CHAPTER 2

ISP 1: USE CRITICAL AND CREATIVE THINKING TO SEEK SOLUTIONS

In the following story, you will meet Ms. Gonzalez, a sixth-grade teacher who engages her scholars in the ISP of using critical and creative thinking to seek solutions. As you read, look for . . .

- How Ms. Gonzalez facilitates critical and creative thinking
- How scholars use critical and creative thinking to seek solutions
- Ways the learning experience provides opportunities for scholars to engage in ISP 1

●●● THE STORY OF MS. GONZALEZ

Ms. Gonzalez (she/her) checked to make sure she had a variety of tools such as small screwdrivers, scissors, paper bowls, arduino electronics kits, hair dryer, flashlights, and a range of batteries before her scholars entered her classroom. Ms. Gonzalez, a sixth-grade teacher, was still learning the ropes of integrated STEM teaching, a newly adopted focus at her school. Although only in the early stages of implementation, she was already feeling the excitement and buzz around STEM that was spreading throughout the school. She was eager to try and thought her scholars would get engaged in the STEM task: Deconstructing and Reconstructing an Object.

As her fourth-period class returned from lunch, Ms. Gonzalez noticed the scholars were excited to share the nonfunctioning items they had been asked to bring to class. Ms. Gonzalez had several nonfunctioning items scholars could use if they wished (i.e., calculators, spring scales, wall clocks, old nonworking laptops, and printers), and some scholars brought their own object from home.

Cristina had her digital watch. "This has been stuck at 12:02 p.m.," Cristina told Leon.

"Oh, that's definitely not working. I have my calculator. When I turn it on, the screen lights up but never changes from a bright screen and you can't see the numbers," Leon responded.

"I hope we can get these fixed today. I spent my own money on this thing!" Cristina exclaimed.

"Please get out a pencil and the item you brought in today," Ms. Gonzalez said. While scholars retrieved their items, Ms. Gonzalez handed out a structured reflection tool designed to help scholars document their learning throughout the task.

STEM Structured Reflection Tool

DECONSTRUCTING AND RECONSTRUCTING AN OBJECT

What you need...

- Item or toy that no longer works (preferably with moving parts and possibly a motor)
- Tools to take it apart
- A bowl or bag to keep parts
- Device with camera (optional)

1. Record how your object works when functioning properly. (Written, oral, or video blog)

   Does it move something?

   Does it make noise?

   Be as specific as possible.

2. What is not working on your object?

   Which part that you identified previously does not work?

   If it is not in your previous list, then possibly you need to add it.

   Is the problem visible?

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"With your table partner, I want you to take turns talking about the item you brought with you today. Explain to each other what the item is, how it functions, how it is supposed to work. Be as specific as possible. Once each person has shared, write your descriptions of the item on your structured reflection tool. You have 5 minutes to complete this step. What questions do you have?" Ms. Gonzalez told scholars to begin, set the timer for a specified number of minutes (she found that 5 minutes usually was the appropriate amount of time for group discussion of this level), and started circulating to listen to scholars' conversations and probe their thinking.

"So, this is my calculator. Last week when I turned it on, it just had a blank screen. Nothing happens. It's supposed to light the numbers up, but that's not what happens," Leon shared with his group.

"OK, my turn," Cristina interrupted. "This is my digital watch. It's stuck on this screen. The alarm isn't working or any of my notifications."

After the scholars shared, Ms. Gonzalez showed them her object so she could model her description of the function of her object: "My 3D pen stopped working last week. This 3D pen extrudes plastic (or filament) that can be used to create three-dimensional objects. It must be plugged in to work. The pen heats up so that it melts the filament. This small button triggers a motor that pushes filament through the opening (or extruder). There is also a slider that changes the speed of the motor." Noticing several scholars adding more to their descriptions after hearing her describe the 3D pen, Ms. Gonzalez gave her scholars time to revise their descriptions.

"Now that you've described what's wrong with your object, let's consider some possible solutions. For example, with this 3D pen, filament goes in, but it doesn't come out the extruder. Work with your shoulder partner to explain which part of your object might not work, if the problem is visible or hypothesized, and brainstorm some possible solutions. Be sure to write down the ideas you talk about," Ms. Gonzalez said.

"The screen is stuck on my watch. That's visible," Cristina said, leaning over to Leon.

"How would you fix that?" Leon asked.

"Hmmm. I'm not sure. I've tried charging it, and that didn't work. Maybe there's more to it than the battery power."

"Maybe you could try turning it off and then on again. That has worked for me when my computer had a similar issue. Or maybe you have to take it apart and see if there's something else going on since changing the batteries didn't work. The problem with mine is that it turns on but the screen just stays blank. It seems to have enough power to turn on. It doesn't light the numbers up, and the calculator functions don't load."

"So how could you fix that?" Cristina inquired.

"I don't know. Maybe I should take it apart and see if there's a piece broken inside. I normally just turn it on, but I need to know if there's a removable battery in there that needs to be replaced." After the conversation, Cristina and Leon wrote their ideas down on their structured reflection tool.

Next, Ms. Gonzalez said, "Now that you have brainstormed problems and solutions, I want you to decide on your next steps. If you need to break down or take apart your object, how will you do it? Are there any screws holding your object together? Are there other parts? What tools will you need? Once you decide what tools you need, you can meet me at the back table to collect your materials. As you deconstruct your object, use your structured reflection tool to record the steps you take. You can also take pictures to help you remember where parts go. As you take apart your object, make sure to place the parts in a bowl so you don't lose anything," Ms. Gonzalez explained. "And remember our conversation about safely using the tools and watching for sharp edges. Please wear the protective eyeglasses as you work." (See Figure 2.1.)

Leon identified the need to use the correctly sized screwdriver to open the battery case on his calculator. He found new batteries Ms. Gonzalez had brought in to replace the old ones. While he was able to get started on that, Cristina looked for a similar solution for her watch. "My watch doesn't have a place to use a screwdriver to take it apart. What should I do?" Cristina asked Ms. Gonzalez. After a brief conversation, Cristina decided to try what Leon had suggested—turning on and off her watch.

After 10 minutes of work time, Ms. Gonzalez interjected, "Let's re-examine your ideas. What do you think will work now? Is there a different problem than what you hypothesized? Will you need a new solution? It's okay to repeat this step again and again if your solution doesn't work."

Ms. Gonzalez walked around the room observing her scholars, asking them questions, and offering intentional suggestions and encouragement if scholars became frustrated. At Cristina and Leon's table, Ms. Gonzalez noticed a puzzled look on Leon's face.

"Leon, what do you think will make your calculator work again?" Ms. Gonzalez asked.

"I saw there was a screw I could use to open this door, and I saw there's removable batteries in here. Perhaps the batteries don't have any charge

Figure 2.1

Scholars Work Together to Deconstruct a Printer

Source: Kristin Cook

left, and the calculator needs new batteries. I tried that but it didn't work," Leon considered (Figure 2.2).

"Yeah, I'm not really sure what I can do either. I've tried turning my watch on and off and that doesn't do anything. Nothing looks broken. It just isn't working!" Cristina said.

"Hmmm . . . What resources might you use to learn more? What would be helpful? Where could you go look?" Ms. Gonzalez replied.

After considering what other resources they might rely on, Leon decided to look up videos on the internet of others with the same calculator problem for ideas on how to troubleshoot. Cristina thought she could find more information on the company's website. She looked up how to troubleshoot her digital watch and found instructions about restoring the factory settings by pushing various buttons on the watch. "Ah! It looks like I can try to reset the whole watch using these instructions and then resync it with my phone to restore everything!" Leon learned from his internet sleuthing that the connected ribbon is something that causes the numbers on calculators to not appear.

"Be sure to explore those ideas, Cristina and Leon," Ms. Gonzalez encouraged.

After Ms. Gonzalez walked away, Leon used the screwdriver to open the door and carefully pulled out the circuit board from his calculator.

"Sometimes you have to ask if you can fix a broken object," Ms. Gonzalez explained. "Ask yourself the following questions: Do you have the tools you need? Do you need to take it to a special shop? Will it cost too much to fix?"

Figure 2.2

Leon Works With Another Scholar to Open up a Nonfunctioning Calculator

Source: Kristin Cook

"From these videos, it looks like I'm going to need some heat to warm up the connector ribbon attachment points," Leon said. Leon found Ms. Gonzalez had provided a hair dryer, so he planned to use that. When Leon removed the circuit board, he copied what he had seen others do on the videos by laying it out flat and using a hair dryer to heat the connector ribbon. In the video, they used a flat rod to smooth out the ribbon that connected the circuit board to the screen, but since Leon didn't have that, he used his pencil eraser tip to smooth out the ribbon on both sides. Leon thought the smooth edge would mimic what the flat rod was able to do—and it turned out he was right! The numbers reappeared on the screen. Meanwhile, Cristina followed the instructions she found online to reset her watch and was busy resyncing it with her phone to see if it worked. When it did not, Cristina wondered about next steps. If the battery charging didn't work and neither did the factory reset, she had to consider if it would be cost-effective taking it to a shop for help. Ms. Gonzalez asked her, "What are some possible options now? What are the important aspects of the consideration of these options?"

"Great job figuring out what was wrong and coming up with solutions today!" Ms. Gonzalez said as she walked back toward the front of the classroom bringing the class back together.

"Be sure you reconstruct your object. You wrote your steps down as you deconstructed. Now you can follow those steps in reverse order to put your object back together. Once you have your object back together, talk with your shoulder partner about what you did, if it worked, and what you learned," Ms. Gonzalez announced. ●

Source: From Cook et al., 2021.

What Is ISP 1: Use Critical and Creative Thinking to Seek Solutions

The practice standards across all the different STEM content areas (e.g., Standards for Mathematical Practices [SMPs], Science and Engineering Practices [SEPs], and Technology and Engineering Practices [TEPs]) emphasize the importance of critical and creative thinking in solution seeking. It's important that scholars have the opportunity to engage regularly in critical and creative thinking, especially as they start to build and design solutions for nonroutine real-world challenges encountered in their community and beyond. We chose to use the term *solution seeking* rather than *problem solving*. We believe the notion of problem solving is often limiting, conveying to scholars that

(a) all problems can be solved and (b) problems have a definitive end. Solution seeking focuses on equipping scholars to provide or find multiple possible solutions to tasks that are captivating and challenging: captivating in the sense that scholars are interested in the topic and challenging in the sense that there is more than one solution or path to the task. This requires educators to use captivating tasks that do not have a single solution, which also helps to counteract the dominant idea that there is always one right way. Also, there are so many aspects of life where we can make positive progress, but a final or resolute solution may never be reached (such as reducing pollution, though we can never eliminate it). Helping our scholars grasp this truth while empowering them with the ownership to feel compelled to tackle these complex topics is how we make our world better for generations to come.

In this section and throughout this text, we will emphasize the importance of seeking solutions, instead of using the term *problem solving,* to convey the importance of connecting challenges to scholars' interests and to emphasize the collective solution seeking and innovating we find in integrated STEM. There are three components of this first integrated STEM practice:

1. defining and understanding challenges,
2. thinking critically for solution seeking, and
3. thinking creatively for solution innovating.

Sometimes criteria are set by the content standards in which you are operating. Criteria can be broadened to include indicators set by the group who has created the task (e.g., community partnership).

ISP 1 is called *Use Critical and Creative Thinking to Seek Solutions* because scholars are empowered as they encounter challenges that are deeply interwoven with their lives and interests and they feel individual and collective ownership to seek solutions and innovations leveraging integrated STEM.

Defining and understanding challenges requires scholars to make sense of a task so they can design a set of possible successful solutions. Scholars should ask questions to identify criteria for success and constraints placed on designing possible solutions. Criteria refers to the specific indicators by which solutions will be judged as successful or not successful.

Constraints are limitations placed on the design. Constraints can be resources (e.g., materials, time), knowledge, and costs. Defining and understanding the challenge also involves understanding the need or want inherent in the task, particularly so scholars understand how others can benefit from the solutions being presented.

Scholars can study the positive and negative impacts and/or influences on different populations or audiences, especially those of the global majority, for each solution presented.

As scholars progress in their abilities to define and understand challenges, they should also consider the data necessary both to design and evaluate solutions and the forms of evidence that can be used to support potential solutions.

Critical thinking for solution seeking in STEM requires scholars to analyze, evaluate, and synthesize information through logic and reasoning skills to provide and evaluate potential solutions. Several processes exist as a model that you can draw on to guide scholars as solution seekers through critical thinking. For example, the Engineering Design Process[1] (NASA, 2018) structures scholars' thinking around

- asking questions to identify challenges,
- imagining solutions through brainstorming,
- planning for possible solution(s),
- creating and testing the solution(s), and
- improving the solution(s).

The Design Thinking Process from Stanford (Plattner, 2010) is another model to guide critical thinking by focusing on

- empathy,
- defining problems,
- ideating,
- prototyping, and
- testing.

Although these different models vary slightly, they all provide a helpful structure for you to facilitate your scholars' journey as they analyze, evaluate, and synthesize information to reach possible solutions by following a logical order.

Creative thinking for solution innovating in STEM requires scholars to investigate, imagine, and innovate to produce ideas based

[1]There are many accepted and well-researched engineering design process models. We chose to use the NASA BEST engineering design model because it best fits well with a majority of K–12 science curricula and with the Science and Engineering Practices in the Next Generation Science Framework.

upon questioning and reasoning. When scholars are given nonroutine, real-world challenges that have multiple possible solutions or paths, they are called to use their creativity to seek possible solutions. This mimics the work scientists, engineers, mathematicians, and all STEM professionals do as their professions require them to be creative in their approaches. When scholars are exposed to these nonroutine challenges, they go beyond discipline-specific applications and apply creative thinking skills as they work with ideas from across multiple disciplines. To encourage this type of creative thinking, it is important for the teacher to be "curator of opportunities and supporter of possibilities" (Brennan, 2017, p. 8), rather than leading scholars through fixed pathways. For example, rather than telling Cristina the next step, Ms. Gonzalez asked Cristina what other resources she could use to troubleshoot how to fix her watch. In this way, Ms. Gonzalez guided her to use her own knowledge base to discern next steps and the best use of resources. Further, it empowered Cristina to be the scholar and expert in this scenario, rather than focus on Ms. Gonzalez as the "qualified" expert.

Solution ideas that do not lead you to the outcomes desired in the task or challenge are simply solution ideas for another task or challenge that has not yet been identified.

Critical and creative thinking are the cornerstone of ISP 1. The key idea is that there are no bad ideas throughout this process. There are only ideas that need a pivot or other improvements made to them.

Creating space in your classrooms where scholars are free to present ideas and solutions to challenges and tasks without criticism and without the drive for perfectionism is critical in implementing ISP 1.

●●● SO YOU'VE BEEN TOLD . . .

You can only teach STEM if you know all the disciplines well.

REALITY CHECK!

Not true! STEM is a team sport! At the middle and secondary grades, hardly any teachers are experts in more than one of the STEM disciplines. That's okay and expected! You have to know so much about "your" subject. Remember, you aren't going through this alone! Capitalize on the knowledge of your colleagues, families, and the broader community. For example, in the story of Ms. Gonzalez, facilities staff could offer some tool options, or STEM-related teachers, such as the computer science or industrial technology teacher, might help brainstorm solutions, especially the really tricky ones! ●

Stop, Think, Reflect (2A)

1. How would you describe ISP 1 to a colleague?
2. How would you describe ISP 1 to a scholar who is engaging in the practice?

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Why Does ISP 1 Matter?

Take a moment to imagine what our world would be like if we did not promote and engage scholars in critical and creative thinking. We would have no innovation. No creativity. Everything would look the same. Perform the same. Sound the same. We would all solve the same problems the same way. Life would be stagnant. The world would be pretty dull and boring.

When every scholar is given access and opportunity to use critical and creative thinking, they are empowered and have agency. They are not hedged in to think the same way, act the same way, or focus on the "right" way. Let's take a moment and consider why this is important. Scholars realize and come to understand they are essential contributors to their and others' knowledge. Their minds are vehicles to make the world better for others, themselves, and future generations. Scholars begin to become more reliant on their own reasoning and critical and creative thinking rather than the thinking of others, particularly those in positions of power such as their teachers. This helps to disrupt the system of paternalism dominance (e.g., telling scholars how to do a task or what's best, often without the scholar's input) that so often contributes to scholars' lack of a sense of belonging. Instead, scholars are empowered, positioned as qualified in their given scenarios, and vested in finding or working toward solutions. They see and begin to understand the *why* of learning because they are able to apply learning across multiple disciplines. Scholars' use of critical and creative thinking provides the stepping stones to empowerment and positive STEM identity, which are needed to become societal change agents for the communities in which they live.

Stop, Think, Reflect (2B)

1. How did you see Ms. Gonzalez engage scholars in ISP 1? What specific actions did she use throughout the task?
2. How did Cristina and Leon define and understand the challenge?
3. How did Cristina and Leon use critical thinking?
4. How did Cristina and Leon use creative thinking?

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Diving Deeper: Ms. Gonzalez as a STEM System Disruptor

In the Deconstructing and Reconstructing an Object task, Ms. Gonzalez engaged her sixth-grade scholars in using critical and creative thinking to seek solutions. By starting with an object that did not work, Ms. Gonzalez encouraged scholars to explain the function of the object and what was wrong with the object. Cristina and Leon explained their digital watch and calculator, respectively. They clearly defined and understood their challenges as a digital watch not working and a calculator not functioning properly when it was turned on.

As Ms. Gonzalez worked with Cristina and Leon in the Deconstructing and Reconstructing an Object task, she directly challenges ideas of paternalism, perfectionism, and defensiveness. As scholars use their own critical and creative thinking to identify the problem with their objects, they were going beyond the ideas of others. The scholars were empowered to use their own ideas to make decisions to fix the broken objects. Scholars possessed the confidence and critical thinking to go beyond found resources to experiment with what might work in their situation (e.g., Leon used the resources he had at hand to solve the problem). In some cases, the object was not fixable and scholars had to use that experience to weigh the next best steps. To address ideas of perfectionism, Ms. Gonzalez combats Cristina's sense of frustration to prompt her to consider the resources she has available to her. This does not lead to a sense of failure at the task; instead, it is seen as a critical step in defining the problem. The conversations between Ms. Gonzalez, Cristina, and Leon also serve as a model to combat defensiveness. Ms. Gonzalez questions scholars to further their thinking. The scholars offer feedback to each other, such as when they shared ideas for the other person to explore. Neither scholar was defensive at the suggestion of a different idea.

Critical Thinking and Problem Solving

Once the tasks were defined and understood, Ms. Gonzalez led scholars through an exploration where they used **critical thinking** to come up with potential solutions for their challenge.

The structured probing questions used by Ms. Gonzalez guided scholars through a logical thinking process to think critically. Cristina and Leon had to describe their object, explain how it did not work, and describe what steps they had already taken. Ms. Gonzalez also encouraged scholars to document their progress and take pictures as they deconstructed their object so they could reconstruct it later. This attention to detail is important as scholars are developing critical thinking skills.

This type of logical thinking also exemplifies the type of thinking we want scholars to use in mathematics when they make sense of challenges faced in our world. Scholars have to understand what the problem is asking, try a potential strategy to get the solution, and then evaluate if the strategy and solution worked or are best for the problem. As scholars engage in this type of solution seeking in many contexts, their ability to apply those skills inside and outside of the STEM classroom will be enhanced.

Ms. Gonzalez also intentionally reminded scholars that they were trying something new, that it might not work, and that it might take more than testing one potential solution to find something that would work. This is a necessary skill when practicing technology and engineering design (International Technology and Engineering Educators Association [ITEEA], 2020). She prompted them to identify something they could try and, depending on the results, continue from there or try something else. It is essential for STEM teachers to attend to the **dispositions** associated with STEM learning environments.

Dispositions

Perfectionism is so often the driver in our society. However, failure is an essential and expected part of the learning process and really where our scholars learn and grow. While not all of the objects would be fixed in this learning experience, forward progress was made toward a solution or next step (e.g., Leon now knows how to fix a connector ribbon and Cristina now knows to try the factory reset option).

●●● SO YOU'VE BEEN TOLD . . .

Students need to learn basic skills, facts, and procedures before they can engage in critical and creative thinking. They aren't ready for problem solving yet.

REALITY CHECK!

Our scholars were born ready to be solution seekers! Scholars enter school curious and creative, and traditional school environments often stifle and steal their curiosity and interest. The truth is, engaging them in critical and creative thinking is a gateway to our scholars learning the STEM disciplines more deeply. It gives them a reason to care and empowers them to use science, mathematics, and broader STEM knowledge for the greater good in the world. It helps them to understand why they need to know STEM to begin with and brings purpose and intentionality to the conversation. We promise, scholars really ARE ready! Let them surprise you! ●

Ms. Gonzalez also encouraged her scholars to use **creative thinking.** While critical thinking was used to diagnose the challenge, creative thinking was used to innovate and design possible solutions. Leon explored a variety of ways to fix his calculator (first the battery replacement, and then when that didn't work, he found Internet resources that pointed him to the connector ribbon). Creative thinking involves not just innovation but also attending to efficiency when looking at the solutions. The **utility and applicability** of this lesson applies to daily life as we use our STEM practices to creatively and critically identify challenges and seek different solutions to the challenges around us.

Utility and Applicability

The design of the components in Leon's calculator is an example of creative thinking in design because the pieces are organized in a manner to maximize efficiency and provide a successful experience. Cristina engaged in creative thinking as she explored the components of her digital watch to determine if there was a way to get the components to work. Exploring resources and using them in unexpected ways is a characteristic of creative thinking in STEM.

Putting ISP 1 Into Action: What Does It Look Like?

Scholars engage in critical and creative thinking to seek solutions to real-world nonroutine challenges. In Table 2.1, we describe characteristics of what a classroom would look like when the teacher and scholars engage in ISP 1.

Table 2.1

Putting ISP 1 Into Action

	ISP 1 COMPONENTS	TEACHER ACTIONS	SCHOLAR ACTIONS
ISP 1: Use critical and creative thinking to seek solutions	Defining and understanding challenges	Find, modify, or create nonroutine real-world tasks that require scholars to use knowledge from multiple disciplines and with multiple stakeholders.	Observe, question, and research ideas to define and understand the task. Identify stakeholders. Identify constraints on the design and criteria for a successful design.
	Critical thinking for solution seeking	Introduce and model a framework for critical thinking, such as the Engineering Design or Design Thinking, to encourage logical solution seeking.	Use a logical process, such as Engineering Design or Design Thinking, to document the process used to seek solutions.
	Creative thinking for solution innovating	Encourage and model innovative uses of materials. Encourage brainstorming a variety of ideas to seek solutions to develop creative thinking skills.	Explore properties of materials and come up with nontraditional ways to use materials to seek solutions. Generate a list of ideas to seek solutions, including sketches, that can be refined later.
	Seeking solutions	Provide scaffolds for reasoning from evidence. Intentionally construct collaborative groups to dissect the learning experience.	Analyze trade-offs of proposed solutions or ideas. Consider multiple perspectives from other scholars and stakeholders.

Assessing ISP 1

Assessing critical and creative thinking can seem vague. When scholars are actively involved in critical and creative thinking activities, they are analyzing, evaluating, synthesizing, investigating, imagining, and innovating (ITEEA, 2020). In the story of Ms. Gonzalez, a reflection tool structured the STEM task as scholars wrote down initial thoughts about the task, articulated potential solutions, and then revised solution plans as they continued to deconstruct and examine their objects. Documenting your ideas and iteratively revising them are key elements to critical thinking. Ms. Gonzalez could have also had scholars draw pictures of their objects, the problem they identified with their objects, and/or solutions. Creating pictures and diagrams helps to connect creative and critical thinking—using both to try out different solutions to the challenge under investigation.

If additional resources are available, taking pictures of the objects throughout the deconstructing process and using the pictures to put together a story of the solution(s) journey is a great way to expand scholars' communication and media knowledge. This can also aid in communication if scholars are still working on communication through writing. Video documenting the process would work as well. Using a tablet, phone, or other video recording device, a scholar could video their deconstruction process themselves or for a shoulder partner. In the video, it would be important to point out different parts of the object and how they might work together. It would also be important to point out any potential roadblocks and brainstorm ways to overcome them. Scholars could video themselves fixing the object and conduct a "failure analysis" to determine which actions have which consequences. This will help them identify next steps. Many times a solution will not work and will be considered a failure. Teachers should encourage scholars to "fail forward"—learn what worked and did not work in the failed solution and try again with a revised solution. As with all the ISPs, it is important that failure is seen as a positive part of the process and that scholars are encouraged to continue being creative and critical thinkers.

SO YOU'VE BEEN TOLD . . .

Assessing STEM tasks is too complicated and time-consuming!

REALITY CHECK!

Actually, assessing scholar learning from STEM tasks is a more authentic and perhaps meaningful approach to assessment. Such an approach moves us away from procedural, surface-level multiple-choice and short-answer assessments and toward a way of offering scholars the opportunity to demonstrate their understanding in ways that more closely mirror how they will be held accountable for their knowledge in their professional and personal lives.

Assessment of STEM tasks and the ISPs encourages scholars' creativity and will better illuminate their thinking for you as the teacher, which is a win–win! Circling back to the story of Ms. Gonzalez, scholars were asked to break down the problems into steps, trying one possible solution to see if that worked before trying something else. Scholars asked questions and made observations and used the evidence they built to back up their claims, prioritize criteria, understand constraints, and consider trade-offs.

In the Moment Feedback

In the Moment Feedback is a tool that educators can use as they assess scholars on ISP 1. The first set of questions are formative assessment questions meant to generate a discussion among and between you and your scholars. Such discussions will help you gain an understanding of where scholars are and what additional supports they might need as they engage in ISP 1. The Design Notebook Prompts are prompts you can provide your scholars for them to respond in writing to facilitate literacy and written communication, encourage engineering design thinking processes, and serve as a record of activity similar to what is often expected in the workforce. We encourage the use of the design notebook that showcases scholars' growth on ISP 1.

Formative Assessment Questions (teachers asking scholars)

Purpose: In the Moment Feedback

- What are some potential challenges or limitations with this learning experience? What are your ideas for overcoming them?

- What's a unique way that might not have been tried before in this learning experience?
- If you had unlimited resources, what ideas would you have for seeking a solution for this learning experience?
- Have you seen a similar task before? If so, where? What solutions do you think they tried?

Design Notebook Prompts (scholars complete individually or in groups)

Purpose: Continuous record of learning experiences/final showcase of work

- When I first saw this task, I thought ____________. I had the following questions about the task (list at least two questions).

____

____

____

____

- If you had unlimited resources, an idea for a solution for this learning experience is ____________. What resources would you need for this solution?

____

____

- The most unusual solution for this learning experience would be ____________. What makes it unusual?

____

____

- List the ideas you generated for the experience.

____

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- Indicate if these ideas are sustainable or not sustainable.

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- Pick one idea that is sustainable and explain why.

____

____

- Pick one idea that is not sustainable and explain why.

____

____

ISP 1 RUBRIC

In Table 2.2, we provide a rubric that you can use to assess your scholars' engagement in ISP 1.

Table 2.2

ISP 1 Rubric

ISP 1 COMPONENTS	NEEDS MORE SUPPORT	APPROACHES EXPECTATION	MEETS EXPECTATION	ACHIEVING SOCIETAL CHANGE AGENT
Identifying the challenge (Critical Thinking)	Challenge and context are not yet mentioned. It is unclear what is being investigated.	Challenge is vaguely defined. Context may or may not be present. While a broken or nonfunctioning object is present, it is vague regarding the challenge.	Challenge is specifically defined for the project. The criteria for how the object is supposed to work are clearly defined. Constraints are somewhat considered.	Challenge is specifically defined as well as the constraints. Goals for the object are specific and able to be tested.
Identifying solutions (Creative Thinking)	Only one solution is constructed for the challenge.	Describes a few solutions but it's not yet clear how they will be carried out.	Describes multiple solutions with a plan for how to carry them out. For example, ranking how the solutions should be approached.	Describes multiple solutions with justifications. Understands the constraints of the solutions and has a plan for carrying them out.
Testing and revising solutions (Critical and Creative Thinking)	Solution is not yet tested or there is no plan for testing.	Tests and makes changes to solutions, but there is not yet a clear path to the ultimate solution. The different trials do not yet build on each other or prior results.	Uses an iterative process to test different solutions. Carefully documents and plans each test based on the results of the previous test.	Uses an iterative process to test different solutions, taking into consideration each previous test and additional constraints learned along the way. The process is carefully documented.

Stop, Think, Reflect (2C)

1. How could you use ISP 1 in your own classroom?
2. How could you turn a current lesson into one that engages scholars with ISP 1?

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Recap This!

Big Ideas!

ISP 1

Use Critical and Creative Thinking to Seek Solutions

The most meaningful STEM tasks are deeply interwoven with scholars' lives and interests, and they feel individual and collective ownership to seek solutions and innovations. Engaging in ISP 1 enables scholars to see the **utility** and **applicability** of STEM in the world around them.	Critical thinking toward solutions in STEM requires scholars to analyze, evaluate, and synthesize information through logic and reasoning skills to provide potential solutions. When scholars engage in **critical thinking** to seek solutions, they become **empowered** and see themselves as agents of change.
Creative thinking for solution innovating in STEM requires scholars to investigate, imagine, and innovate to produce ideas based upon questioning and reasoning. Being engaged in the solution-seeking process develops scholars' positive **dispositions in STEM** and enables them to see themselves as makers and doers of STEM.	Don't wait to engage your scholars as solution seekers! **Solution seeking** and engaging in ISP 1 serves as ways to develop STEM content, practices, and skills in your scholars.

●●● STEM STARTERS

- Your work planning an ISP learning experience will be primarily on the front end. Once you begin implementing, your scholars will be the ones doing the hard work (critical and creative thinking), as they should be!

- Instead of adding to your plate, the ISPs help streamline your efforts! The ISPs aren't an add-on. The ISPs are a strategic tool for addressing existing standards in a more high-quality (and more efficient) way.
- Not only does considering STEM through an ISP lens provide focus and direction to your STEM efforts, but embodying the ISPs ensures scholars have access to the types of STEM tasks they rightfully deserve.
- Adopting the ISPs and implementing them intentionally is a commitment to equity, access, and a strengths-based approach to instruction!

Questions to Ponder/Book Study Prompts

What are some captivating contexts in your school, community, or in current events that would draw in your scholars?

Who might you enlist as collaborators to implement your ISP 1 STEM learning experience?

How will you ensure scholars' critical and creative thinking remain a focal point of the learning experience? (not give too much away or overproceduralize)

How will you leverage the lived experiences and strengths scholars bring to the ISP 1 STEM learning experience, rather than focus on perceived deficits?

What are some challenges you anticipate related to this chapter? What ideas do you have for removing these barriers or overcoming these challenges?

online resources Available for download at **qrs.ly/uyf1luv**

TRY THIS!

Whether you're trying a new STEM task or reimagining one you've used in the past, try the following in Table 2.3 to highlight the aspects of ISP 1 we have discussed in this chapter.

Table 2.3

ISP 1: Use Critical and Creative Thinking to Seek Solutions

COMPONENTS TO ISP 1	ASPECTS OF TASK	QUESTION PROMPTS FOR SCHOLARS
Defining and understanding challenges	Make authentic connections Identify criteria and constraints Be clear about connections to mathematics, science, technology and engineering	How does this connect to your life? What specific goals (criteria) and limitations (constraints) do you have? How did you use ideas of science and mathematics to help you seek solutions to this task?
Critical thinking	Identify important information Apply logic to solution seeking Consider multiple perspectives	What information is needed as you work to approach this task? If you could change one aspect or variable, what would change? Who else is impacted by this issue? In what ways might other people perceive the issue differently?
Creativity	Encourage exploration of materials Allow time for brainstorming a variety of ideas Embrace mistakes	What types of tools do you need? What might these tools offer? What are the limitations of the tools we have? What are some other ideas you could try? What did you learn from taking risks? What did you learn when your idea did not work?
Seeking solutions	Probe for reasoning Consider trade-offs Structure collaborative groups for diverse thinking	Why did this solution seem like the best approach? For this solution, what were the trade-offs you had to make? What unique contributions did each group member make?