

Learning to Look, Looking to Learn

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Abstract

In order to plan and implement lessons that will be effective for a wide variety of learners, teachers must assess what students know and how they know it. They must also know students' academic strengths, challenges, and preferences. Careful observation of what students do and say as they work provides a rich source of data about both their knowledge and ways of learning. We highlight three strategies we use to help teachers refine their understanding of individual students: (a) building teachers' skills in observing without making judgements; (b) teaching teachers to use a shared, neurodevelopmental framework through which to view student learning and behavior; and (c) facilitating collaboration among general education and special education teachers in using these tools to assess student learning and plan lessons. The combination of careful observations, a neurodevelopmental lens through which to see and interpret the observations, and the different perspectives of general and special education teachers, builds a foundation for planning appropriately leveled and rigorous lessons that leverage students' strengths while supporting them in their weaker areas.

Keywords: Mathematics, STEM, Informal assessment, Neurodevelopmental framework, Low-inference observations, Lesson planning

Student work is a source of data that is commonly used by teachers to reflect upon students' learning. But while it can give teachers important insights, work samples are often not enough for teachers to gain deep insights into students' thinking, as illustrated by the following examples. Recently, in a meeting about student work in mathematics, a group of teachers was looking at a student's solution to a word problem shown in Figure 1. They

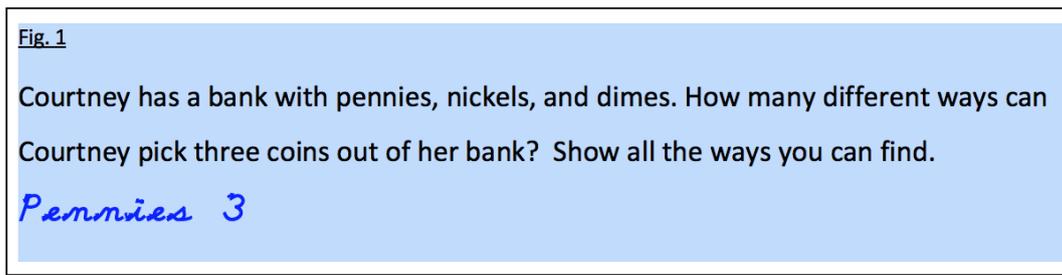


Figure 1. A Student's Solution to a Math Word Problem

were confounded by her response. They noticed that she came up with a partial solution, but did not fully answer the question that was asked. Was she able to read the problem? What did she understand about what she read, and what did she think about to come up with her response? How can we know how to help her?

Similarly, in other STEM fields, students' final work products provide teachers with some information only. Figure 2 shows a prototype desktop toy designed by a group of high school students in an afterschool program focused on mechanical engineering. We can take note of things such as the beauty of its design, and whether or not the gears work as intended. But there are many things that we cannot see by simply looking at their work

product: What tools did students use to create their project? Did they iteratively test and improve their design? What is their understanding of the engineering design process and the physics behind the gear system they used? How did they make their design decisions? Did all students in the group contribute equally to the work?



Figure 2. Desktop Toy With Gears

While we can learn a great deal from students' products, student work includes much more than what appears on their papers or in their final projects. The written work or projects show end results, but most often do not reveal important aspects of the process by which students arrive at those results. Objects cannot tell us about the thinking that led to them, and written or verbal explanations might not help. If, as College and Career Ready Standards claim, understanding resides in ideas and thinking, then it behooves us to try to capture student thinking objectively as it happens. In order to do that, we need to observe students while they are doing their work and talk with them to elicit their thinking.

Careful documentation of what students do and say as they work gives us a rich source of data about their thinking (Cohen, Stern, & Balaban, 2008; Himley & Carini, 2000). In addition, observations provide a window into other aspects of student learning. As we watch, we can learn something about whether students can remember directions, whether they think best with objects, images, or symbols, and whether they learn best alone or with others. We know that students differ in their learning profiles, i.e., the areas of strengths and needs they bring to any given task (e.g., Pohlman, 2008). We also know that sometimes failure to learn may be less about difficulty with concepts than about other challenges that impede learning (e.g., Boaler, 2016) Sometimes the difficulty lies in being unable to read, being unable to retain multiple constraints of a problem in working memory, or perhaps being unable able to organize one's work. Teachers need to assess students' subject matter understanding as well as identify their learning strengths, challenges, and preferences in order to plan and implement effective lessons.

Helping Teachers to Refine Their Observations of Students at Work

For the last several years we have been providing professional development (PD) to teachers in grades K–5 to help them make high-quality mathematics accessible to the wide range of learners in their classrooms, including students with disabilities. Teaching teachers how to carefully observe students while at work, is a key aspect of our work. To help teachers refine their observational skills, we are utilizing the following three strategies:

- We highlight the importance of low-inference observations (observing without making judgements) and give teachers the opportunity to practice conducting observations in this manner;
- We introduce them to a neurodevelopmental framework through which to view student learning and behavior;
- We have general and special education teachers collaborate to interpret what students do.

The combination of careful observations, a lens through which to see and interpret the observations, and the different perspectives of general and special education teachers serves as the foundation for planning accessible mathematics lessons that leverage students' neurodevelopmental strengths while supporting them in their weaker areas.

The Importance of Low Inference Observation

When students fail to perform tasks or complete projects we assign, there is often little or no evidence in their work to explain why. Without good evidence, teachers often rely on their own intuitions about the students. We have heard students described as lazy, careless, and unmotivated based solely on the fact that their work is not done. Yet, when a student does not complete a piece of work, or even follow seemingly simple directions, we cannot know why without careful investigation. Observations do not tell us about a students' motivation or other internal states.

What does it mean when a student closes his eyes and puts his head on a desk while the teacher is explaining a concept? He might be bored, or sick, or defiant. On the other hand, he might be helping himself to listen by shutting out other stimuli. We encourage teachers to practice making low-inference observations, to only describe what they see without judgement and without making inferences about internal states. A low-inference observation for the example above might be "The child's head is on the desk and his eyes are closed". By contrast, a high-inference observation would be: "The student is slumped at this table, trying to avoid doing his work again". Often, a two-column recording sheet, one column for observations, the other for interpretation, helps teachers differentiate between what they see and hear, and how they are reacting (see Figure 3). As they become more practiced, they notice more about student behavior, and they are better able to consider a variety of sources of that behavior. Teachers can also see what a student is good at, and exactly where difficulties arise. Most important, teachers can use this data to adapt their lessons so that students have better access to high-level content.

<i>What I saw</i>	<i>What I think it means</i>

Figure 3. Sample Recording Sheet for Observations

A Neurodevelopmental Lens

Once teachers have observational data on student behavior, they can think about what it might mean. The following list (Berringer, Pohlman, & Robinson, 2010) describes neurodevelopmental constructs that we use as lenses through which to view and understand student behavior. Viewing students at work through these lenses can elucidate the strengths students bring to their work, as well as challenges that might impede their success. The constructs help generate hypotheses about observed behavior. They also help teachers think about demands that the structure of particular tasks make on students.

- **Attention:** Does the student stay focused on the work? Does the student process incoming information? Does the student regulate his/her responses? Does the task demand long-term attention?
- **Temporal-sequential ordering:** Does the task require taking in or acting in serial order? If so, does the student succeed in maintaining that order?
- **Spatial ordering:** Does the student succeed in processing or producing any visual and/or spatial information in the task?
- **Memory:** Does the student remember information stored in long-term memory? Is the student able to retrieve that information? Does the task require a great deal of working memory? Does the student have enough working memory to complete the task (e.g., can the student remember all the constraints of a complex task, while in the process of working on it)?
- **Language:** Does the student understand the language in the problem? Can she read it? Does the student use discipline-appropriate language while working and reasoning on the task or project? Does the task use words and phrases unfamiliar to the students?
- **Neuromotor function:** Does the student successfully perform any motor activities necessary for the task (e.g., working with tools or manipulatives)?
- **Social cognition:** Does the student successfully engage with peers when collaboration on the task is involved?
- **Higher order cognition:** Does the student engage in complex and sophisticated thinking when required?

As they become practiced in using the neurodevelopmental framework, teachers have found that they have much more nuanced understanding of their students' learning profiles. They use the framework to develop hypotheses about how students best learn and to design mathematical tasks with students' strengths in mind. Thus their planning becomes more student-focused. For instance, a teacher might discover that a student has some weakness with processing written language, but significant strengths in attention, spatial ordering, and higher order thinking. This knowledge makes it possible for the teacher to make adaptations in mathematical activities to eliminate barriers that are not essential to the goals of the activity. So instead of having this student read a word problem and write his answers, the teacher may present the problem verbally and allow the student to draw his answers.

The Role of Collaboration

In our PD program, we encourage teachers to work in teams of one general education teacher and one special education teacher. We ask them to choose a single student to focus on for the duration of the PD. Usually this is a student whose learning is puzzling, who seems to be a different kind of learner. Over a period of time, both teachers observe the same student through a variety of different neurodevelopmental lenses. For example, one time they might pay attention to a student's strengths and challenges in the area of memory. Another time they might focus on language. The general and special education teachers often notice different behaviors, strengths, and challenges. The general

education teacher is often focused more on the subject matter content, while the special educator might be more aware of neurodevelopmental issues. As they work together using the neurodevelopmental lens, both teachers build a deeper appreciation for the challenges the learning activity presents, the student's neurodevelopmental strengths, and what they must do as a team to make the tasks accessible to this student. In all our years of working with teachers, they have consistently reported that they found collaborating with their peers on understanding students and mathematical tasks to be the most enriching part of a PD day.

It is important to point out here that teachers report that this intensive work with one student creates benefits for the entire class. Teachers' feedback tells us that planning for student outliers includes and improves accessibility for the entire class. This idea, planning for the outlier, is illustrated in Figure 4. Teachers often notice how paying attention to the needs of one or a few "outlier" student(s) leads them to use instructional strategies that benefit many others as well. One teacher wrote:

As I planned for my focal child I discovered that with all of my students, I needed to find more effective ways for them to communicate and express their strategies in words. This area appears to be difficult for the students as they sometimes are able to solve the problem, but later are unable to communicate using words what they did.

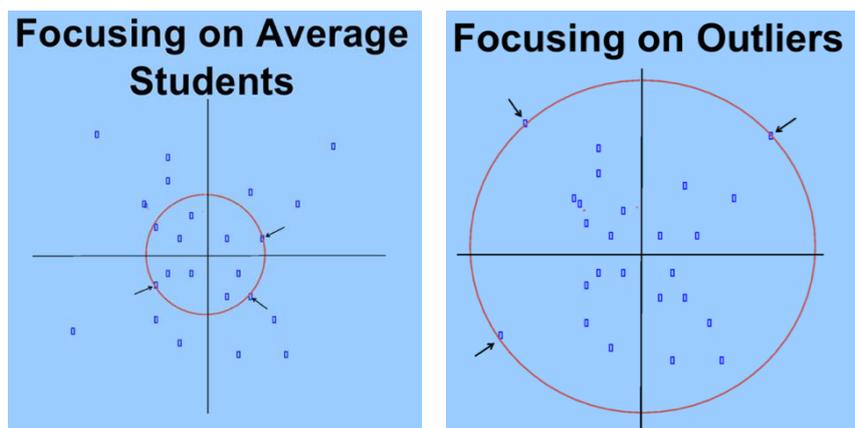


Figure 4. Planning for the Average vs. Planning for the Outliers

Putting it all Together

The knowledge and skills teachers develop during our PD prepare them for planning rigorous and accessible mathematics lessons. The lesson planning process we ask teachers to engage in is illustrated in Figure 5. Teachers work collaboratively to apply the neurodevelopmental framework to better understand the demands of mathematical tasks and individual students' strengths and needs. They discuss the mathematical goals of the task and then chose instructional strategies based on individual students' strengths and needs, being careful not to undermine the rigor of the concepts and skills to be learned as they make adaptations. Careful, low-inference observations (avoiding judgements and conclusions about internal states) of their focal students as they work on the adapted task, helps teachers learn more about their students' strengths and needs and whether their adaptations were successful. The lesson planning cycle concludes with teachers reflecting collaboratively on the success of their adaptations.

- Focus on one (or a few) student(s) during planning.
- Explore the assigned task hands-on and analyze its neurodevelopmental demands.
- Observe the focal student(s) and consider their neurodevelopmental strengths and needs.
- Determine the goals of the assigned task (in order to avoid changing them when making adaptations).
- Select instructional strategies that build on focal students' strengths and that strengthen their weaknesses.
- Observe how the focal student(s) respond(s) to the adapted task.
- Reflect on how the adapted lessons worked out for the focal student(s) and the rest of the class.

Figure 5. Protocol for Collaborative Lesson Planning.

Looking at Students *at Work*

For many teachers it is a radical shift to refocus their attention from teaching toward the way students learn. Teachers must have a command of the content they teach, but that is really not enough. In order to select learning activities that are both challenging and accessible, teachers need a neurodevelopmental understanding of the learners in their class. This paradigm shift happens for many teachers as they observe their focal students closely and try to understand who they are as learners. Teachers find that observing students as they reason, struggle, and solve problems provides them with deeper understanding of students' strengths and challenges. With that understanding, they are able to better plan lessons that successfully engage students in rigorous activities. They are better able to push students' thinking about subject matter content and engage them in higher-level thinking. As the process of observation becomes a habit of mind for the teachers, the focal student benefits, and so does the entire class.

While our work has historically occurred within the domain of mathematics learning and teaching, and we have had powerful successes with teachers in that area, it should become clear that this neurodevelopmental lens and focus on outliers is an approach to learning and teaching that is important across all subject areas. The following quote from one of our teachers illustrates this point: "*What we learn through [the] neurodevelopmental framework applies to any discipline, it just so happens that we learn about strategies in the context of math, but I could have a conversation with a social science teacher, an art teacher, a reading teacher, but it's really about making lessons accessible.*" In fact, close observation of students may be most critical when used with multidisciplinary STEM projects. Because of the open-ended nature of such projects, the process and the thinking that students engage in when creating them is perhaps more important than the product itself. Observation of students at work provides a powerful form of assessment that allows the teacher to develop a fuller understanding of the whole student and complexity of learning.

¹In a recent large-scale, randomized controlled study, we found that our PD program (Math for All) had statistically significant impacts on teachers' emotional support provided to students during mathematics instruction and teachers' self-reports of preparedness and comfort to teach students with disabilities. We also found a statistically significant impact on students' mathematics achievement (Duncan, Moeller, Schoeneberger, & Hitchcock 2018).



Karen Rothschild is a member of the faculty of the Leadership in Mathematics Program at Bank Street College of Education in New York City and an independent math consultant. Dr. Rothschild is interested in how children learn mathematics and the potential of all students to appreciate and learn it.



Marvin Cohen is a Senior Faculty member (Niemeyer Chair, 2005) at Bank Street College of Education in New York, New York. He is a faculty member of the Leadership in Mathematics Program faculty, where he teaches mathematics pedagogy and content classes and serves as an advisor. With his colleagues, Dr. Cohen helped to develop the ten video case studies that are the foundation of the Math for All professional development curriculum, aimed at increasing access to meaningful mathematics for all children in Grades K–5.



Babette Moeller is a Distinguished Scholar at the Center for Children and Technology of the Education Development Center in New York City. Her work focuses on the development of and research on technology-enhanced programs in science, technology, mathematics, and engineering that help to ensure that all students will be included in and benefit from educational reform efforts. Dr. Moeller is one of the lead authors of the Math for All professional development program.



Barbara Dubitsky is a faculty member emeritus at Bank Street College of Education in New York City, where she was the Director of the Leadership in Mathematics Education Program and served as the Chair of Computer Programs. She is one of the lead authors of the Math for All professional development program. Currently, Dr. Dubitsky is working as a volunteer at the Bronx Arena High School in New York, a transfer school for students who are getting a second chance at finishing their high school degree. She is helping them to create a series of new mathematics curricula.



Nesta Marshall is an instructor and advisor of general education and special education teachers at Bank Street College of Education in New York City. Ms. Marshall is committed to equipping teachers with tools to plan and execute effective inclusive lessons that meet the needs of diverse learners.



Matt McLeod has a background in teaching, coaching and professional development in K-12 mathematics primarily in large urban districts. Mr. McLeod's philosophy is that all children can learn deep mathematics, and each one should be provided the opportunity by engaging them in the act of doing mathematics. He believes that a teacher's role is not to disseminate information, but to facilitate learning by establishing the right environment and providing the necessary resources for every student.

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