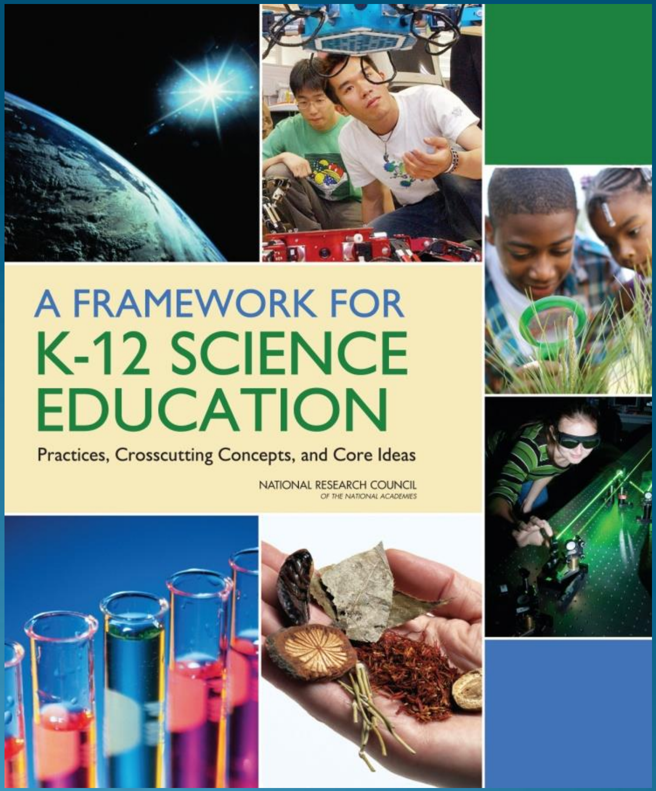
Understanding the Research Base

Presentation to CSSS
October 1, 2011



Vision

"Students, over multiple years of school, actively engage in science and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas."

Elements of the Vision

- All students can learn science from the earliest grades
- Focus on core ideas over multiple years
- Learning through engagement in the practices
- Links to crosscutting concepts

Children Are Born Investigators

Children's Competence

- Children starting school are surprisingly competent. They already have substantial knowledge of the natural world.
- They are ***not*** concrete and simplistic thinkers and can use a wide range of reasoning processes that form the underpinnings of scientific thinking
- Instruction in must build on these foundations

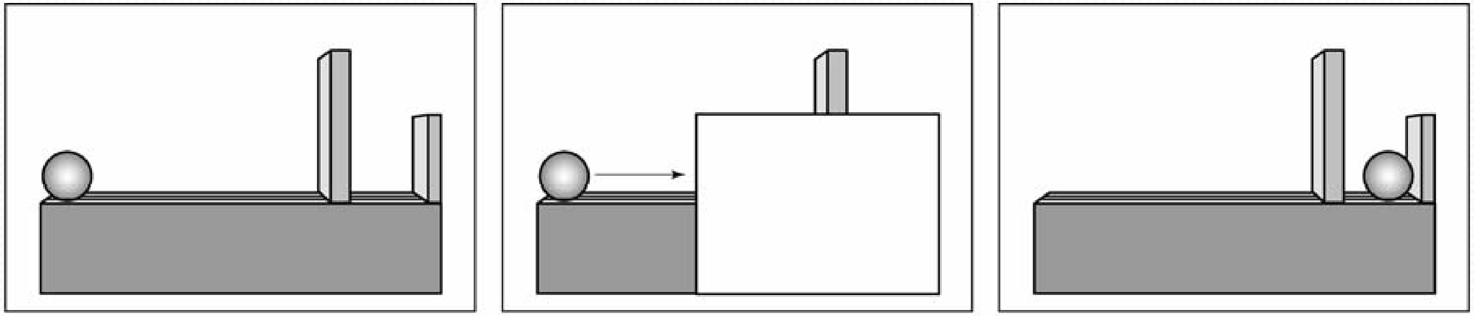
Children's Knowledge of the Natural World

- Some areas of knowledge may provide more robust foundations to build on than others.
  - Physical mechanics
  - Biology
  - Matter and substance
  - Naïve psychology (theory of mind)

- These appear very early and appear to have some universal characteristics across cultures throughout the world.

- Earth science and cosmology – not early and universal

Research with Infants



Children's Reasoning

- Young children can think in sophisticated, abstract ways. For example, they:
  - Distinguish living from non-living
  - Identify causes of events
  - Know that people's beliefs are not an exact representation of the external world

- Practice and instructional support are key
  - Children can learn how to control variables
  - They can learn how to evaluate evidence objectively

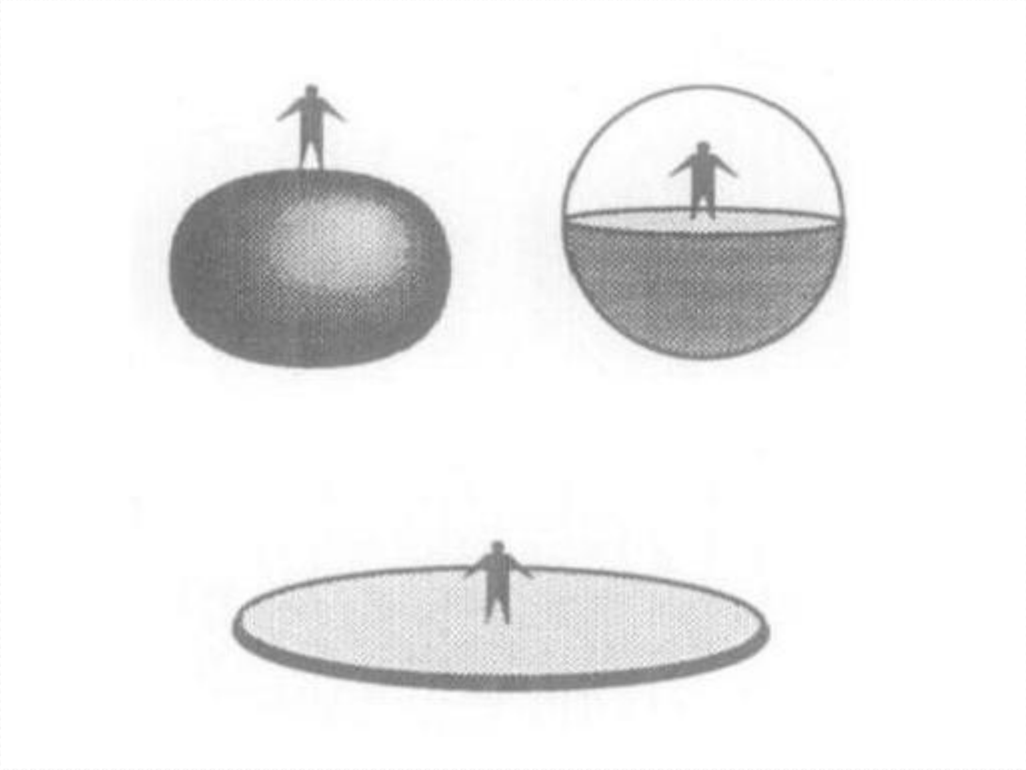
Constraints on Children's Reasoning

- Conceptual knowledge – children are universal novices
- Nature of the task
- Awareness of their own thinking (metacognition)

Focus on Core Ideas
and
Understanding Develops
Over Time

Prior Understandings

- Understanding is constructed on a foundation of existing understanding and experiences.
- Prior understanding can support further learning
- Prior understanding can also lead to the development of conceptions that act as barriers to learning

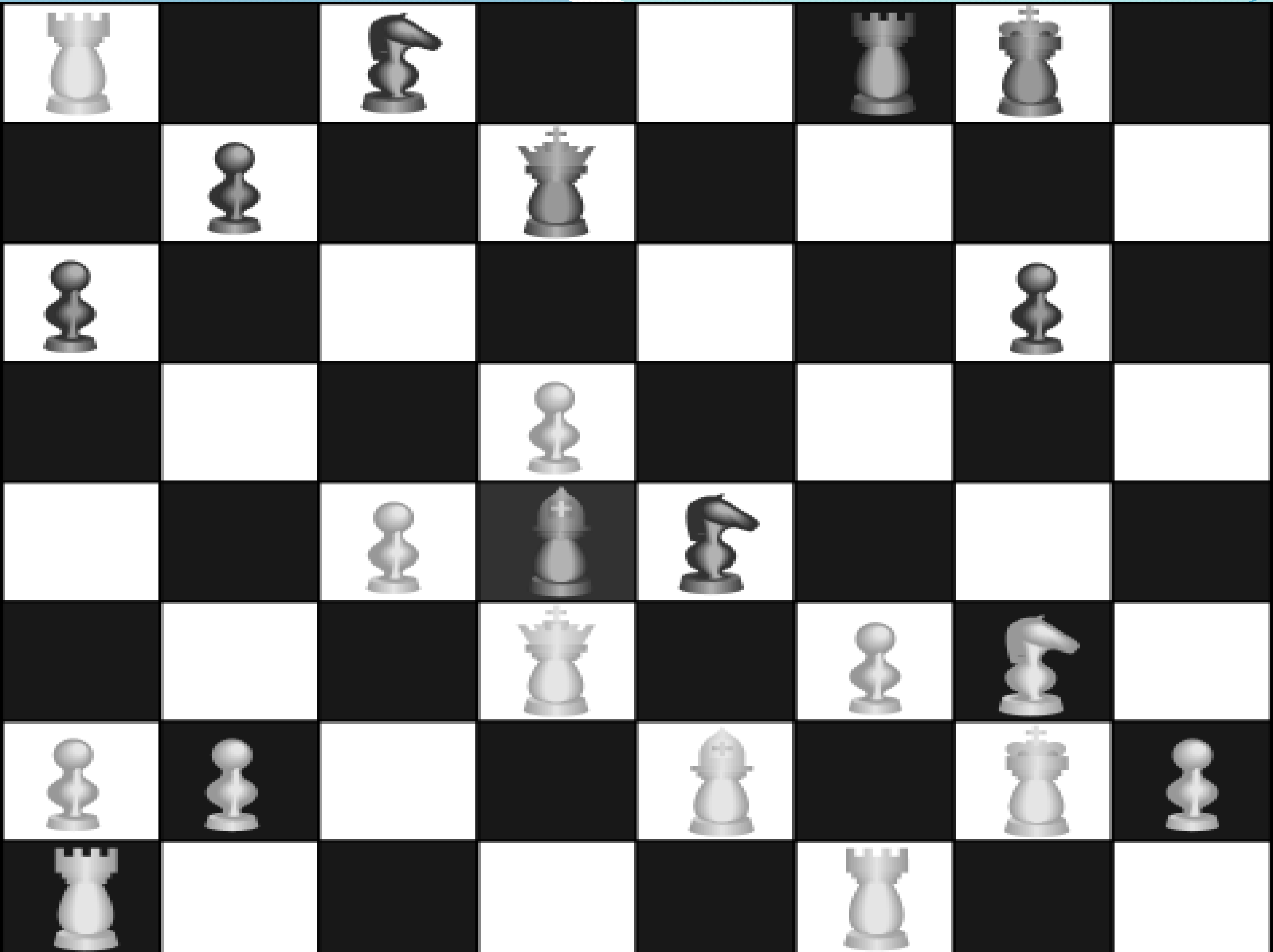


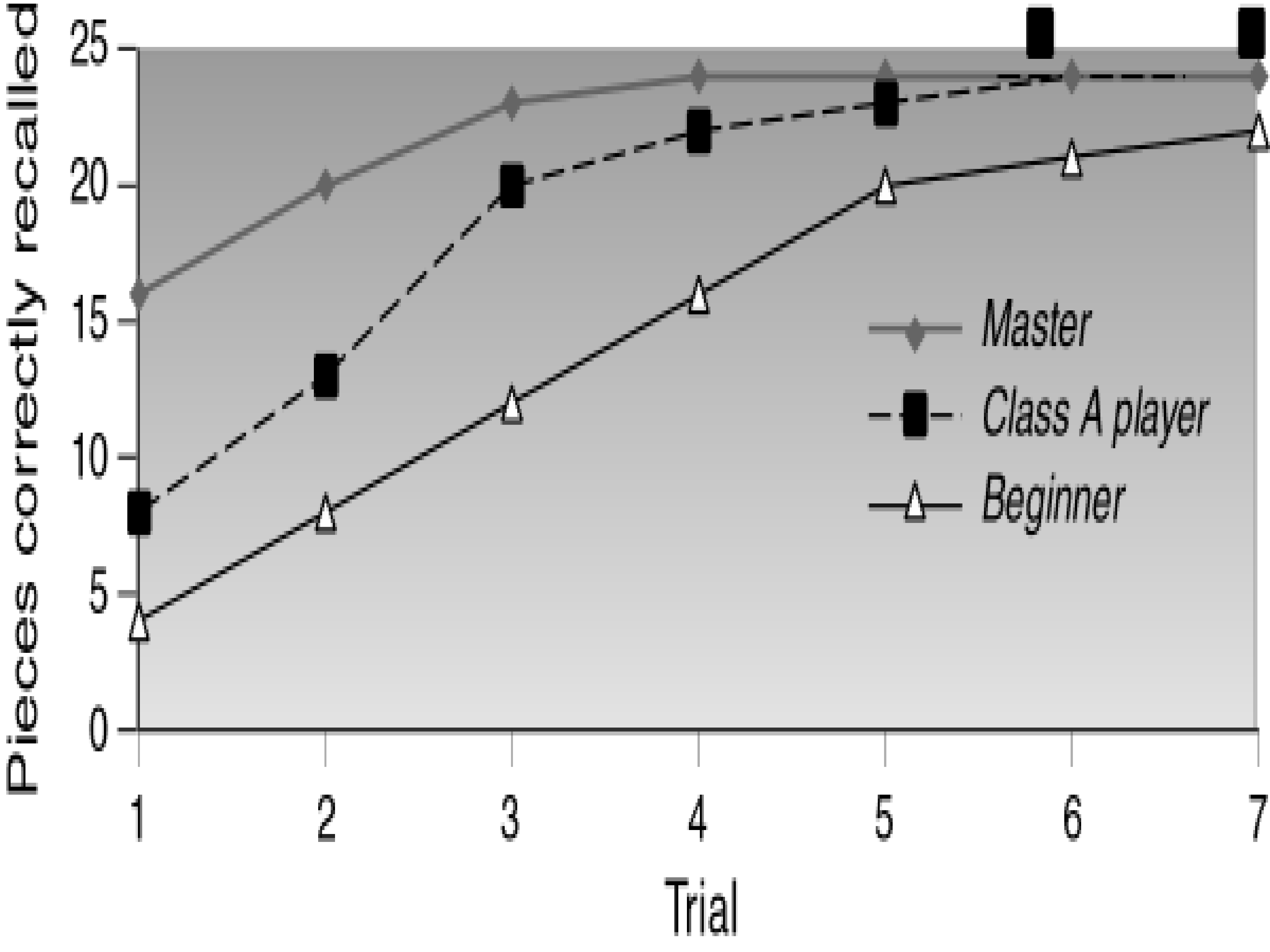
Prior understanding and "misconceptions" in science

- Children's understandings of the world sometimes diverge from accepted scientific explanations. These are often described as "misconceptions" to be overcome.
- But students' prior knowledge also offers leverage points that can be built on to advance students' science learning.
- Emphasis on eradicating misconceptions can cause us to overlook the productive knowledge they bring

The Power of Conceptual Knowledge

- Proficiency in science is more than knowing facts. It is ***not*** a simple accumulation of information.
- Factual knowledge must be placed in a conceptual framework to be well understood.
- Students need to learn how ideas are related to each other, and their implications and applications in the discipline.





Pieces correctly recalled
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Trial
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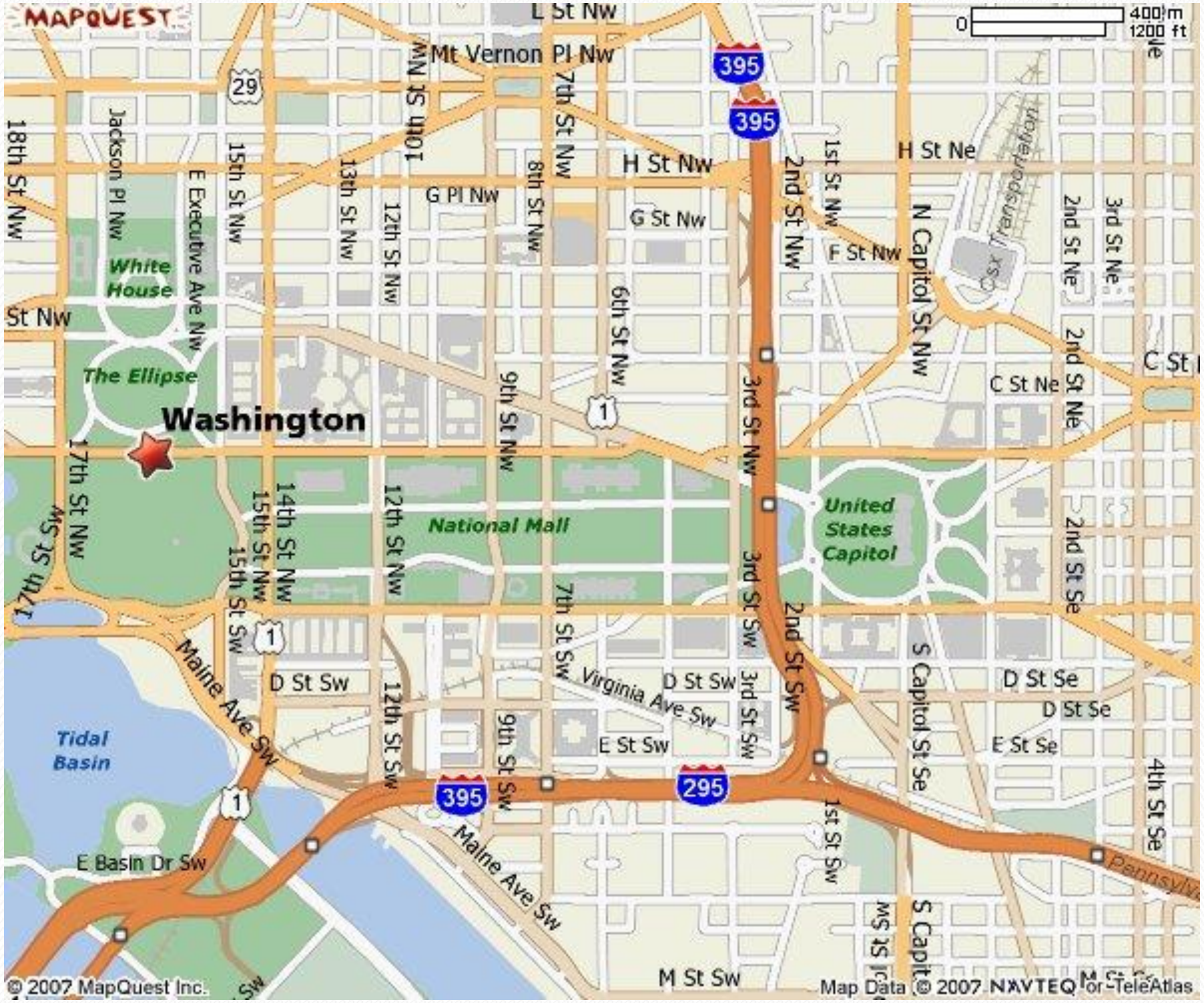
Class A player
Beginner



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Conceptual Change in Science

- Some kinds of conceptual change occur naturally, some require intentional effort.

- For many ideas in science, students are unlikely to arrive at an understanding of them without explicit instruction (for example, understanding atomic-molecular theory or genetics).

- Major changes in conceptual frameworks are often difficult and are facilitated by instruction – they take time!

Supporting Reflection (Metacognition)

- Metacognition – people's knowledge about themselves as learners, or "information processors"
- Focus on helping students develop the ability to take control of their own learning
- Support students' ability to reflect on the status of their own knowledge

Metacognitive Strategies

- Explaining to oneself.
- Predicting outcomes.
- Noting comprehension failures.
- Activating background knowledge

Example: Metacognition

In the past I thought the book on the table had only 1 force, and that force was gravity. I couldn't see that something that wasn't living could push back… This year I began to think about the book on the table differently. Last year I was thinking on the macroscopic level and not on the microscopic level. Last year I was looking at living beings as the important focus and now I am looking at molecules as being the important focus. When I finally got my thoughts worked out, I could see things from a different perspective. I found out that I had no trouble thinking about two balanced forces instead of just gravity working on the book. It took me a whole YEAR to figure this concept out!!! Now I know it was worth THE YEAR to figure it out because now I can see balanced forces everywhere!

Implications

Learning Develops Over Time

- More expert knowledge is structured around conceptual frameworks
  - Guide how they solve problems, make observations, and organized and structure new information
- Learning is facilitated when new and existing knowledge is structured around the core ideas
- Learning difficult ideas takes time and often come together as students work on a task that forces them to synthesize ideas
- Developing understanding is dependent on instruction

Learning Progressions

- Sustained exploration of a core set of scientific ideas over months and years.
- Core ideas should be central to a discipline of science, accessible to students in kindergarten, and have potential for sustained exploration across K-12.
- Findings from research about children's learning and development can be used to map these learning progressions.

Practices and Crosscutting Concepts

- Practices engage students in science AND leverage learning – provide opportunities for reflection and consolidating understanding

- Crosscutting concepts provide frameworks to facilitate making connections and solving problems