

DMT INSIGHTS

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FROM SCREENS TO SENSEMAKING: WHAT ARE WE MISSING?

How digital tools support and limit mathematical understanding

Introduction

Adaptive software, online games, and video-based lessons now occupy a substantial part of many elementary students' mathematics time. These tools can offer flexible pacing and immediate feedback. The important question is what kind of mathematical learning they support.

Students can practice skills and complete digital assessments accurately. In DMTI's approach, the question is whether students also identify units and quantities, represent relationships, and explain their reasoning. Hands-on materials, discussion, and shared attention with a teacher support this work. Digital tools can support it too, depending on how they are used.

Key Idea • What students learn from a digital tool depends on what the tool asks them to do. The value of a digital tool depends on the mathematical relationships it represents, the work students do with it, and how teachers use it during instruction.

How Children Learn Mathematics

Piaget (1952) described learning as an active process of constructing knowledge through interaction with the world. Vygotsky (1978) emphasized the social mediation of learning, in which language and interaction with more knowledgeable others shape what a child can do.

Research on grounded and embodied cognition proposes that thinking draws on perception and action as well as language (Barsalou, 2008; Glenberg, 2010). In mathematics, children who were taught to gesture while learning to solve equivalence problems learned more than children who were not (Goldin-Meadow et al., 2009). Spatial skills are also related to mathematics: in a longitudinal study of preschoolers, early spatial skills were associated with later mathematical skills (Verdine et al., 2017).

Screen-based tasks often ask students to click or drag. These actions can represent mathematical relationships, but students can also complete them without attending to the quantities involved. A student who uses five blocks to show $5 = 2 + 3$ can examine how the quantity of five is composed of two and three. A digital representation can support the same relationship when students examine and explain it. What matters is whether the task asks students to identify the unit, represent the relationship, and explain it.

What Digital Tools Do Well and Where They Fall Short

Digital platforms can provide adaptive feedback, dynamic representations, and flexible practice. A meta-analysis found that virtual manipulatives had a moderate average effect on achievement compared with other instructional treatments (Moyer-Packenham & Westenskow, 2013). Concrete manipulatives also show positive effects, and those effects depend on how instruction connects the materials to the mathematics (Carbonneau et al., 2013).

The effect of technology depends on how it is used. Clark and Feldon (2014) emphasize the importance of instructional methods when evaluating multimedia learning. A meta-analysis of 74 studies found a small positive average effect of educational technology on mathematics achievement (Cheung & Slavin, 2013).

Many digital programs are designed for individual use, and their feedback often stops at whether an answer is correct. Without discussion, students may become accurate with a procedure without examining why it works or how it connects to other ideas.

Three Elements Teachers Provide

- **Representation and gesture:** Folding a paper strip, building with blocks, or gesturing while explaining can help students attend to units and relationships (Goldin-Meadow et al., 2009). Virtual manipulatives can represent many of the same relationships. In either case, a material supports learning when students connect it to the mathematics it represents (Carbonneau et al., 2013).
- **Discussion and reasoning:** When students explain their ideas, question one another, and compare strategies, they examine the relationships underlying their work (Chapin et al., 2009). Many screen-based programs provide feedback only on correctness. Teachers can add discussion by asking students what each number represents and why a strategy works.
- **Motivation and relationships:** Self-determination theory proposes that motivation depends on autonomy, competence, and relatedness (Ryan & Deci, 2000). Points and badges can increase short-term participation. Teacher feedback and opportunities to explain mathematical thinking can contribute to students' sense of competence and connection with others.

Understanding and Fluency

Skemp (1976) distinguished instrumental understanding, knowing how to obtain an answer, from relational understanding, knowing why a procedure works and how ideas connect. Hiebert and Carpenter (1992) described understanding as the connections students make among ideas, facts, and procedures. Digital practice can build accuracy and efficiency. Students also need opportunities to connect that practice to the relationships it represents, because conceptual understanding and procedural fluency develop together.

Consider $\frac{1}{2}$ and $\frac{2}{4}$. Students can partition the same unit of 1 into two equal parts and then partition each half into two equal parts. They can see that one-half and two-fourths represent the same quantity (Figure 1). A digital fraction

strip can represent the same relationship. Either representation supports learning when students identify the unit and explain why the two fractions are equal.

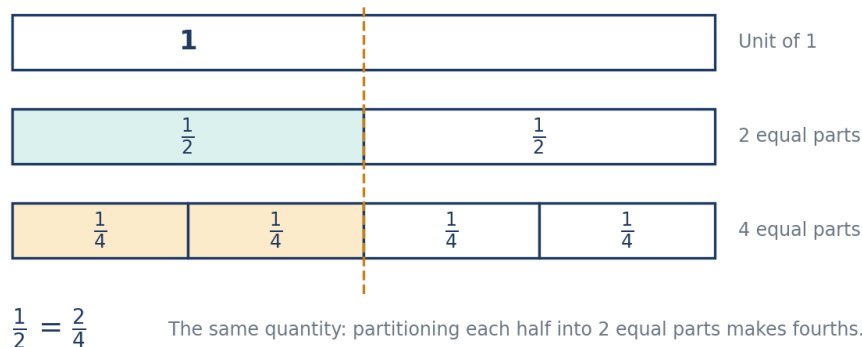


Figure 1. The unit of 1 partitioned into 2 equal parts and into 4 equal parts: $\frac{1}{2} = \frac{2}{4}$.

Student errors are also evidence. When an answer is incorrect, a teacher can ask students to explain their reasoning and examine how they are interpreting the units, relationships, and procedures involved. Most programs record that an answer is wrong without asking the student to explain it.

Key Idea • Digital practice can help students develop accuracy and efficiency. Teachers can also connect that practice to the mathematical relationships students are learning.

Using Technology for a Mathematical Purpose

Technology is most useful when it is chosen for a mathematical purpose. Teachers can select digital tools that represent units and relationships clearly, pair digital work with discussion, connect virtual and physical models when both are available, and use digital practice to build accuracy and efficiency with relationships students can explain. These choices do not require a fixed sequence of materials. Teachers decide which representation helps students examine the relationship in a given lesson.

Implications for Schools

For young children, pediatric guidance emphasizes high-quality content and adult co-engagement with media (American Academy of Pediatrics, 2016). For schools, the question is what students are asked to do during digital work. Curriculum and professional learning can help teachers decide when a digital tool supports reasoning and when hands-on materials or discussion serve the lesson better. Assessments should examine accuracy and procedural fluency as well as students' ability to represent relationships and explain their reasoning.

Summary

Digital tools can support mathematical learning through representations, feedback, and practice. Their effectiveness depends on the mathematical tasks students complete and how teachers connect those tasks to units, quantities, relationships, and procedures.

Physical materials, digital representations, explicit instruction, discussion, and practice all have a place in developing conceptual understanding and procedural fluency.

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Social Media

Can a student get every answer right on a screen and still not know what the numbers represent?

Digital tools can offer flexible pacing, immediate feedback, and dynamic representations. Inside this DMT Insight, we look at:

- What research says about virtual and concrete manipulatives
- Why discussion and gesture support mathematical reasoning
- How a fraction strip, physical or digital, shows that $1/2 = 2/4$
- How teachers can choose technology for a mathematical purpose

Read the full Insight at mathsuccess.io/dmtinsights.

When your students work on screens, how do you know what they understand?

