Windows Into Student Thinking

Entries for Purpose Sense-Making Notebooks

(Editors’ note: This article is second in a series on science and mathematics notebooks. In our first article, we discussed the importance of sense-making notebooks as a strategy to increase student understanding. Sense-making notebooks incorporate the three key findings from ‘How People Learn’ (Bransford, 2000): accessing prior knowledge, building conceptual frameworks, and providing opportunities for metacognition. In this article, we discuss the role of the teacher in helping students construct sense-making notebooks by addressing various types of student entries that scaffold thinking.)

Uncovering vs. Covering the Curriculum

As educators, we often have no knowledge of what students know until we administer a test, and then by then, it can be too late to make a positive difference in learning. When we “tell” students the curriculum to stay on pacing guides and “get through” the information, we often miss student thinking. How can we uncover our students’ prior knowledge, misconceptions or budding conceptions which, in turn, should guide us throughout our instruction?

Consider what a teacher might know about student thinking by uncovering the curriculum as seen in these three following examples:

• When third grade students were asked to describe what is in the day or night sky, they talked about celestial bodies like the sun, moon, stars, as well as clouds, birds and rain. Some mentioned planets and a few knew about the asteroid belt. When asked to describe what moves in the sky, they replied, “The sun, we on Earth stand still. Their thinking reflected their experiences – after all, the sun rises in the east, travels overhead and sets in the west.

• Seventh grade students were shown a pedigree of a rat family. Two black rats produced a white rat. Two white rats produced a black rat. These offspring were mated and produced a black rat. Students were then asked, “What types of offspring would a mating of these two black rats produce?” Answers included “Black because there are more of them,” “Black because it is stronger,” and “White because it was a different species.”

• A group of fourth graders were investigating electromagnets. They experimented with the number of coils and the strength of the magnet. When asked to summarize their data, the typical response was: “It picked up more.”

In each of these cases, teachers can effectively use sense-making notebooks to move students from their prior knowledge to a better understanding of the concepts – rotation and revolution; speciation and genetic; strength of an electromagnet. Notebooks could also help students learn how to make claims supported by this process because the writing in the notebook reflects the student’s thought process. Consequently, the teacher is able to adjust teaching based on the information in the notebook.

Selecting Entries Appropriate for Purpose

How does a teacher help students create sense-making notebooks? One vehicle for scaffolding student thinking is to recognize that different notebook entries require students to gather and interpret information in different ways. In a study funded by the National Science Foundation, Carolyn Landel and colleagues at Western Washington University analyzed samples of student work in science notebooks from all grade levels, demographic groups and geographic regions.

Eight distinct categories emerged, each with a distinct purpose. In Table 1, the eight entry types most frequently used by K-12 teachers are characterized in detail. The website (www.sciencenotebooks.org) illustrates each entry type with multiple samples of student work stored in a searchable online database.

Table 1: Science Notebook Entry Types (Landel, 2009)

<table>
<thead>
<tr>
<th>Entry Type</th>
<th>Definition and Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drawings</strong></td>
<td>Students generated drawings of materials, scientific investigation set-up, observations or concepts. Three common types of drawings used in science notebooks include:</td>
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<tr>
<td></td>
<td>1. Sketches: informal pictures of objects or concepts created with little detail.</td>
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<tr>
<td></td>
<td>2. Scientific Illustrations: Detailed, accurate, labeled drawings of observations or concepts.</td>
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<tr>
<td></td>
<td>3. Technical Drawings: A record of a product in such detail that someone could create the product from the drawings.</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Students use drawings to make their thinking and observations of concrete or abstract ideas visible. Drawings access diverse learning styles, allow entry to the writing process for special needs students and emergent writers and assist in vocabulary development (e.g. visual explanations, group discussions, ideas).</td>
</tr>
<tr>
<td><strong>Tables, Charts and Graphs</strong></td>
<td>Formats for recording and organizing data and observations.</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Students use tables and charts to organize information in a form that is easily read and understood. Recording data in these forms facilitates record keeping. Students use graphs to compare and analyze data, display patterns and trends, and synthesize information to communicate results.</td>
</tr>
<tr>
<td><strong>Graphic Organizers</strong></td>
<td>Tools that illustrate connections among and between ideas, objects and information. Example include, but are not limited to, Venn diagrams, “T” and “X” charts and concept maps.</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Graphic organizers help students organize ideas to recognize and to communicate connections and relationships.</td>
</tr>
<tr>
<td><strong>Notes and Practice Problems</strong></td>
<td>A record of ideas, observations or descriptions of information from multiple sources, including, but not limited to, direct instruction, hands-on experiences, videos, readings, research, demonstrations, solving equations, responding to guiding questions, and developing vocabulary.</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Students use notes and practice problems to construct meaning and practice skills for current use and future reference.</td>
</tr>
<tr>
<td><strong>Reflective and Analytical Entries</strong></td>
<td>A record of a student’s own thoughts and ideas, including, but not limited to, initial ideas, self-generated questions, reflection, data analysis, metacognition, application of knowledge to new situations, and conclusions.</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Students use reflective and analytical entries to think about scientific content from their own perspective, make sense of data, ask questions about their ideas and learning processes, and clarify and revise their thinking.</td>
</tr>
<tr>
<td><strong>Inserts</strong></td>
<td>Fragments or artifacts placed within a notebook, including, but not limited to, photographs, materials (e.g. flower petals, crystals, chromatography results) and supplemental readings (e.g. newspaper clipping).</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Students use inserts to document to and enrich their learning.</td>
</tr>
<tr>
<td><strong>Investigation Formats</strong></td>
<td>Scaffolds to guide students through a controlled investigation, field investigation or design process. Examples include, but are not limited to, investigation planning sheets or science writing handouts.</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Students use investigation formats to guide their thinking and writing while they design and conduct investigations. Students also use these formats to reflect on and discuss their findings and ideas.</td>
</tr>
<tr>
<td><strong>Writing Frames</strong></td>
<td>Writing prompts used to focus a student’s thinking. Examples include, but are not limited to, “I smelled… I felt… I observed…”, “My results show…”, “The variable I will change is…”, “I think that because…”</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Students use frames to organize their ideas, prompt their thinking and structure their written responses. Frames help students become more proficient in scientific writing and less reliant upon the prompts.</td>
</tr>
</tbody>
</table>
A new report from the Council of Chief State School Officers (CCSSO) funded by the National Science Foundation has documented what the K-12 Alliance has known and implemented for years: quality professional development positively impacts student learning.

The report, Effects of Teacher Professional Development on Gains in Student Achievement: How Meta Analysis Provides Scientific Evidence Useful to Education Leaders, cites three major factors in professional development (pd) that had positive impact in improving student achievement:

a. more time (average of 91 hours) spent in providing teachers with content-based teacher development
b. active methods of teacher learning
c. multiple follow-up activities over 6 months to a year conducted in the schools where the teachers work.

Active support from mentors and colleagues in the schools were also factors common to successful programs.

Well, no #1/#2/#3. Sherlock!

Our issues aren’t about what makes quality science professional development. The K-12 Alliance has been a forerunner in offering premier pd for 24 years. We know what to do: No, our issue is a school/district’s lack of time and focus to do it.

The CCSSO report comes at a time when our citizens are showing their scientific renaissance and understand the predictable patterns of segregation and understand the predictable patterns of brown.

For example, if the goal is to determine the extent to which learning goals have been met and determine how best to intervene. The following list of writing frames will elicit responses about confidence and competence in mathematics and/or science:

- I am sure about _______
- I am not sure about _______
- What questions are still answered about _______
- I need more help understanding _______
- I am not sure about _______
- I am sure about________
- What patterns do you notice in________
- The most important part of solving a problem is____
- I know I was right when________
- Tips I would give a friend to solve this problem are____
- What could you do differently to answer this question?

Landel’s work was with science notebooks, but a group of K-12 Alliance math staff developers who reviewed these science entries made alternative suggestions. For mathematical journals, they advised that Graphic Organizers, Inserts and Investigative Formats be replaced with Multiple Representations, Affective Mathematics Prompts and Proofs/Conjectures, respectively. Multiple representations are commonly used in mathematics in lieu of graphic organizers. Affective Mathematics Prompts are more appropriate in mathematics than Inserts and address student phobias about learning mathematics.

Selecting Entry Types: Getting Started

There are many questions that come to mind when considering which strategies are appropriate for learning. One good rule to follow: You don’t need every type of entry in every activity! The point is to be selective.

Determine the learning goals for the experience. For example, if the goal is to build students’ understanding of cause and effect, the use of charts, graphs and summary statements encourages students to make the cause and effect connections. If the goal is to increase the students’ observation skills and focus on detail, then they have drawn labeled illustrations, not sketches. If the goal is to build students generalize, then entry types should reflect the individual pieces that have to be summed for the concept.

In our beginning genetic scenario involving black and white rats, a teacher would work with many genetic crosses will help students see the law of segregation and understand the predictable patterns of dominant and recessive genes.

Reflective entries can be powerful because teachers can use students’ thinking to determine the extent to which learning goals have been met and determine how best to intervene. The following list of writing frames will elicit responses about confidence and competence in mathematics and/or science:

- I am sure about ______
- I am not sure about ______
- Explain everything you know about________
- What questions are still answered about________
- I need more help understanding________
- What patterns do you notice in________
- The most important part of solving a problem is____
- I know I was right when________
- Tips I would give a friend to solve this problem are____
- What could you do differently to answer this question?

Another reflective strategy uses a signal light as a metaphor. Students draw a red, yellow or green circle next to their work. A red circle means, “I am confused and need help.” A yellow circle indicates, “I may be correct, but need some help.” Finally, a green circle communicates, “I am sure about my work.”

It’s time for you to reflect on your practice. Examine Table 1 carefully and check out the sample entries on page 4. Which entries do you use? Which new entries would you use? Why?

In our next article in the series, we address the analysis of student work in science notebooks and math journals.
Life Lessons – with Dancing, Too!

BY SHANNON MALONE

My career path has certainly taken some interesting twists and turns, starting at my early days as a math major at USC volunteering at a local high school, to six years teaching at schools in the Pasadena Unified School District (PUSD). But it wasn’t until I became the Curriculum Resource Teacher and Language Arts Resource Teacher at Hamilton Elementary that I realized where my true passion was: coaching other teachers. I was very excited to work with the teachers, helping them set goals, following through and seeing them succeed.

When I was assigned in the fifth grade classrooms, my team teachers and I decided to departmentalize and I taught math for all fifth grade students. Then I had the opportunity to become a math coach. This was very intriguing!

This new Math Coach position – with the Pasadena Math Pipeline, funded by the California Mathematics and Science Partnership (CaMSP) – beckoned with two enticing reasons: teaching math and collaborating with my peers. While I was hesitant to leave the family atmosphere of Hamilton Elementary, I decided this would be a good chance to expand my leadership skills.

Being a math coach was a wonderful experience. Going to different schools really gave me a larger perspective of education and I began to see the need for better professional development within our district. I enjoyed facilitating workshops, leading TLCs and working with students in various classrooms. I believe teachers receive some of the best lessons when we work together.

Collaboration, another need within our district, wasn’t an easy sell to all teachers. But as they observed the increased level of student engagement within their classrooms, the teachers looked forward to the coaching sessions and TLCs.

At the institutes, we practiced being flexible, spontaneous, collaborative and caring all at the same time. The institutes taught me how to be a good coach and I learn how to listen to people and work together to provide appropriate and relevant professional development.

The K-12 Alliance provides this awesomeness safe place to take risks and discover new ways to contribute to the goal of providing better support to our teachers and, therefore, better instruction for our students.

Today, I continue to use the skills I learned with the K-12 Alliance to good use. For example, this summer, I put together my own “Summer Institute” that focused on math (of course) and writing. Trainers worked on student engagement and differentiation strategies.

Remembering the element of fun from K-12 Alli ance Summer Institutes, I scheduled a few opportunities for game-like work within the classrooms. After the instruction, the teachers were excited to the coach on the coaching sessions and TLCs.

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Through many discussions the science and math teachers realized that integrating subjects inherently go hand-in-hand. We then needed to decide how best to introduce certain concepts to the students; would it be in a math or science class?

We discovered that often concepts are best intro duced in science first because it provides a real context for problems. Here is real data, real situations with concrete applications. Students don’t have to ask (as they often do in math class), “When will we ever use this concept?”

Working in this collaborative fashion, I see that when science lessons incorporate math concepts, stu dents realize that applied mathematics is messy and often contains uncertainty, acceptable errors and different levels of precision. Pure mathematics is elegant in its solutions and certainty, but math is so very useful beyond the theoretical.

Math concepts help students explain and/or pre dict messier things in the world. Infomed by data on a scatterplot, a line of best fit suggests a linear relation ship or trend. A linear graph exactly depicts a func tional relationship. Here is math at its finest.

Putting science and math together helps students see how an understanding of math can clarify the sci ence; likewise, science shows how powerful math is as a diagnostic tool. Students learn that math patterns can be recognized as scientific data.

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Fanning the Flames

BY BRENDA REES

A few weeks ago, my 10-year-old daughter Kate decided to build a seismometer using a cereal box, straws and string. It’s quite a little marvel.

But I know we aren’t the end makers in her science education. To keep that fire going, I depend on her teachers to fan those flames. I count on her school to encourage thinking that is creative, open and challenging.

I’ve been editing this K-12 professional development newsletter for a whopping 10 years, a decade of taking a peek “behind the scenes” of what goes on for math and science teachers in our state. I knew teachers had tough jobs, but this newsletter experience has taught me that teachers give so much more than those seven hours they have with our kids in their classrooms.

I am happy to hear stories of so many teachers who are fanning the flames of learning for their students – but I’m equally thrilled to see that something else is keeping the spark alive for these teachers who often get caught in isolated ruts, doing the same motions, day-in and day-out.

That something else is the K-12 Alliance. It’s you! All of you who participate, lead workshops, attend meetings, advocate for better systems, all of you who want to create energetic environments so that students and teachers can feel the excitement of discovery, each and every day.

I am honored to work with all of you, teachers, administrators and facilitators who truly want to do good with their job – good for their students, good for their own psyches. Teachers aren’t automatons, blindly feeding dusty concepts to a conveyor belt string of pupils.

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