

DMT INSIGHTS

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UNLOCK STUDENT UNDERSTANDING: PRIORITIZING CONCEPTUAL LEARNING IN MATHEMATICS

Introduction

Teaching for conceptual understanding in mathematics focuses on helping students build a deep, connected understanding of mathematical principles, allowing them to solve problems more flexibly and transfer their knowledge to new situations. This approach contrasts with procedural understanding, which emphasizes mastering step-by-step processes or algorithms without necessarily understanding the underlying concepts. There has been a growing consensus in mathematics education that conceptual understanding should precede procedural skills, as this provides a stronger foundation for long-term learning, problem-solving, and knowledge retention.

Pressing Students Conceptually

Research in mathematics education has supported the shift toward emphasizing conceptual understanding before procedural learning. This perspective moves instructional practices beyond simply teaching algorithms and procedures. Instead, teachers are encouraged to press students to explore the relationships between different mathematical models, formalize their informal methods, and engage in higher-order thinking (Carpenter & Lehrer, 1999; NRC, 2001; Siegler & Alabali, 2004). Students can generalize new situations by comparing and connecting various solution methods, leading to deeper learning.

A key element of this instructional strategy is the creation of classroom experiences that help students integrate new knowledge into their existing mathematical framework, often referred to as schema theory in cognitive psychology. For example, when students first encounter multiplication, they can connect it to their previous understanding of addition, patterns, and area. These connections help create a web of knowledge that allows students to approach new problems more effectively. From a social learning perspective, teachers can use classroom discourse to encourage students to reflect on their mathematical models and those of their peers, which helps them build a more coherent and organized mathematical framework (Hiebert & Carpenter, 1992).

This mathematical discourse guides students to think critically about how they model problems, moving from concrete, enactive representations to more formalized iconic and symbolic models. For example, first graders might initially solve a problem with cubes, then transition to using bar models or number lines, and finally work with symbolic notations. These opportunities to connect multiple representations foster deeper understanding and move students toward fluency with abstract mathematical concepts (Brendefur & Frykholm, 2000; Moschkovich, 1999, 2012).

The Importance of Conceptual Understanding Before Procedural Knowledge

Several key reasons have been identified for prioritizing conceptual understanding before procedural knowledge in mathematics education:

- **Better retention and transfer:** Conceptual understanding allows students to retain their knowledge more effectively and apply it to new situations. Students with strong conceptual foundations can reconstruct procedures they may have forgotten, unlike those who only learned procedural steps.
- **Flexible problem-solving:** Students who understand the underlying concepts can approach novel problems flexibly, applying their knowledge in various ways rather than relying solely on memorized procedures.
- **Stronger learning foundation:** Research consistently shows that gains in conceptual knowledge lead to gains in procedural knowledge more reliably than the reverse (Rittle-Johnson et al., 2001).
- **Deeper engagement:** Teaching for conceptual understanding encourages students to make sense of mathematical concepts rather than simply memorizing procedures, leading to more meaningful engagement with math.
- **Alignment with expert problem-solving:** Mathematicians and scientists rely on their conceptual understanding to solve complex problems. Teaching for conceptual understanding prepares students to think like experts in these fields.
- **Support for procedural fluency:** The National Council of Teachers of Mathematics emphasizes that procedural fluency should be built on a foundation of conceptual understanding. Without this foundation, procedural knowledge can become fragile and disconnected.

Research on Conceptual and Procedural Understanding in Mathematics Education

Research strongly supports the prioritization of conceptual understanding in mathematics education. Rittle-Johnson et al. (2001) show that students with a solid conceptual understanding can better adapt their knowledge to different problems and perform well in routine and novel mathematical situations. These studies demonstrate the iterative nature of learning, where initial conceptual understanding facilitates the acquisition of procedural skills. In contrast, teaching procedural knowledge without the underlying conceptual framework can lead to a superficial understanding of mathematics, where students may struggle to remember or apply their knowledge in different contexts.

Another critical factor highlighted in the research is the role of teachers' conceptual understanding. Many studies have shown that teachers who lack a deep understanding of mathematical concepts tend to overemphasize procedural instruction, perpetuating a cycle of superficial learning (Hussein, 2022). Teacher preparation programs and professional development focusing on improving educators' conceptual knowledge can profoundly impact student learning, ensuring that future generations of students are better equipped to engage meaningfully with mathematics.

Cognitive Psychology Perspective

The cognitive psychology framework supports teaching conceptual understanding first. Schema theory describes how learners organize and integrate new knowledge into their existing mental frameworks. It outlines three key processes: assimilation, accommodation, and equilibration, essential for understanding how students learn new mathematical concepts.

- **Assimilation:** Students incorporate new information into their existing schemas when it fits their prior knowledge. For example, when learning multiplication, students may connect it to their understanding of repeated addition.
- **Accommodation:** When new information does not fit with their existing schemas, students must adjust or create new schemas to accommodate this information. This might occur when a student encounters a concept that challenges their understanding, such as the transition from whole numbers to fractions.
- **Equilibration:** This is the process by which students balance assimilation and accommodation to maintain cognitive stability. Equilibration drives cognitive development as students continuously refine their mental frameworks to accommodate new knowledge.

In mathematics education, schema theory explains why conceptual understanding should come before procedural learning. When students first build a solid conceptual framework, they are better able to assimilate new procedures and apply them meaningfully. If students are taught procedures without the underlying concepts, they may struggle to accommodate new information or adapt their procedures to new problems.

Conceptual understanding also plays a crucial role in developing procedural fluency. Research by Rittle-Johnson et al. (2016) emphasizes that conceptual and procedural knowledge develop iteratively. Initial conceptual knowledge facilitates procedural learning, which in turn reinforces conceptual understanding. This iterative process aligns with schema theory and underscores the importance of teaching for understanding rather than simply focusing on procedural accuracy.

Moreover, studies on working memory and cognitive load suggest that students with a strong conceptual understanding can better manage the cognitive demands of complex mathematical procedures (Gilmore et al., 2017). A solid conceptual foundation frees up cognitive resources, allowing students to focus on problem-solving rather than memorizing steps.

Conclusion

Mathematics education and cognitive psychology research strongly support the notion that teaching conceptual understanding before procedural understanding leads to more effective and meaningful learning. By fostering a deep understanding of mathematical principles, students are better equipped to engage with complex problems, transfer their knowledge to new situations, and develop the procedural fluency necessary for success in mathematics. Prioritizing conceptual understanding in mathematics education enhances students' cognitive development and promotes long-term retention, flexible problem-solving, and deeper engagement.

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We are excited to share our latest research overview on the significance of teaching **conceptual understanding before procedural skills** in mathematics! This article investigates how focusing on deep, connected mathematical concepts helps students **build a strong foundation for long-term learning, problem-solving, and retention**. The article emphasizes the iterative relationship between conceptual and procedural knowledge, from schema theory to classroom strategies. Learn how moving from enactive to iconic and symbolic models can transform student engagement and lead to better cognitive development and flexible thinking in mathematics education!

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