



Developing Mathematical Thinking: Why Measurement Matters

RESEARCH OVERVIEW

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BUILDING BLOCKS OF MATH: WHY MEASUREMENT MATTERS

(RESEARCH OVERVIEW)

Abstract

This research overview synthesizes key insights from the literature on measurement education, framing it as a foundational element for mathematical understanding rather than an isolated topic. It addresses common misconceptions, explores the interplay between qualitative and quantitative approaches, and integrates the work of prominent researchers like Richard Lehrer. The overview highlights effective instructional strategies that promote deeper conceptual understanding and emphasizes the importance of starting with measurement to enhance students' number sense and overall mathematical fluency.

Introduction

Imagine a world where children intuitively grasp mathematical concepts, seamlessly connecting abstract numbers to concrete realities. This vision begins not with the rote memorization of algorithms but with the tangible exploration of measurement. The etymology of measurement itself traces back to humanity's earliest needs—quantifying land for agriculture, constructing shelters, and facilitating trade. Historically predating formal mathematics, measurement is interwoven with our understanding of quantity and comparison (Lehrer, 2003). This overview equips educators with the knowledge and strategies necessary to cultivate intuitive understanding in their students, fostering success in mathematics and beyond.

Conventional instruction often relegates measurement to a procedural exercise, emphasizing the "how" at the expense of the "why." This approach neglects measurement's profound role in developing mathematical thinking, leading to persistent challenges for learners (Outhred & Mitchelmore, 2000). Research, particularly the work of Richard Lehrer, advocates for a paradigm shift—prioritizing conceptual understanding and engaging students in activities that mirror the historical evolution of measurement.

The Power of Qualitative Exploration

Before diving into numerical precision, students need to understand the *essence* of what they are measuring. This begins with qualitative exploration—observing, comparing, and describing attributes using non-standard units and sensory experiences. Think of young children using their hands to measure the length of a table or comparing the weights of different objects by feel.

This qualitative phase is not merely a preliminary step; it lays the groundwork for a more sophisticated quantitative understanding. It helps students define what is being measured and why it matters, providing context and depth that inform subsequent numerical approaches. By grounding measurement in sensory experiences, educators can tap into students' natural curiosity and build a solid foundation for abstract thinking (van den Heuvel-Panhuizen, 2005).

Bridging Qualitative and Quantitative Understanding

As students develop a qualitative understanding of measurement, they can explore quantitative aspects—assigning numerical values to attributes using standardized units. This transition should be gradual and purposeful, with explicit connections made between the qualitative and quantitative domains.

For example, after comparing the lengths of different objects using non-standard units, students can introduce rulers and explore how these tools provide more precise and consistent measurements. This process should emphasize the importance of selecting appropriate units, understanding scale, and appreciating the inverse relationship between unit size and number of units (Lehrer, 2003).

The Foundational Role of Measurement in Mathematical Development

Research consistently demonstrates that early exposure to measurement enhances students' number sense and overall mathematical fluency. Measurement provides a concrete context for exploring abstract numerical concepts, making them more accessible and meaningful.

Measurement tasks involve counting units, comparing quantities, and reasoning about relationships. This helps students contextualize numbers and operations in real-world scenarios. For instance, measuring the perimeter of a rectangle involves adding the lengths of its sides, reinforcing the concept of addition in a practical setting. Similarly, partitioning a length into equal units tangibly introduces the concept of fractions.

Core Conceptual Challenges in Measurement

Despite its importance, measurement presents several conceptual challenges for learners. These challenges often stem from misunderstandings about its nature and its relationship to other mathematical concepts.

Conceptualizing Measurement as a Process: Students often struggle to see measurement as more than just using a ruler. They may not grasp the underlying principles of identifying an attribute, selecting an appropriate unit, and iterating to quantify it (Lehrer, 2003).

Understanding Units and Standardization: Students may not appreciate the importance of standard units for communication and comparison. They may fail to understand that using non-standard units can lead to inconsistent and unreliable measurements.

The Inverse Relationship Between Unit Size and Number of Units: Students often fail to recognize that smaller units will result in a larger numerical measurement and vice versa. This misconception can hinder their ability to estimate and compare measurements accurately.

Effective Instructional Strategies and Representations

Instruction must focus on conceptual development, utilize varied representations, and employ precise language to address these challenges. Brendefur and colleagues' work emphasizes the importance of these approaches.

Building Conceptual Understanding: Engage students in activities that allow them to invent their measurement tools and units, fostering a deeper understanding of the underlying principles (Lehrer, 2003).

Utilizing Multiple Representations: Use enactive (concrete), iconic (visual), and symbolic (abstract) representations to help students comprehensively understand measurement. Explicitly link these representations to show their connections (Bruner, 1964).

Importance of Structural Language: Use precise language, such as *attribute*, *unit*, *iterate*, *partition*, *compare*, *standardize*, and *scale*, to provide a foundation for conceptualizing measurement and its relationships.

Creating Effective Measurement Instruction

Effective measurement instruction requires a multifaceted approach, prioritizing conceptual understanding and procedural fluency. A key focus should be on developing measurement sense by encouraging students to estimate, judge the reasonableness of answers, and build intuition about measurement processes.

Teachers should also explicitly address common misconceptions by designing activities that challenge these misunderstandings directly. Providing opportunities for students to explore measurement through hands-on activities and real-world problems further enhances learning by making abstract concepts more concrete and meaningful (Stephan & Clements, 2003).

Summary

Fostering a robust understanding of measurement requires a comprehensive and deliberate approach. Educators must emphasize underlying concepts, varied interpretations, and diverse measurement representations. By attending to common misconceptions, utilizing precise language, and grounding instruction in meaningful contexts, educators can empower students to develop a flexible and confident understanding of measurement. This approach addresses the immediate challenges of measurement comprehension and sets students up for success in future mathematical endeavors, providing a solid foundation for more advanced mathematical concepts.

By prioritizing measurement instruction, educators can create a strong foundation for other mathematical topics, such as number sense, fractions, geometry, algebra, and data analysis, making abstract concepts more accessible and meaningful for young learners. Measurement provides a concrete context for understanding place value, decimal operations, and the metric system while supporting problem-solving skills across various mathematical domains. This approach sets students up for success in future mathematical endeavors, including proportional reasoning, spatial visualization, and statistical analysis, ultimately fostering a deeper and more interconnected understanding of mathematics.

References

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The research underscores the critical role of measurement as a foundational concept in developing students' mathematical understanding. **Introducing measurement early** in the curriculum provides a concrete context for exploring abstract numerical concepts, enhancing number sense and overall mathematical fluency. Experts like Richard Lehrer and other researchers advocate initially allowing students to invent their measurement tools and units to foster deeper conceptual understanding.

Key strategies include balancing **qualitative** exploration with **quantitative** precision, using multiple **representations** (enactive, iconic, and symbolic), and employing precise **language** such as "attribute," "unit," "iterate," and "scale." These approaches help students grasp the underlying principles of measurement, bridging the gap between tangible experiences and abstract mathematical ideas.

Join us in exploring these powerful strategies and their impact on mathematical thinking!

#ElementaryMath #MeasurementEducation #STEM #MathematicalThinking #TeachingMath #DMTI
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