ST Math

The Art of Facilitation

MIND RESEARCH INSTITUTE

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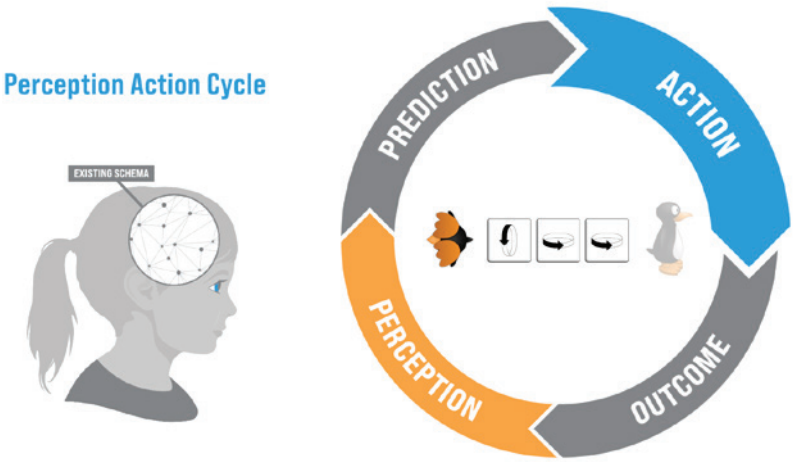
At MIND Research Institute we believe that every student has the potential to deeply understand and truly love math. As a math and neuroscience non-profit organization, we leverage our research and understanding of how students learn when we design our products, resources, and experiences so that we may continually promote deep conceptual learning.

Perception-Action Cycle



According to neuroscience research, a powerful system for deeper learning is the perception-action cycle. Our flagship program, ST Math, is designed to engage students in that cycle through visual, spatial-temporal models and informative feedback. The perception-action cycle describes how our brains make sense of the world around us. As we experience the world we create and test hypotheses about how the world works. This process is called the perception-action cycle, and is a feedback loop helping us build an understanding of how the world works. Learners are continuously perceiving, predicting, acting, and adjusting their thinking as the brain processes experiences with the world around it.

Schema Building

When students are presented with problems, tasks, puzzles, or something they need to understand, the brain immediately looks to find prior understanding to connect it to. These understandings, or the way we look at the world, are called schemas. Schemas are a network of neurons that are connected to different paths. The way those networks get created and connected ends up defining a concept or understanding of the topic. It is like a map or blueprint our brain makes that helps make sense of the world around us. We all have schemas about a variety of things and when we support students in creating strong schemas around the topics they are learning, it gives them the ability to solve challenging problems they haven't seen before.

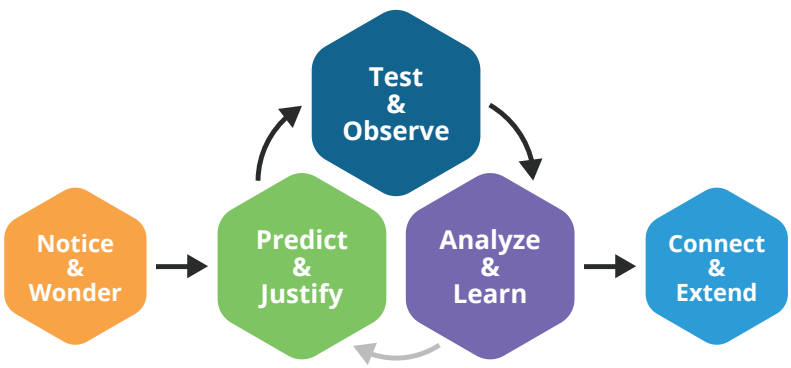
Connecting schemas leads to conceptual understanding. Conceptual understanding in math is the creation of a robust framework representing the numerous and interwoven relationships between mathematical ideas, patterns, and procedures. This framework can be used to coherently integrate new knowledge and solve unfamiliar problems.

Conceptual learning requires building, revising, and connecting schemas. To support student development and understanding of math concepts it is important that mathematics isn't taught as a series of isolated concepts. This causes students to compartmentalize their ideas around different mathematical topics. They are more likely to think of them as rules to learn and procedures to follow. Instead it is important to help students consider concepts and their relationship to one another.

Good Facilitation Helps Build Strong Schema

It is important for students to build schema, make connections, construct knowledge, and stretch their understanding. To do that, students have to "think" about their thinking. We believe that the teacher plays a pivotal role in making that happen by facilitating thinking through questions as students work through the problem-solving process. Research supports the fact that facilitation plays a key role in having rich mathematical discussions and promoting student thinking in the classroom (Chapin, O'Connor, and Anderson 2009; NCTM 2014; NRC 2001; Seeley 2016; Smith and Stein 2011). One of the eight National Council of Teachers of Mathematics (NCTM) Mathematics Teaching Practices directly addresses facilities. It states, "Effective teaching of mathematics uses purposeful questions to assess and advance students' reasoning and sense-making about important mathematical ideas and relationships." (NCTM, 2014)

Facilitation and ST Math



When students play ST Math, they engage in the perception-action cycle (PAC). ST Math games take students through this cycle over and over, giving them a safe place to fail, providing new information through immediate and informative feedback, and inviting them to try again until they find the solution. The immediate and formative nature of the feedback is critical to the PAC. The feedback either reinforces and strengthens the neural pathways in students' brains or gives valuable information that informs and triggers their brains to build new or extend existing schema. This ongoing information exchange can be hard for students to recognize. They need to process what they are learning and how to apply it. The problem-solving process is a powerful way to help make students thinking visible and support them in processing their predictions, actions, and outcomes as they work on ST Math puzzles.

Teachers play a vital role as facilitators in engaging students as they play ST Math puzzles. This facilitation should occur during ST Math 1:1 time, and while discussing strategies during Puzzle Talks. The components of the problem-solving process can be used by teachers to promote discourse and by students to engage in self-facilitation.

As students engage in the ***perception*** part of the PAC, teachers can facilitate student thinking by inviting students to "***Notice & Wonder***." They do this by asking questions aimed at focusing students' thinking as they notice the information in the puzzle and discover or "wonder" what they may need to do to solve it.

As students engage in the prediction part of the PAC teachers can uncover student thinking by inviting students to "***Predict & Justify.***" They do this by asking questions focused on helping students identify a strategy and predict and justify what will happen when they try their strategy. It is important for students to name their strategies and describe what will happen when they try these strategies.

Teachers can facilitate student thinking by inviting students to "***Test & Observe***." They do this by asking questions that focus on students applying their strategy and observing what happens. This is often a step that students rush through. It is important once an action is taken that students take time to observe the ***outcome***. When we are asking students to analyze, they need to understand what it is that they are analyzing. Giving them a pause to pay attention to what they observe gives them time to process.

Teachers can then facilitate student thinking by inviting them to "***Analyze & Learn***." They do this by asking questions focused on students observing the outcome, analyzing what happened, and determining what they can learn from it. If they got it wrong students take what they learned and start the process again. If they got it right they can connect and extend their thinking. It is the process of building, revising, and extending schema.

Teachers as Facilitators

Effective facilitation does not just happen because teachers ask a question, it happens because an environment has been created where students are encouraged to share their thoughts and ideas and engage in discussions around the thoughts and ideas presented by others. Students understand that they are accountable for their thinking, not just giving correct answers. As teachers continue to engage students in focusing on what and how they are thinking, students will build confidence, increase their communication skills, and deepen their understanding of concepts.

Creating an environment for effective facilitation requires purposeful planning around the way students will interact with other students, with the teacher, and with the content (including technology). Planning should also include classroom management, strategies for handling opposing thoughts, unclear thoughts, and changing thoughts. As we develop resources to support teachers as facilitators not just around ST Math, but as facilitators of learning, all of these areas are being considered in the design. This drives our work toward creating resources that are not only instructional tools, but also tools that can support teacher development. Now let's take a closer look at facilitating the problem-solving process.

Asking Purposeful and Effective Questions

At MIND, we believe that an effective facilitator asks purposeful and effective questions to support student thinking as they engage in the problem-solving process. This is not a checklist of questions to ask, but instead is a focus on why we ask the questions in the first place. In order to help students build schema, it is important that we ask questions that help them understand and articulate their thinking. They need to be engaged in thinking about their thinking and the thinking of others.

You may consider asking facilitation questions at various points to help students get started on the problem. You may also ask questions to better understand student thinking as related to their strategy. Another reason you may ask questions is to help students make connections. Whatever your goal there should be a purpose directly related to the thinking students are doing while problem solving.

At the start of the problem-solving process

When students are presented with a problem, the questions asked should **focus** students' thinking on what is important and help them make any connections to prior knowledge. This allows students to pause and take notice of the information they are given, make sense of the problem, identify the question they are answering, and connect to their previous knowledge.

When formulating a plan to solve a problem

Once students have made sense of the problem and taken into account the important information, questions asked should aim to **uncover** the students' thinking and support the development of a solution pathway. This gets to the "how" students are thinking: how they plan to address the problem; where they entered the problem; what they think will happen and why; what a reasonable solution should look like.

When applying the strategy to solve the problem

As students apply their strategies, questions asked should **facilitate** students' thinking about their strategy and prompt them to explain the action they will take. Having students communicate their strategy and then observing what happens when it is applied provides them an opportunity to focus on what happened when they tried their strategy. To help students refine or change their strategy, it is important for them to first understand what happened when their strategy was applied. It is hard to analyze their results without first recognizing and understanding the results of applying their strategy.

In addition, this is a great opportunity to engage students in thinking about additional strategies or solutions to the problem. As students apply their strategy, they may notice the need to make adjustments. This is especially true for multi-step problems or tasks. This again is a great opportunity to ask questions and encourage students to think aloud.

When analyzing the solution

Once students have applied their strategy and observed what happened, questions should **engage** students in evaluating their thinking, analyzing the feedback/results, and revising their understanding. By examining their thinking, whether they are correct or incorrect, students are able to either reinforce their strategies or examine their errors providing them an opportunity to learn from their mistakes. This is also a great opportunity to help students formulate viable arguments, justify solutions, compare strategies, and communicate what they have learned.

When making connections and extending thinking

Once students ascertain the correct solution, it is important to help them connect it to their existing schemas to deepen their understanding of the concept. This can be done by asking questions that **stretch** students' thinking; help them make connections; and apply their learning to novel situations. Asking questions that extend student thinking not only supports students in engaging in the problem-solving process, it also moves their thinking forward, helps them align ideas, evaluate their ideas in light of new and novel situations, and make room for opportunities to learn.

Goals of Facilitation

As teachers ask questions to facilitate thinking, they give students the opportunity to be the authors of the ideas and sense-makers of mathematics. Effective facilitation puts the accountability for the thinking on the students. When facilitating it is important not to focus on telling students, but instead to ask questions that promote student thinking and support them through the problem-solving process.

Thinking is critical to facilitation. In the role of a facilitator, teachers must focus on teaching students how to think instead of what to think. This is done by asking purposeful questions structured to require students to do the thinking work that allows them to build, connect, and reinforce their schemas.

Facilitating student thinking is a skillful practice that benefits the student by providing an opportunity to deepen connections between and among mathematics concepts. It enables teachers to analyze student thinking and to engage in ongoing formative assessment.

One goal of teachers as facilitators should be to make student thinking visible. Visible thinking "can be described as clarity and transparency in one's cognitive processes." (Hull, Balka, Miles, 2011) The idea here is to provide opportunities for students to develop an awareness of and be able to communicate their thoughts. For students to move effectively through the problem-solving process, they must develop an awareness of how they are thinking about problems and situations so that when they receive feedback, they can analyze it and synthesize new information to construct learning.

Another goal of the teacher as the facilitator should be to ask the type of open-ended questions that prompt classroom discussions or individual responses in which students are held accountable for their thinking. Right or wrong, when students have to share and explain their thinking aloud, they learn to connect claims and evidence around their topic to make clear and compelling arguments. As students listen to others share their thinking, it helps them to understand, analyze, evaluate, and refine their own thinking. This gives students ownership in the discussion, builds important communication skills, and deepens students' conceptual understanding.

Far too many students who struggle in mathematics believe that they do not possess the type of thinking that is necessary to be successful. They tie their intelligence to the right and wrong answers they get in mathematics. Many students develop math anxiety thinking that they used to be good at math until they reached a certain grade or struggled with a certain concept. Students get stuck feeling like they have a ceiling on their mathematics ability. Neuroscience proves that all students are capable of deep mathematical thinking when given opportunities. "A lot of scientific evidence suggests that the difference between those who succeed and those who don't is not the brains they were born with, but their approach to life, the messages they receive about their potential, and the opportunities they have to learn." (Boaler, 2016)

Facilitation is an important part of the mathematics classroom. When facilitation focuses on supporting student thinking, students learn that their mistakes are part of developing powerful thinking around mathematics; these are their opportunities to learn. Facilitation allows teachers to provide rich learning opportunities focused on thinking and when we connect those opportunities to what we know about neuroscience, we connect to the natural process of learning.

The Art of Facilitation

There is an art to facilitation that goes beyond just asking questions. It involves planning facilitation around the learning outcomes desired, thinking through the questions and interactions you will have for the students. It is also important to plan questions that build on and honor student thinking. Artful facilitation provides students the opportunity to lead the learning while keeping the key mathematical concepts an essential part of the discussion.

By focusing on the process, facilitation allows students and teachers to co-lead the learning. Students develop agency and accountability because they understand that their thinking is important. It is what will lead them to a deeper understanding. Facilitation is thinking driven, not answer driven. That distinction is what will ensure that the facilitation that occurs in the classroom is effective and impactful.

References

Boaler, Jo. 2016. Mathematical Mindsets: Unleashing Students' Potential Through Creative Math, Inspiring Messages and Innovative Teaching. San Francisco, CA: Jossey-Bass A Wiley Brand

Buschkuehl, Martin. What are Schemas? mindresearch.org; MIND Research Institute. https://blog.mindresearch.org/blog/schema-in-education

Chapin, Suzanne H., Catherine O'Connor, and Nancy C. Anderson. 2009. Classroom Discussions: Using Math Talk to Help Students Learn, Grades K–6. 2nd ed. Sausalito, CA: Math Solutions Publications.

Hull, Ted., Balka, Don., Miles, Ruth Harbin. 2011. Visible Thinking in the K-8 Mathematics Classroom. Thousand Oaks, CA: Corwin & National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics (NCTM). 2014. Principles to Actions: Ensuring Mathematical Success for All. Reston, VA: NCTM.

National Research Council (NRC). 2001. Adding It Up: Helping Children Learn Mathematics, edited by Jeremy Kilpatrick, Jane Swafford, and Bradford Findell. Washington, DC: National Academies Press.

Nisbet, Nigel, 2020. How the Brain Science of Games Helps Students Reach 'A-Ha' Moments. Gettingsmart.com; Getting Smart. https://www.gettingsmart.com/2020/02/how-the-brain-science-of-games-helps-students-reach-aha-moments/

Sbar, Eric. Schemas Are Key to Deep Conceptual Understanding. mindresearch.org; MIND Research Institute. https://blog.mindresearch.org/blog/schemas-deep-conceptual-understanding

Seeley, Cathy L. 2016. Making Sense of Math: How to Help Every Student Become a Mathematical Thinker and Problem Solver. Alexandria, VA: ASCD.

Smith, Margaret S., and Mary Kay Stein. 2011. 5 Practices for Orchestrating Productive Mathematics Discussions. Reston, VA: National Council of Teachers of Mathematics.

Wright, Calli. The Four Neural Subsystems of Deeper Learning. mindresearch.org; MIND Research Institute. https://blog.mindresearch.org/blog/neural-subsystems-deeper-learning

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At MIND Research Institute, our mission is to ensure that all students are mathematically equipped to solve the world's most challenging problems. So, when implementing our approach to learning, we focus on creating mathematical content to serve that mission.

In the classroom, our PreK-8 visual instructional program ST Math focuses on dynamically engaging our students as learners. ST Math builds a deep conceptual understanding of math through rigorous learning and creative problem solving.

To learn more about ST Math, visit us at stmath.com or click the link below to request information on the program.

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