to even the youngest students. When kids are allowed to bring their own interpretation to the work, they are empowered and engaged in new ways. But the best part is that leaving them room for interpretation allows students to generate solutions you could never have considered. And not surprisingly, their creativity will blow you away!

Sometimes you will have a group of kids who struggle with whatever challenge you craft. This happens most frequently with challenges that require lots of new skills and/or lots of new knowledge. I see this most frequently with students experiencing their first robotics challenge. It can be overwhelming to learn how each robotic component works and how to code appropriately. Often robotic kits come with specific instructions for how to assemble several different robots. Sometimes when kids are really struggling, they just want to follow the instructions. They're not interested in my lovingly created challenge. And that's fine. I let them follow the specific directions for building and coding, they make a functional robot and feel satisfied, and hopefully they're primed and ready to work on something more open ended during our next challenge.

Takeaway

Coming up with fun and appropriate maker challenges for your students requires that you invest some time up-front to create problems that will really work for your students. Carefully considering the aforementioned questions will allow you to generate great problems for your group. Make sure to take some time after each unit to reflect on your process as a teacher so that you can continue to grow your ability to make great problems for your students to solve.

Reference

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