

# Learning from Research: Using Worked Examples in Math Class

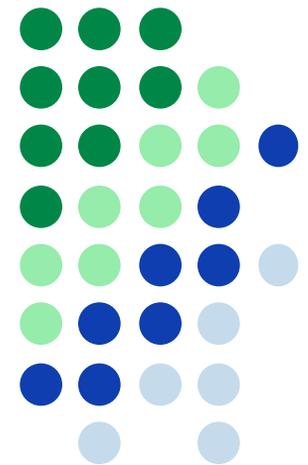
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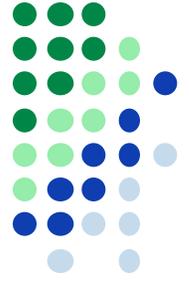
NCTM Annual Meeting

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Session #119

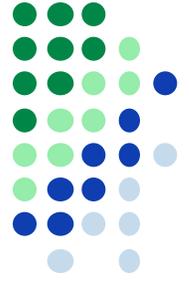


# National Center for Cognition in Mathematics Instruction



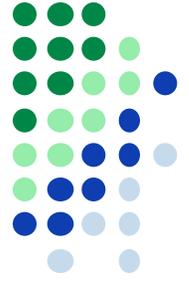
- Research Partners
  - WestEd
  - Carnegie Mellon University
  - Temple University
  - University of Illinois, Chicago
  - University of Wisconsin, Madison
  - Worcester Polytechnic Institute
- In collaboration with 53 school districts in 20 states

# Background to the Research Study



- *Given:*
  - CMP supports improved student learning
  - Research suggests cognitive design principles can further improve student learning
- *Proposition:*
  - Applying the cognitive design principles to CMP will improve classroom-based learning
- **Research Question**
  - Do students who learn with revised curriculum materials (treatment) have greater improvements in mathematics performance than peers who learn with the original materials (control)?

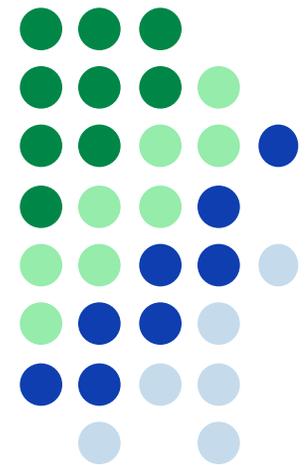
# Cognitive Design Principles



- Visual Verbal Mapping
- Spaced Practice and Formative Assessment
- Worked Examples

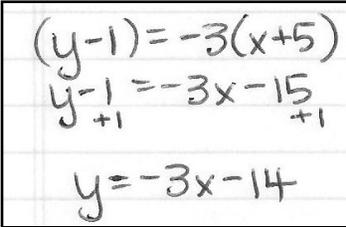
# Worked Examples

Worked Example Principle  
Self-Explanation Principle



# Worked Example Principle

(e.g., Sweller, 1999)



Handwritten algebraic steps for solving a linear equation:

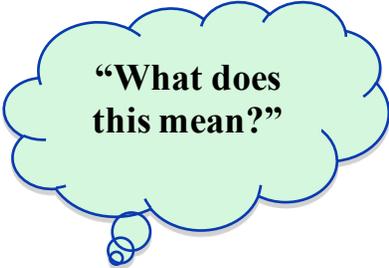
$$(y-1) = -3(x+5)$$
$$y-1 = -3x-15$$
$$y = -3x-14$$



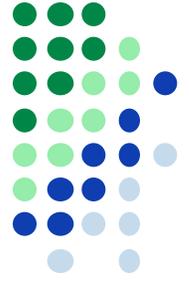
- Replacing some problems in a practice session with an example of how to solve a problem
  - Reduces working memory load (compared with long strings of practice problems), so learners can focus on learning the steps in problem solving
  - Allows students to process the information more deeply when not just routinely applying procedures
  - May naturally generate more self-explanations

# Self-Explanation Principle

(e.g., Chi et al., 1994)

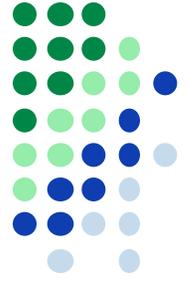


“What does  
this mean?”



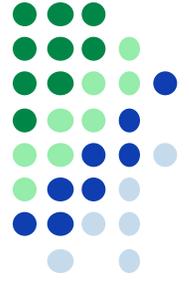
- Prompting learners to explain information as they read or study
  - Facilitates integration of new information with prior knowledge
  - Forces learners to make their knowledge explicit
  - Prompts learners to generate inferences to fill gaps in their knowledge
- Also applicable in problem solving:
  - How did you get your answer?

# Three Kinds of Worked Examples



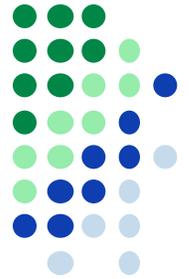
- Examining Correct Work
- Examining Partially Completed Work
- Examining Incorrect Work

# Implementing Correct Worked Examples



- Students might be asked to:
  - Explain the work shown for a particular task
  - Extend the work to a second part
  - Answer a question about the response
  - Offer an alternative approach
  - Explain how they know it is correct
  - Determine how the correct response might have been found

# Implementing Partially Completed Worked Examples



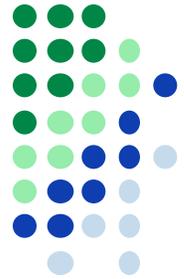
- Students might be asked to:
  - Complete work where a student was stuck and explain the reasoning behind the steps to complete the work
  - Complete a student's work and answer a question about the work

# Incorrect Worked Examples

(e.g., Siegler, 2002)

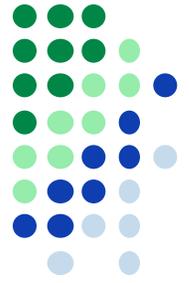
X

$$\begin{array}{r} k - 6 = 3 \\ -6 \quad -6 \\ \hline k = -3 \end{array}$$



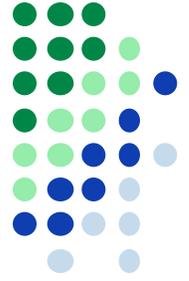
- Showing students common incorrect ways to solve problems, and having them explain why the procedure is inappropriate
  - Provides negative feedback, which reduces the relative strength of incorrect strategies
    - Helps them accept that the procedure is wrong
  - Forces students to see the differences between the presented problem and others where a procedure does work
    - Exposes and fixes misconceptions

# Implementing Incorrect Worked Examples



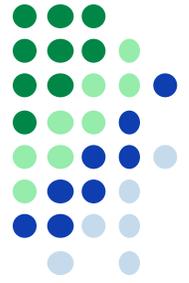
- Students might be asked to:
  - Find the error, fix it, and explain the fix
  - Explain why an incorrect response is incorrect
  - Fix the incorrect response and complete the work
  - Answer a question about the incorrect work on the item
  - Explain why the item is incorrect; then complete it correctly

# The Challenge of Incorporating Worked Examples into CMP7



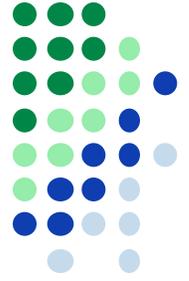
- Adapting the technique when practice problems sets are diverse and integrated
  - Grounded, contextual problems
  - Problems with multiple components
  - Single instances of problems in a given set
  - Review (Connections) and challenge (Extensions) problems

# Teacher-Identified Benefits of Using Worked Examples



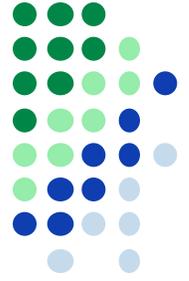
- The worked examples were very useful for getting the students started on their homework problems.
- The worked examples are going much better because they are getting the hang of how to respond to the person's work and not to the actual question.
- Parents have commented that it helps them assist their child when doing homework.
- The worked examples are a great addition to the homework and lend to great class dialogue.

# Teacher-Identified Challenges with Using Worked Examples



- Some are still wanting to just give an answer to the question instead of analyze the given/partial solution.
- Students are having a difficult time understanding what question they're supposed to answer.
- Some students find them confusing even after regular explanations.

# Wrapping Up



- More on cognitive design principles
  - IES Practice Guide, 2007: *Organizing Instruction and Study to Improve Student Learning*
- More on worked examples
  - “A Worked Example for Creating Worked Examples” by Kelly McGinn, Karin Lange, and Julie Booth
    - *Mathematics Teaching in the Middle School*, August 2015