Introduction

How to Use This Guide

This facilitator's guide is a companion for *How the Brain Learns Mathematics,* by David A. Sousa. It is designed to accompany the study of the book and provide assistance to group facilitators, such as school leaders, professional development coordinators, peer coaches, team leaders, mentors, and professors. Along with a summary of each chapter in the book, David A. Sousa has provided supplemental information, chapter discussion questions, activities, and journal writing prompts. For facilitators who conduct workshops, a sample workshop evaluation form is also included.

When using the guide during independent study, focus on the summaries and discussion questions.

For small study groups, the facilitator should guide the group through the chapter work.

For small- or large-group workshops, the facilitator should create an agenda by selecting activities and discussion starters from the chapter summary and discussion questions that meet the group's goals and guide the group through the learning process.

Additional Resources for Facilitators

Corwin Press also offers a free 16-page resource titled *Tips for Facilitators* that includes practical strategies and tips for guiding a successful meeting. The information in this resource describes different professional development opportunities, the principles of effective professional development, some characteristics of an effective facilitator, the responsibilities of the facilitator, and useful ideas for powerful staff development. *Tips for Facilitators* is available for free download at the Corwin Press Web site (www.corwinpress.com, under "Resources/Tips for Facilitators").

Chapter-by-Chapter Study Guide

How the Brain Learns Mathematics

by David A. Sousa

Introduction

Summary

- Human beings are born with some remarkable capabilities. One is language. Toddlers can carry on running conversations without the benefit of direct instruction. Another innate talent is number sense—the ability to determine the number of objects in a small collection, to count, and to perform simple addition and subtraction, also without direct instruction.
- Why do so many children have difficulty learning mathematics in school? One reason is that spoken language and number sense are survival skills; abstract mathematics is not. In schools, we present complicated procedures to a brain that was first designed for survival in the African savanna. Human culture and society have changed a lot in the last 5,000 years, but the human brain has not.
- Thanks to modern imaging devices that can look inside the living brain, we can see which cerebral circuits are called into play when the brain tackles a task for which it has limited innate capabilities. The fact that the human brain can rise to this challenge is testimony to its remarkable ability to assess its environment and make calculations that can safely land humans on the moon and send a space probe to a planet hundreds of millions of miles away.

with the type and strength of the genetic input and the environment in which the individual grows and learns.

Supplemental Information

Although some Piaget-oriented psychologists still question whether human beings possess number sense, the research findings from cognitive neuroscience in support of an innate number sense are very convincing. Rather than hanging on to outdated ideas about how limited youngsters might be in processing numerical quantities, we should welcome the research findings. They imply that most students have an inherent capability to be successful at basic and concrete arithmetic operations.

Discussion Questions

1. Describe number sense. What are its capabilities and limitations?
2. How does our current understanding of number sense compare with Piaget's beliefs about a child's ability to deal with numbers and arithmetic operations?
3. Describe subitizing and its two types.
4. How does a child's sense of counting develop?
5. How does a child's native language affect learning to count?
6. Describe the internal number line. What are its capabilities and limitations?
7. What kinds of abilities are included in the expanded view of number sense? To what degree can these abilities be taught?
8. How does number sense relate to Gardner's description of logical/mathematical intelligence?

Activity

- ***Subitizing Versus Counting***

Time: 15 minutes
Materials: *How the Brain Learns Mathematics,* an overhead transparency (or PowerPoint slide) similar to Figure 1.2 on page 14 of the text, chart paper, markers

The purpose of this activity is to help the participants recognize the difference between subitizing (knowing number without counting) and counting. This is often a difficult concept for some to grasp, but it is important for understanding the difference between an innate capability (subitizing) and a learned process (counting).

Make sure that the participants have their textbook closed. Put the **covered** transparency on the overhead projector. Quickly reveal the top two boxes (Box A and Box B) for only a second or two. Ask

6. Describe the four levels of sorting.
7. Describe the four levels of classifying.

Activity

- ***Practicing a More Logical Counting System***

Time: 15–20 minutes, with reading
Materials: Paper, pencils, *How the Brain Learns Mathematics*

The purpose of this activity is to get the participants to think of counting words in a new format that mimics the counting system of some major Asian languages, such as Chinese and Japanese. Ask the participants to read "An Easier Counting System" on page 87 of the text, and to study the chart on page 88. Give them enough time to feel comfortable with the Asian-like counting system. When they have finished this task, ask them to close the text. Now ask them to write down on a piece of paper five two-digit numbers and to say each number to themselves using the system they just studied on page 88. However, they should **not** write down the counting words on the paper. Now ask them to take the paper with the five numbers with them as they get up, move across the room, and find a partner. They will then exchange the paper with their partner and take turns reading each of the five numbers aloud to their partner, using the Asian-like counting system. When completed, ask the pairs to discuss whether they believe this system can be of benefit to young children learning to count.

Journal Writing

What are two things I learned from this discussion that will help me in my teaching (or parenting)?

Chapter 5. Teaching Mathematics to the Preadolescent Brain

Summary

- The limbic area is largely involved in generating emotional responses. The emotional (and biologically older) system develops faster and matures much earlier than the frontal lobes. The limbic area is fully mature around the age of 10 to 12 years, but the frontal lobes mature closer to 22 to 24 years of age. Consequently, the emotional system is more likely to win the tug-of-war for control of behavior during the preadolescent

Activity

- ***Planning a Layered Curriculum Unit***

Time: 30–35 minutes, with reading
Materials: Chart paper, markers, *How the Brain Learns Mathematics*

The purpose of this activity is to give the participants some practice in designing a teaching unit using Kathie Nunley's successful approach known as layering the curriculum. This activity goes faster if the participants have already read pages 143–148 of the text.

Divide the participants into groups of four or five by similar grade levels. For example, you might have smaller groups divided into middle school and high school. Larger groups could be divided by grade levels, if there are enough to make a reasonable group. Give each group a few sheets of chart paper and markers, and ask them to select a recorder.

Tell them that they will have about 10 minutes to silently read (or review) pages 143–148 of the text. When the reading is completed, the group's task is to select a topic in mathematics appropriate to their grade level(s) and to outline a layered curriculum unit for that topic. They will have about 20 minutes for this task. The recorder should write down the outline on the chart paper.

When time is up, each recorder (or selected recorders, if there is a large number of groups) briefly describes the unit to the entire group.

Journal Writing

What advantages are there to using the layered curriculum approach? Any disadvantages?

Chapter 7. Recognizing and Addressing Mathematics Difficulties

Summary

- The percentage of school-age children who experience difficulties in learning mathematics has been growing steadily. Why is that? The answer to this question is complicated by at least two considerations. First, we need to distinguish whether the poor achievement is due to inadequate instruction or some other environmental factor, or whether it is due to an actual cognitive disability. Second, exactly how is mathematics being taught? Instructional approaches can determine whether a cognitive deficit is really a disability at all. For example, one instructional approach emphasizes conceptual understanding, but another approach places heavy emphasis on procedures and facts. A student with a deficit in retrieving arithmetic facts might not be considered as having a learning disability in the first approach because of the de-emphasis on