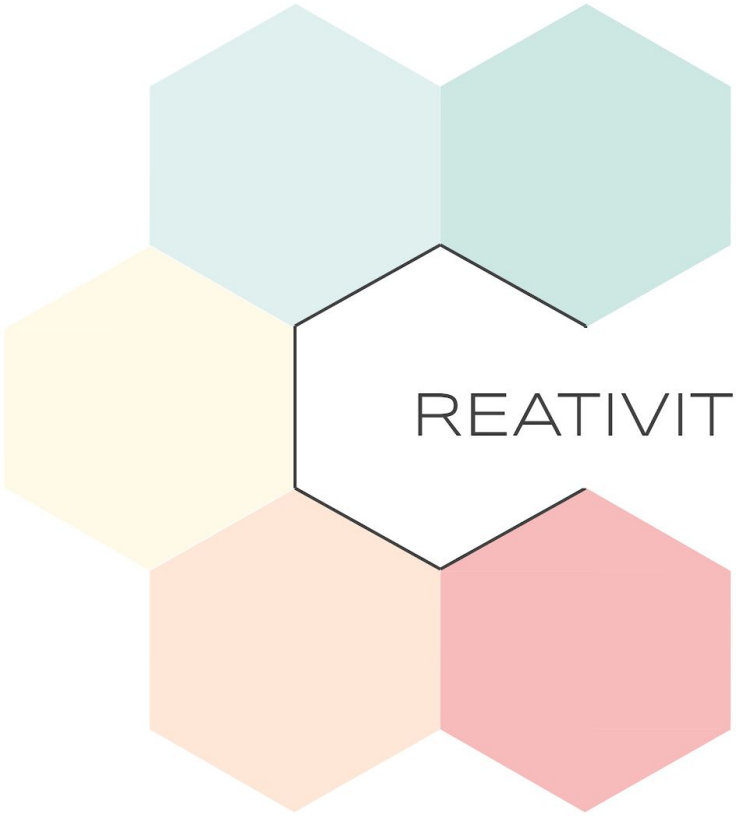


REATIVITY ROADMAP

A Educator's Guide to Creativity in the Math Classroom

By
MIND Research Institute

MIND Research Institute is a nonprofit, social impact organization committed to transforming education and closing the experience gap for all learners. MIND's flagship program, ST Math, is a PreK-8 visual instructional program that leverages the brain's innate spatial-temporal reasoning ability to solve mathematical problems. ST Math's unique, patented approach provides students with more equitable access to deep conceptual learning.

MathMINDs gives students, teachers and families a different way to experience math. Math is a global, shared, human experience—math is from everywhere, in everything, and for everyone. The more we share that universal experience together, the deeper our appreciation for math will grow.

Our Core Assumptions About Creativity

Humans enjoy discovering new things. Look at a young child endlessly asking “why?” or the sheer joy we all experience in an ah-ha moment. This form of creativity is intrinsically rewarding.

Humans also enjoy making things. Consider the popularity of television shows around making music or food. Making things is fundamental to what it means to be a human. We make tools, music, food, stories, and more. We find it so valuable that we put forth incredible effort to produce creative outputs; sometimes we even devote our entire lives to it regardless of material benefit.

Creativity is intrinsically rewarding.

Creativity in the form of problem-solving is key to humanity's survival. It always has been. The 21st century problems are hard to solve. If they were easy, they probably would have been solved already.

Creative problem-solving is necessary, intentional, and effortful.

Creativity isn’t a black box which some lucky ones have ample access to while the rest of us don’t have a “creative bone in our body.” Yet some seem to be deeply creative and, no matter what they touch, they make an impact. This is in no small part because they’ve developed the skills and mindsets to relentlessly pursue ingenuity.

While it is true that creativity in one area doesn’t automatically impose creativity in another, there are certain mindsets and skills central to creativity that cross multiple domains. That is, we aren’t limited to only being a creative engineer or a creative artist or a creative (insert your favorite hobby here).

Creativity can be developed and is transferable.

Creativity also requires a climate that supports the decision to “be creative.” This climate can be macro (e.g., classroom, school, district, community, news outlet) and micro (e.g., our families, our own minds). Even the most creative among us, don’t “turn it on” at the DMV and come up with clever names to put on their driver’s license.

Creativity can be turned on or off, and is especially fragile in students.

While we cannot control every possible moment of a child's life, as educators we can make a huge impact on building the creative problem-solving capacity of our students.

The goal of this document is to unpack pragmatic steps within our immediate control that can build and sustain our students' creativity. To do so, we'll step through five landmarks on the way to fully operationalizing creativity in our classrooms.

Mass STEM Week 2020

As it relates to the 2020 Mass STEM Week, we focus only on landmarks one at two. Trying to do all five in a single project runs a significant risk of trying to do everything and thus not really doing anything. It would also be overwhelming to implement, especially during the uncertainties of the current pandemic.

Ultimately this is good news. Just like in math class, we don't need to teach every possible aspect about, say, fractions, right away. A complete understanding takes time and effort to build. In the same way, we can make a big difference in our students' lives without digesting hundreds of pages in a book. For now, just take the first two steps. It's manageable, and worth it.

Under the theme of Making STEM Viral, our focus is building human connections despite social distancing. Students can help make STEM go viral by getting others in their communities involved with STEM, in this case "M." This creates a challenge that has immediate real-world impact. Students' work serves a direct human need. By designing a high quality math game for people to enjoy, students become a force for social bonding in a time of distancing.

With this, we can now dive into the first two steps along the Creativity Roadmap followed by a few project logistics.

Landmark 1: Creative Climate

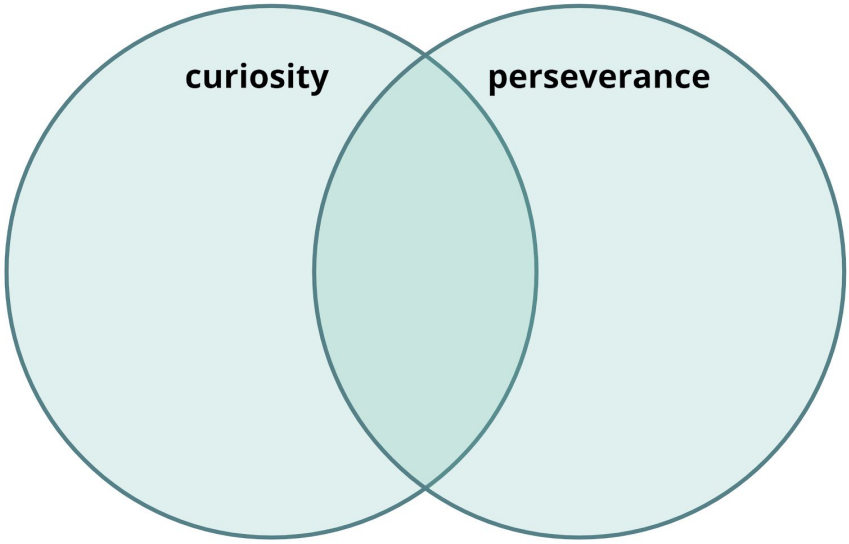
Those who become true masters, in addition to working hard, exhibit two core characteristics: value and purpose. They value their craft: specifically the effort it takes to improve. And they find meaning in their work, almost entirely by what it can do for others. In other words, they value working hard to improve at something that is bigger than themselves.

It's perhaps one reason why "home field advantage" exists in sports. The home team gets a jolt of purpose — the crowd. In a recent interview about resuming basketball after COVID-19, Shaquille O'Neal said that playing without fans will be tough because when you are in the stadium, the crowd makes the moment bigger than playing for yourself.

Value + Purpose → Mastery

Value and purpose drive meaning that, with hard work over time, becomes mastery. Regardless of the type of problem you use to motivate students or provide context, spending a little extra time to drive meaning through both value and purpose carries wonderful dividends.

We can see these two traits manifest themselves in an intense curiosity and a seemingly limitless perseverance. Creative people are relentless. Based on research, these are the two most important mindsets required for being creative. To build creative capacity in our students, we must intentionally design for the intersection of curiosity and perseverance.



There are three deeply interconnected areas we have some control over that can be orchestrated to marry both curiosity and perseverance. We dive into the **Three E**'s in the next sections — experiences, environment, emotions.

Before we do, there's a bit of bad news. Working at the intersection of curiosity and perseverance isn't all that transferable. Students can be both interested and persistent on one task but not on the other. For example, kids demonstrate both at recess but not five minutes later in math class.

They can also be curious on one task, persistent on the very next one and still never live at this intersection. For example, kids enjoy a fun math video (curiosity) then do a standard worksheet (perseverance), yet do not display creativity. This is because we need experiences that intentionally marry the two.

When going for curiosity and persistence, look for students to demonstrate both

… at the same time and within the same task(s)
that are directly relevant to the area that
you want to boost creativity…

Because our experiences have a large impact on our environment and emotions, let's start there.

Creative Experiences

It is quite easy to design for engagement at the expense of effort or for rigor at the expense of curiosity. As it relates to creativity, though, these tasks have a down side. It is very unlikely that we can have one experience that builds curiosity and another one (no matter how close in time) that builds perseverance, then hope that students develop the ability to exhibit both on the same task.

The up-side is that students prefer tasks that live at this intersection. Case in point: video games. Even as adults, this intersection happens in our lives all the time and we find it desirable. Think of your favorite hobby that requires focus, skill, and effort. When you engage in that activity, before you know it you've lost track of time and you feel effortfully refreshed. The best hobbies require our complete attention so that we push aside the ins and outs of daily life. This is what the intersection of curiosity and perseverance feels like.

These types of experiences, beyond improving our mood, are foundational for creativity-building.. You can think of creativity as a sort of curious rigor.
Mathematics needs experiences that feel this way. If you have a task that is wonderful for curiosity, look for ways to make it more effortful without killing engagement. If you have a task that is very effortful, but fairly dull, look for ways to tie into a student's curiosity.

There are times for routine work; learning scales on the piano, learning how to spell your name, or practicing multiplication facts. These are not inherently bad tasks, but they may not be maximally developing creativity.

Creativity-building experiences merge
curiosity and perseverance.

Creative Environment

Research suggests it's better to enhance creativity by changing conditions in the environment than by trying to make people think creatively[1]. One good argument for having a strong culture of creativity in our classrooms is that creativity is fragile. Kids can seemingly turn it off very quickly and for a variety of reasons. To build and sustain growth in our students' creative capacity, we need to make sure we have a culture that allows creativity to thrive — much like plants. For plants to grow, you treat the soil. In the same

way, students have inherent creative capacity. But, they need the right environment to see it grow.

This is great news! We don't have to learn a million ways to come up with genius ideas or learn the absolute best way to conduct a scientific test. We simply need to, as a first step, make sure we aren't designing creativity away. A student's environment is their soil. The environment we seek is one that promotes both curiosity and perseverance. We can take a few steps to help make this happen.

First, try to **minimize distractions**. Don't offer every color of paper possible, or every game piece or trinket you can think of. If a kid decides she needs something, then she can find it or make it. The reason for this is that in a child's curiosity over the new things, they become distracted. In this case, curiosity can actually work against perseverance. The other reason to minimize distractions is that creativity is evoked primarily when there's a high expectation that requires complete attention. Creativity happens when we sustain both curiosity and perseverance. You can't be distracted and do this.

Second, **minimize consequence**. Missing the free throw while shooting blind-foled at recess is much less of a consequence than bombing the midterm math test or changing lanes abruptly. When consequences are high, we often feel as though failure is overly detrimental or that we have to fit into whatever box that takes the consequence away (e.g., just do what the guy at the DMV says so you can go home or always stop when you see a red light). These are good things, and there's the right time and place. But when it comes to creativity-building, don't make your tasks too heavy.

Real-word tasks are great, but sometimes they feel so paramount that the consequences are high. Sometimes just an awareness of the downsides is enough. You don't have to reinvent everything ever done. The goal is to create an environment where students feel free to take appropriate risks. Creativity happens when, instead of avoiding mistakes, we embrace them.

Another way to go about this is to make sure no one person, not even the teacher, is seen as the expert. This way, students feel free that we can all mess up together. Your job, when it comes to creativity, isn't to have all the answers, but to facilitate students in finding their own.

Third, **offer novel, non-routine challenges**. Students need to be thrown into a brand new situation and figure out what to do about it. For example, make a fun challenge out of writing with your non-dominant hand. It's so weird yet approachable (novel), that a student needs to give it full attention (no distractions), and every single one of us expects to mess

up and will find value in the mistakes because they'll be funny (mistakes embraced and desired).

Finally, **value autonomy and feedback**. Students need to have a sense of control or agency over their actions. It's not enough to give them choice over the project they do. When doing the project, their actions need to be entirely their own. More specifically, even when kids aren't sure exactly what to do, they engage with the activity on their own accord and keep working to figure it out. If you are giving a project overview, give the least amount of information you possibly can that gets them going. This way students feel a refreshing sense of autonomy.

You get bonus points for doing these four with **strong social interactions**. This helps your environment become an ingrained culture because students become the transmission agents of the environment. Plus, it's too hard and unreliable if you are the only change agent. To bring students along in the shift, have them engage with others in positive ways. When this happens throughout your entire classroom you have built a culture of creativity. This will make a noticeable impact in your daily math class even after the project is over.

A creative environment
sustains curiosity and perseverance.

Creative Emotions

Emotions can be tricky. They can also evolve well beyond feelings — what starts as emotions can develop overtime into mindsets and emotions-management. But, within the world of social and emotional learning, we need to accept the role that initial, early emotions have. From a neuroscience standpoint, these "onset emotions" serve as a kickstarter to creativity. In particular, the decision to be creative isn't purely rational — it involves the emotional centers of your brain.

According to Robert Sternberg, "...the major variable in creativity is simply a mindset towards thinking in novel, surprising, and compelling ways — and this mindset can be taught." (10)

Creativity starts with a choice. Some experiences and environments make this choice easy, some make it challenging. But even in the best case scenarios, many of us unknowingly convince ourselves out of being creative. You've probably heard the phrase "I don't have a creative bone in my body." If you think you aren't creative or can't be creative, you likely

pigeonhole yourself out of doing it. You have all the capacity possible, but your emotions can be your own worst enemy.

You don't have to be a starving artist or an eccentric billionaire. You don't have to be rich nor poor. Creativity is available to all people. There's not a single person that can "never be creative."

There's no one perfect emotion to have in order to be creative, but there is a preferred class of emotions. These are

"go for it" emotions.

These are emotions, positive or negative, that drive us to immediate action in direct pursuit of the challenge. They are the feelings that encourage us to be both curious and persistent.

Fear for example, a negative emotion, drives us to avoid the challenge at hand. We back off, we shy away. We aren't creative when we are fearful. On another hand is anger. Still a negative emotion, it drives us to direct action towards the object of our anger. We don't always put creativity to good use in this emotional state, but we are driven to be creative. Interestingly, calm and relaxed are not conducive to creativity because they are passive in nature. Creativity is action.

There are tons of emotions that we'd be happy seeing in our classrooms that drive us to productive creativity — elated, happy, physically ecstatic, loving, supported. Playing games can also produce "go for it" emotions - delight in harmlessly duping another; urgency, but not stress, etc.

To make the choice to act creatively, most of us need a spark of these "go for it" emotions. Two things all "go for it" emotions have in common is that they are intrinsically motivating and create a sense of urgency.

Creativity-inducing emotions should
spark curiosity and perseverance.

You've Got It When ...

There are so many things bombarding our days and it's not helpful to memorize some new set of principles that gets lost in the noise of everything else. So, to be helpful, here's a fairly simple metric you can use to get a benchmark as to when you've found the sweet spot in the Three E's.

You know you've got it when you see...

voluntary, sustained effort
on non-routine challenges.

Some Ways to Get It

- Offer lots of opportunities for curiosity.
- Offer novel, tantalizingly tricky challenges.
- Remove barriers for risk-taking and exploration.
    - Teachers aren't the gatekeepers of "success." Be careful with grades.
- Remove distractions on attention.
    - Offer little to no initial supplies. These distract kids away from the task.
- Make it easy and low-stress to mess up and learn from it.
- Don't tell kids all the steps. Kids should learn to act before they have the answers.
    - If you don't know, have a go. [12]
- Offer strong social interactions.
- High expectations without high pressure
    - Too often we feel both together and many of us shy away.

A ubiquitous example of this is play. Watch kids at recess and many of these components are present. In fact, if you let them, they'd stay in recess longer (interest, curiosity) and come to your classroom sweaty and out of breath (effortful, persistent).

Landmark 2: Productively Manage Missteps

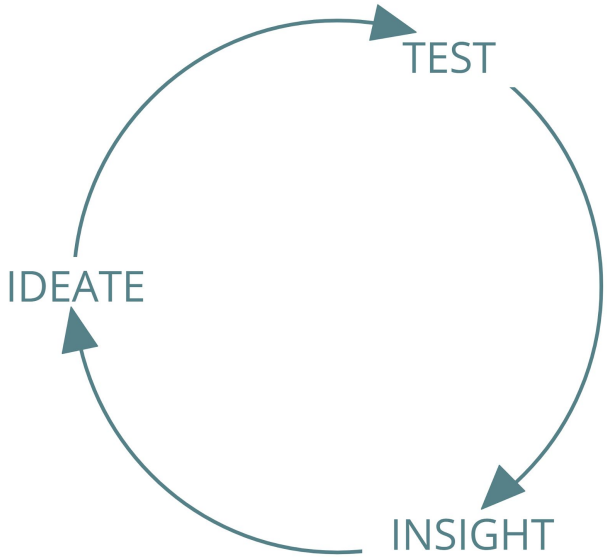
Making the decision to act creatively is often made below our consciousness and can be easily reversed. In the blink of an eye, kids can jump right out of this decision and shrink away or freeze up...adults too. Creativity needs to be cultivated and given space to be put to use. This is the goal of the second landmark in our roadmap.

More than the rest of us, deeply creative people productively manage missteps.

- They are willing to make mistakes.
- They are willing to see their own mistakes and call them out.
- They are willing to change course when they see a mistake.

While many of us are trying to avoid mistakes, and in some cases like driving a car on a narrow road it's a good thing, creative people aren't at all hindered by mistakes. What's expensive to us (messing up) is of no consequence to them. They move away from avoiding mistakes through embracing them and then on to valuing them. The best creative problem-solvers tend to solve the problems better than we do because they fail more often and learn more quickly.

The goal of this landmark is for students to build up their ability to test, fail, learn, and improve as simply and quickly as possible. Quite possibly the simplest flow for kids to learn is:



This cycle, called the Maker Cycle, says that a refinement to an idea should only come after we've learned enough to garner some insight. The best way to get insight is to put your ideas to use — test them out. Learn something and wrap your brain around it. Only then should you re-ideate. This is almost so obvious that we don't think to call it out. As a result, we don't truly use it.

A recent example from the news goes something like this.

"Distance Learning didn't work so we have to go back to class."
"Teachers don't want to work and still get their full salary."
"This is craziness."

Let's take away the obvious judgement that labels all teachers negatively. Looking just at the first statement, their claim is essentially:

Distance learning didn't work last semester, so it <u>can't</u> work again.

Whether this statement is actually true or not is irrelevant for our discussion. Let's digest it from the standpoint of the Maker Cycle. Before stating what we should do about it, we need to understand it a bit more. Insight drives ideation. Without insight, we completely toss away one idea for another. Insight is what allows us to refine and grow. To find some insight, we should get a sense of what happened, why, and what to maybe do about it.

Why didn't DL work?

- Could it be that we slapped it together in a hurry, without a clear plan in the middle of an incredibly confusing and scary moment? If so, could DL actually work OK this time around with proper planning?
- Could it be that enough schools froze grades and kids took that as a "free pass" to stop learning? If so, will we be better off simply by having more standard grading practices?
- Could it be because of the internet and devices? If so, could we solve it by putting pressure on the technology gap?
- Could it simply because it was so new and different and we just needed time to adjust?
- Could it be because teachers and parents had to jointly manage their own homes and workload? If so, are there necessary workplace adjustments?
- Could it be because learning is a deeply social experience? If so, does that social interaction need to be in person or are there other ways?
- Could it be because _____?

Until we have at least a stab as to why it happened the way it did and what to maybe do about it, we don't have insight. I make no claims that the questions above cover all possible bases nor that any of us have the objectively perfect answer. In this example I've left open the door for the "right" answer to be to continue DL or to be go back in-person as soon as possible. I simply suggest that there's more to the DL conversation than the insight-free

assumption of “It didn’t work because it can never work”. Until we have deeper insight than “toss it out wholesale,” we have no business re-ideating.

When solving a challenging problem, it’s worth overtly using the Maker Cycle. When we skip over insight completely and just come up with another idea — like so many kids and adults do — we didn’t iterate. We killed off the existing cycle to start a brand new one. This is not iterating (a.k.a. re-ideate).

The most important next question is: How do we get kids to overtly spin the Maker Cycle? The key to this question is to switch our focus off of the phases and on to the transitions, or the links, between them.

Focus on the Links

Building creativity is not having the perfect test, nor ideating like it’s no one’s business. Transitioning between phases (the links) is where productive management of the unknown lies.

Here’s an example. It’s common for us to ask “How do we perform a good test?” When it comes to building our creativity, it’s generally better to first ask ourselves “How do we get students to test their ideas?”

This shift in perspective is freeing. We don’t have to be robotic in our classroom. We don’t have to do everything right the first time. We don’t have to prepare all the ingredients with painstaking detail before kicking the project off. Creativity is not about baking a cake by following the recipe to perfection. In creativity, we are free to be ourselves, to try things out, to learn from them and keep going. As a facilitator, your role is to help students get the cycle spinning. There’s no need to be rigid and formal.

So, instead of executing each phase perfectly, we want to find ways to reduce friction in the cycle so that kids can get spinning. This requires that we both remove actions that get in the way (things that have created friction) and add in actions that actively reduce friction (things that can lubricate the engine).

We do so by focusing on the linkages, not the steps.

Link 1: How do we get students to test their ideas?

Testing an idea requires that we actually test it, for real. Any project in the classroom that artificializes the test or makes testing arduous or virtually impossible, breaks the link. Any project that makes testing unnecessary (e.g., coming up with a mnemonic for PEMDAS and coloring in a PEMDAS outline) don't require testing and thus breaks the link.

To encourage students to test their ideas, make sure to build a desire and expectation to test, followed by a way to test, for real. Rework any project or challenge that guarantees success — either by being too easy or by merely jumping through hoops.

Any project that gives an "A" by completing the 10-step-rubric or by creating any acronym you want for PEMDAS isn't inherently bad. These just aren't the types of projects that live at the intersection of curiosity and perseverance. Sometimes simple changes can make a big difference. For example, instead of creating a PEMDAS acronym, change the challenge.

- Create the funniest PEMDAS acronym that makes the front office staff laugh.
- Create the weirdest PEMDAS acronym that is a phrase you can't forget.
- Create the most memorable PEMDAS acronym.
    - Front office staff has to recall the acronym two weeks later without practice.

Now, all of a sudden I have a reason to test. I even want to test. It sounds fun. The way to test is simple. For example, give or say the acronym and see if someone laughs.

When you remove barriers to testing, you'll find that testing is more natural and desirable than it is unnatural.

In our Math Maker projects to help make testing more desirable and approachable, and to get across the maker cycle quickly and easily we have developed the Math Maker Story. Getting started is as easy as flipping open the first page.

There are all kinds of projects in which students test. Perhaps you are thinking of a school science project. Those aren't easy tests and they tend to be rubric-heavy (formal). You are correct. And they can be very valuable projects. However, they aren't the kind of project that builds transferrable creative capacity. When looking at the linkages, no phase exists in isolation. The kind of test we are looking for is one that produces real-time insights.

Link 2: How do we get students to gain insight from their tests?

In the context of building our creative muscles, a test should focus on building insight. This is, and should be, different from hypothesis testing. Not all good tests are the right kinds of tests all the time.

There's a time and a place for formal, robust research-like testing. There's a time and a place for validation testing. There is also a time and a place for testing just to figure out what's going on. In the kind of testing I'm talking about, if you are gathering data it needs to be actionable not merely analyzable. Nobel Prize-winning Chemist Ernest Rutherford goes so far as to say

If your experiment requires statistics,
you ought to have done a better experiment.

His point is that tests that give us information don't necessarily give us insight. A science fair project is good and well and its tests use data to help us make up our mind. But they often stop short of producing insight as to why the hypothesis worked or didn't. Why does cookie A taste better than cookie B? More importantly, what can I do about it to make an even better cookie C?

Often, the best way to gain insight from a test is in real-time, right there, in front of your eyes. This insight comes from meaningful feedback. Sometimes we are able to pick up this feedback, but often we need others to help us. Either way, meaningful feedback is the kind of feedback that helps you wrap your brain around what worked and what didn't as well as the why. It helps you refine your thinking.

It also tends to have just enough encouragement so that the receiver doesn't feel trapped, belittled, or ganged up on. A practical way to tell if you've gained insight from your test is when you have an intuition about these three questions.

What happened?
Why could it have happened this way?
What **might** I be able to do about it?

If you have a stab at answering these questions, you likely have enough insight to re-ideate. Insight is not a moment of perfection, but of illumination. The goal is to have some sort of feel for the answers — even if imperfect or naive.

Insight sometimes gives you only a glimpse, not the complete picture. But without insight, there's no way to truly iterate. You don't need perfect answers, just illuminating ones. As you continue to cycle, your illumination will become stronger and stronger.
To encourage students to learn from their tests, make sure they gather real-time, meaningful feedback. Remove any test that is too infrequent, too late, too large, too formal, or just to gather data. Gather insight as cheaply, quickly, and often as you can so that you keep cycling. This is how your creativity grows.

Don't overthink or over plan it. Sometimes the old-adage is true.
KISS - Keep It Stupid Simple.

The thought leaders in 21st century entrepreneurship say basically the same thing. A startup is only as good as the number of pivots it has left to make before it runs out of money. Instead of getting more funds, a startup can figure out how to fail and pivot more quickly and cheaply.

Sometimes, kids will have that "ah-ha" moment of insight but when probed more about it they have no idea how to fix it. This isn't the end of the world, after all they are in a creative problem-solving environment. It's supposed to be hard. But, it highlights the importance of turning insight into iteration (a.k.a. re-ideation).

Link 3: How do we get students to put their insight to use?

This is perhaps the most important link of all. You can do the others all you want, but until you turn your insights into something, you aren't being creative. Ideas are cheap compared to actions.

This is also where students tend to exhibit a fatal flaw when tackling difficult problems. When they find an issue in their idea, they want to toss it out wholesale and replace it with a new one. This is not cycling. This is the termination of the cycle you are on and starting a new one. In many ways, it's the antithesis of creativity. Insight gives you a peek into what worked and why, what didn't and why, and offers a first glimpse of what to do about it. Without insight, there's no way to truly iterate. Tossing out an idea wholesale should never be a quick or hasty decision. It should only come after nurturing your current idea(s).

Iteration happens when insight picks up enough knowledge to do something about it. Creativity requires some set of baseline skills or knowledge. You can, and should, pick that knowledge up as you go. Those trying to cure cancer are learning a lot along the way.

Those trying to get to the moon didn't have all the answers on the outset. Creativity doesn't require you to know it all, but that you pick up what you need as you go.

In fact, having the "complete knowledge set" right away is not helpful. We often feel the need to give students a detailed picture upfront, before they start their work. They need to know the project, the steps in the design principles, how it will be graded, and so on. This will overwhelm the student and take away room for their own curiosity. Too much knowledge can narrow assumptions and drown out creativity - expert bias.

To counter this, I propose "just in time" knowledge. Students figure out what they need, or we help them with ongoing knowledge only as they need. To be creative, give students just barely enough to fail forward. Give them just enough baseline knowledge without pigeonholing their thinking. Often, students need a lot less information upfront than we think.

Creative problem-solving requires
just-in-time learning as you go.

Where Do I Start the Cycle?

One potential downfall of using a cycle as a model is that there's no clear beginning or entry point into the cycle.

Where does creativity start?

The simple answer is: It doesn't matter.

Creativity can start from anywhere. You could be in the test phase for project A and — bam — out of nowhere it feels like you get an insight for project B. But the "creative moment" of seemingly pure bliss and genius isn't creativity persay. What you do with that moment determines if you'll be creative or not. Just keep cycling.

Cycle. Cycle. Cycle.

Conclusion: Creativity, School, and Feedback

Several longitudinal studies on creativity reveal a fairly striking pattern. Slumps in creativity tend to coincide with major changes in school — e.g., a student entering kindergarten or transitioning to middle school. In 2015, two researchers Zi-Lin He, Poh-Kam Wong found the major reason for this timed slump is student assessment of school life. In particular, negative associations with school make the transition-slumps more severe.

One could interpret it as though a child's negative relationship with school erodes his/her tendency to act creatively. Perhaps this is why so many people believe that kids lose their creativity by middle school.

If we want students to creatively solve problems, we have to build and sustain positive school culture. To nurture this kind of environment, one strategy empirically shown to nurture creativity is to encourage curiosity and exploration. If our projects suck the curiosity out of our students, it also smothers their creative development. Our classroom environment matters as much as the creative steps we take.

No single experience is enough to get to a point of maximal creativity and stay there. Creativity develops over the course of our lives. In one study, a creative-peak happens around age 40 and stays equally strong until around 70. Your students' creative journey is just beginning. It's better to sustain growth, even if slow, than to speed it up and have it die. It's a classic tortoise and the hare scenario.

Many of our students have views of creativity that say "Don't put yourself out there. If people don't love it, you aren't creative." Simply put, some students will freeze up and not engage. Creativity scares them. This is a learned fear, often trained through rigid process reliance in math class. Even so, we can greatly reduce the number of students freezing up with the right classroom culture (curiosity and persistence).

Research has shown that effective feedback strategies also promote student creativity. In creative problem-solving, this kind of feedback should generally focus on the work (what work, what didn't, and why) and come with enough encouragement for the student to not freeze up while at the same time not so much encouragement that they are convinced they are so good that they don't need to iterate and grow. Feedback should also leave open possibilities.

Meaningful feedback is focused on the work.
It is specific, illuminating, and appropriately encouraging.
It tends to happen best in real time.

Giving good feedback is a selfless act. It's about what to say and how to say it for the benefit of the recipient. Feedback is best given when it is others-focused. The goal is to use feedback to edify and lift up, not destroy or assert dominance.

Feedback is such an important component not just of taking creative steps but of the classroom culture. Based on research by Ronald Beghetto in 2006, middle school students rate teacher's positive feedback on their creativity as the most important single predictor of their belief in themselves as being able to be creative. They didn't give top marks to training to think of lots of ideas or training to execute the perfect test. Teacher feedback takes the prize.

This is precisely why, at first, you need only two steps — they are the bang for the buck activities.

- Culture of creativity
- Use feedback to gain insight and keep spinning the Maker Cycle

As you do these, keep in mind that constant praise, too strong of praise, or complete lack of praise can cause students to play mental games with themselves. When giving feedback, give just enough to feel encouraged and ready to have another go. Too much encouragement can bloat the ego and stop creativity as fast as negative encouragement attacks the ego and stops it.

Creativity is both a self-expression of our uniqueness
and a relevant attempt to tackle the problem at hand.
I need feedback and I need room to be myself.

MathMINDs|Maker: Play, Create Share

Our MathMINDs|Maker projects offer an enjoyable way for students and teachers to immerse in a culture of creativity, build creative capacity, and learn to think like mathematicians. To take the first step with the MathMINDs|Maker program, consider joining us in a game-based project using *Play, Create, Share*.

Well-crafted math games offer a way for students of varying ages and abilities to engage with one another and with mathematics. With a level playing field, students self-manage their time and develop the skill and desire for making purposeful decisions. Great games offer more than random rolls and math facts. In the best games, math fuels gameplay and deep thinking.

When done well, games build a foundation for a creative culture. They offer intrinsic and curious challenges. They are inherently social. They reduce the effect of consequence and thus encourage risk taking and strategy-exploration. They focus our attention on the task at hand. They create urgency without being paramount. The best games do much more than "make math fun".

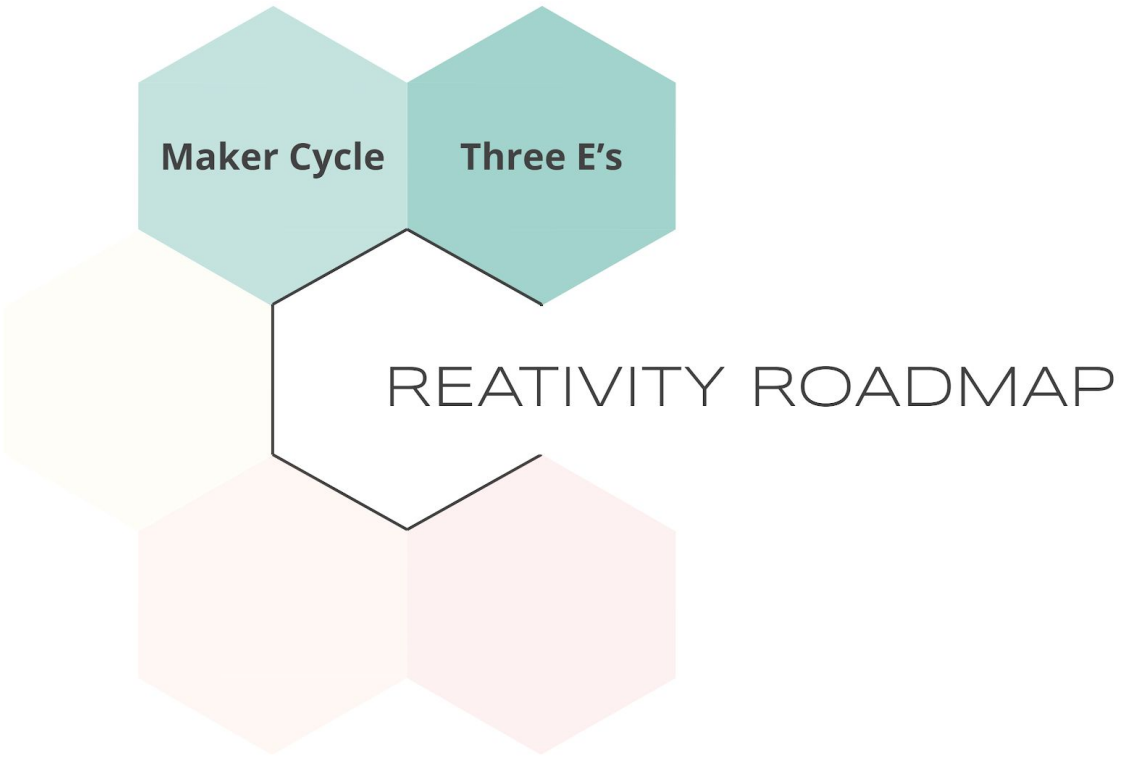
Our *Play, Create, Share* project is founded in this type of gaming experiences. Early on, students play carefully-crafted, research-based math games, then embark on game maker challenges that put them in the driver's seat. To increase the ability to play the game strategically as well as the time spent playing the game, we surround the games with stories. This additionally brings in historical and cultural contexts that connect math to the world around us. After the play stage, students become the makers.

By making more than a trivial, "fun" math flash cards games, students engage others in a similar social experience. Superficial games have little societal impact, whereas well-crafted games are researched for their learning and SEL benefits. In this way, students create a product with real-world impact.

MathMINDs|Maker:
Students will put forth effort to make something
they are proud of and that others actively use.

The Project and Creativity

The *Play, Create, Share* model is designed to directly target the first two steps in the Creativity Roadmap. Namely the Three E's for building a creative climate and the Maker Cycle for productively managing missteps.



To host your own MathMINDs | Maker project, visit stmath.com/massachusetts.

Contact Us

Nothing is perfect, so we would appreciate your feedback as well as any questions you may have along the way. Our goal is to constantly learn and refine the model to be research-based and pragmatically implemented.

We are available at any time for any questions, comments or concerns. Consider joining one of our office hours or e-mailing us at STMathMA@mindresearch.org

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