Instructional Decisions

RESEARCH STORY

Instructional Decisions

The focus on fractions over a long period of time allowed the teams to consider their instructional decisions, from planning over the long-term right down to in-the-moment shifts.

Long-term planning

There were several dilemmas that the teams grappled with related to long-term planning. The teams found that allowing students to interact with the fractions content in smaller chunks, punctuated throughout the school year, benefitted many students. Students were able to make connections across number systems such as decimals and percents because this approach to teaching decreased the compartmentalization of fractions concepts. For example, students were able to connect their work with number lines in fractions to measurement work. Teachers were able to make more precise decisions about next steps for instruction with the increased time between the lesson chunks. However, this type of planning was demanding on teachers, both in terms of their time and their pedagogical content knowledge. It also presented challenges with alignment with board directions about sequencing and timing, data collection for reporting requirements, and alignment with colleagues teaching the same grade.

Teams developed and tested short punctuated lesson sequences (bundles of 3 to 4 lessons) and observed the impact on students' ability to connect new learning to prior knowledge and build flexible thinking. Typically, students treat each math unit as separate, and have difficulty making connections to and drawing on what they already know. For example, in one classroom, students who had just finished a unit on geometry weren't able to think flexibly about using pattern blocks as a tool to explore fractions. In this case, students focused on vertices and sides of pattern blocks, rather than other attributes such as area that would support fractional thinking. Conversely, when teams purposefully integrated fractions and decimals, students were able to identify, and take advantage of, the connections between the two number systems.

In order to further students' flexible thinking, teachers built a community of learners comfortable with explaining, discussing, and defending their thinking as a critical first step. In addition, the increased precision of teacher language for fractions (e.g., $\frac{2}{7}$ read as 'two-sevenths' rather than 'two out of seven' or 'two over seven') reinforced the understanding that *a fraction is a number* (rather than two numbers separated by a line). Similarly, reading the decimal 0.25 as '25 hundredths' rather than 'zero point two five') reinforced place value.

One particularly interesting finding was that when students used manipulatives as the primary site of problem solving, rather than just a communication tool after the fact, they were not only more engaged in the learning, but also developed deeper understanding of fractions concepts. The use of a variety of representations also allowed teachers to uncover misconceptions that students held, even when they did the symbolic (numerical) manipulation correctly. This reinforced the importance of using manipulatives consistently as an integral part of learning throughout the year.

Short-term planning

Prior to planning lessons, the teams allowed students to share what they knew and could do through a rich task (characterized by multiple solutions, solution strategies and having the potential to reveal student misconceptions). Teams often found that the class as a whole had enough knowledge from which to construct subsequent learning, and focused their planning on sequencing tasks that built on the strengths of the class. Rather than evaluate student thinking for correctness or errors, teachers looked for understanding and misconceptions. In other words, teams based their planning on student thinking from prior lessons. This, combined with the emphasis on student math talk, allowed the mathematics to come from the students rather than a textbook or a teacher.

Lesson "bundles" were generated based on the work of the teams to support other teachers in the implementation of punctuated fractions teaching. These lesson bundles (see Resources) focus on some of the new research-based learning of the teams, including the benefits to students when number lines are introduced and used throughout to represent, compare and order fractions.

Lesson planning

Teams spent a lot of time thinking about each lesson. They focused not only on the content, but on the instructional strategies that best aligned with that content. They needed to understand how the concept of the lesson connected across other strands and grades. Planning lessons based on student understanding meant that there was variation from class to class based on student need, even within similar grades.

Key learnings from co-planning and implementation of lessons were:

- Context: when fractions were represented using a set model that involved a food context, students wanted all items to be the same size, which is not necessary for set models. Teams also noted that manipulatives were an excellent example of a real context in-and-of themselves.
- Task design: Teams were able to see how design of the tasks influenced student responses and success. For example, when students were asked to place numbers,

including fractions and decimals, on a number line they had more success than when asked to place fractions alone. Inclusion of improper fractions and mixed numbers along with proper fractions allowed students to build stronger understandings of the related nature of these numbers. Teachers selected tasks that allowed a significant amount of time for students to deeply engage and reason.

- Common difficulties: Teachers designed lessons to build robust understanding and address common misconceptions. Understanding some consistent errors in student reasoning helped the teams to intentionally bring these to the surface so they could be addressed. See examples in chart below:

Common difficulties	**Lesson implications**
Fragile understanding of the meaning of numerator and denominator	Encourage students to select their own tools and representations in order to develop a sense of the whole as well as to consider the role of partitioning to explore the relationship between the numerator and denominator
Limited procedural understanding for generating equivalent fractions	Engage students in constructing equivalent fractions through their own reasoning using manipulatives rather than learning a single algorithm such as doubling both the numerator and denominator
Conflation of characteristics of "parts of a set" and area models (e.g., parts of a set must always be the same size)	Engage students in lessons that expose them to i) area models partitioned in non congruent yet equal sized segments; ii) sets (collections of objects of varied sizes) (See resources: Math for Teaching: Fractions document.)

Rather than focusing on eradication of these difficulties, the lessons were designed to allow students to explore their own understanding and grapple with concepts to realign, deepen and consolidate: "Mistakes are an important part of mathematical learning, what Borasi (1994) called 'springboards for inquiry.' Eggleton and Moldavan (2001) asserted that mistakes are an inevitable part of problem solving and indeed 'if no mistakes are made, then almost certainly no problem solving is taking place'" (Bruce & Flynn, 2011).

- Learning goals: With the increased use of more open tasks, the teams found it sometimes difficult to know just which pieces to have students discuss and deconstruct during the debrief and consolidation phase of the lesson. This difficulty highlighted the need to carefully consider the learning goals and anticipate student responses to the task in order to ease the selection of responses to highlight and to do so in an appropriate sequence. The teams also found it helpful to have some pre-planned questions that were focused on the learning goals for use during the consolidation.

Teachers built a comprehensive resource-bank which, along with their increased pedagogical content knowledge, allowed them to make more precise decisions about subsequent lessons. Moreover, they were able to validate their thinking through discussions with colleagues over time and by referencing the research materials available to them.

Teacher moves in the moment

A strong understanding of the fractions content and their students' understanding of fractions allowed the teams to make more informed decisions during each lesson. They reported increased confidence in interpreting student responses, especially partially correct ones, and used probing questions to support student learning (rather than evaluative or leading ones). Through the use of probing questions, flexible groupings, and carefully selected tasks, teachers were able to provide opportunities for students to build a solid understanding of fractions.