Maximize ALL Students’ Mathematical Learning through the use of Powerful Instructional Strategies and Techniques

Webinar Series

Sponsored by the New Jersey Department of Education-Office of Special Education
Organizing Instruction and Study Time to Improve Student Learning of Key Concepts and Skills

Webinar

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Topics for Today

- Designing instruction to help students of all skill levels achieve success in mathematics.
- Learner Characteristics
  - Strategic learner vs. Non-Strategic Learner
- Better organize instruction and the way students' study materials to facilitate learning and retention through 2 research supported techniques:
  1. Interleave Worked Solutions Strategy-IWSS
  2. Spaced Learning Over Time-SLOT

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Strategies/Techniques

1. Background
   - Interleave Worked Solution Strategy

2. Interleave Worked Solution Strategy
   - Spaced Learning Over Time

3. Spaced Learning Over Time

4. Conclusion

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CCSS for Mathematical Practice

• “The Standards for Mathematical Practice describe varieties of expertise that mathematics educators at all levels should seek to develop in their students. These practices rest on important ‘processes and proficiencies’ with longstanding importance in mathematics education.”


(CCSS, 2010)
CCSS for Mathematical Practices

1. Make sense of complex problems and persevere in solving them.
2. Reason abstractly and quantitatively
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

(CCSS, 2010)
Learning Outcomes of CCSS-MP

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Reasoning and explaining

Modeling and using tools

Seeing structure and generalizing

(McCallum, 2011)
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These are BIG challenges for students with disabilities and those that are struggling. It will only happen if it is purposefully facilitated through teacher INSTRUCTION!

Reasoning and explaining
Modeling and using tools
Seeing structure and generalizing

(McCallum, 2011)
Teaching

• Much of teaching is about helping students master new knowledge and skills and then helping students *NOT* to forget what they have learned.

• Work Smarter *NOT* Harder!
Learner Characteristics

• **Strategic Learners**
  – Able to analyze a problem and develop a plan
  – Able to organize multiple goals and switch flexibly from simple to more complicated goals
  – Access their background knowledge and apply it to novel tasks
  – Develop new organizational or procedural strategies as the task becomes more complex
  – Use effective self-regulated strategies while completing a task
  – Attribute high grades to their hard work and good study habits
  – Review the task-oriented-goals and determine whether they have been met

Learner Characteristics

- **Non-Strategic Learners**
  - Unorganized, impulsive, unaware of where to begin an assignment
  - Unaware of possible steps to break the problem into a manageable task, possibly due to the magnitude of the task
  - Exhibit problems with memory
  - Unable to focus on a task
  - Lack persistence
  - Experience feelings of frustration, failure, or anxiety
  - Attribute failure to uncontrollable factors (e.g., luck, teacher's instructional style)

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To prepare students for Algebra, the curriculum must simultaneously develop **conceptual understanding**, **computational fluency**, **factual knowledge** and **problem solving skills**.

Limitations in the ability to keep many things in mind (**working-memory**) can hinder mathematics performance.

- **Practice** can offset this through automatic recall, which results in less information to keep in mind and frees attention for new aspects of material at hand.
- Learning is most effective when **practice is combined with instruction** on related concepts.
- Conceptual understanding **promotes transfer** of learning to new problems and better long-term retention.

NMAP, 2008
Learning Processes-NMAP-2008

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Instructional Practices-NMAP-2008

Research on students who are low achievers, have difficulties in mathematics, or have learning disabilities related to mathematics tells us that the effective practice includes:

- Explicit methods of instruction available on a regular basis
- Clear problem solving models
- Carefully orchestrated examples/sequences of examples.
- Concrete objects to understand abstract representations and notation.
- Participatory thinking aloud by students and teachers.

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Six Critical Features of explicit instruction

1. Daily Reviews
2. Presentation of New Content
3. Guided Practice
4. Explicit feedback and Correctives
5. Independent Practice
6. Weekly and Monthly Reviews

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Six Critical Features of explicit instruction

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Main focus for our Webinar today is in these 4 areas

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Essential Question for Teachers

• Essential Question
  – What do you do *instructionally different* to support learning for the struggling students?

• Asked during instructional planning and after instructional delivery!!!
Breakout Activity-3 minutes

• Pause the webinar and discuss the following questions:

1. What do you do to help students complete:
   • Homework (or other independent practice opportunities)
   • tasks at independent stations or centers
   • Study for tests
   • Review important skills

2. What do you to help students remember important information from previous lessons throughout the course of the year?
Excellent Resource: IES

- Institute of Education Science
  - Review research to determine instructional strategies and techniques that are supported by high quality evidence
Excellent Resource: IES

Table 1: Institute of Education Sciences Levels of Evidence

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
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| Moderate| In general, characterization of the evidence for a recommendation as moderate requires studies with high internal validity but moderate external validity, or studies with high external validity but moderate internal validity. In other words, moderate evidence is derived from studies that support strong causal conclusions but where generalization is uncertain, or studies that support the generalizability of a relationship but where the causality is uncertain. Moderate evidence for this practice guide is operationalized as:
  - Experiments or quasi-experiments generally meeting the standards of the What Works Clearinghouse and supporting the effectiveness of a program, practice, or approach with small sample sizes and/or other conditions of implementation or analysis that limit generalizability, and no contrary evidence; OR
  - Comparison group studies that do not demonstrate equivalence of groups at pretest and therefore do not meet the standards of the What Works Clearinghouse but that (a) consistently show enhanced outcomes for participants experiencing a particular program, practice, or approach and (b) have no major flaws related to internal validity other than lack of demonstrated equivalence at pretest (e.g., only one teacher or one class per condition, unequal amounts of instructional time, highly biased outcome measures); OR
  - Correlational research with strong statistical controls for selection bias and for discerning influence of endogenous factors and no contrary evidence; OR
  - For assessments, evidence of reliability that meets The Standards for Educational and Psychological Testing but with evidence of validity from samples not adequately representative of the population on which the recommendation is focused. |
| Low     |
|         | In general, characterization of the evidence for a recommendation as low means that the recommendation is based on expert opinion derived from strong findings or theories in related areas and/or expert opinion buttressed by direct evidence that does not rise to the moderate or strong levels. Low evidence is operationalized as evidence not meeting the standards for the moderate or high levels. |
Strategies/Techniques

1. Background
2. Interleave Worked Solution Strategy
3. Spaced Learning Over Time
4. Conclusion
Recommendation #1: Interleave Worked Solution Strategy

- Interleave worked example solutions and problem-solving exercises
- Literally, alternate between worked examples that demonstrate one possible solution path and problems that the student is asked to solve independently
- Alternating completed problems with independently solved problems can markedly enhance student learning

Recommendation #1: Interleave Worked Solution Strategy

• Typical Math Homework assignment
  – Pg. 155 #1-21 odd
• Students are required to solve all problems.

Solve $5 + 3x = 20$ for $x$

Recommendation #1: Interleave Worked Solution Strategy

• Interleaved Homework assignment
  – Pg 155 1-10 (all)
  – Odd problems

Below is an example solution to the problem:

“Solve $12 + 2x = 15$ for $x$”

Study each step in this solution, so that you can better solve the next problem on your own:

$$12 + 2x = 15$$
$$2x = 15-12$$
$$2x = 3$$
$$x = 3/2$$
$$x = 1.5$$
Typical Practice with Fractions

7. \(1\frac{3}{5} \times \frac{1}{6} =\) 
8. \(3\frac{1}{2} \times \frac{3}{4} =\) 
9. \(\frac{1}{3} \times 2\frac{1}{3} =\)

10. \(\frac{3}{2} \times 1\frac{1}{11} =\) 
11. \(2\frac{1}{2} \times \frac{5}{4} =\) 
12. \(2\frac{1}{2} \times \frac{5}{2} =\)
IWSS Practice with Fractions

7. \( \frac{3}{5} \times \frac{1}{6} = \)

\[
\frac{8}{5} \times \frac{1}{6} = \frac{8 \times 1}{5 \times 6} = \frac{8}{30} = \frac{4}{15}
\]

8. \( \frac{3}{2} \times \frac{3}{4} = \)

\[
\frac{1}{3} \times \frac{7}{3} = \frac{1 \times 7}{3 \times 3} = \frac{7}{9}
\]

9. \( \frac{1}{3} \times 2 \frac{1}{3} = \)

\[
\frac{5}{2} \times \frac{5}{4} = \frac{5 \times 5}{2 \times 4} = \frac{25}{8} = 3 \frac{1}{8}
\]

10. \( \frac{3}{2} \times 1 \frac{1}{11} = \)

11. \( 2 \frac{1}{2} \times \frac{5}{4} = \)

12. \( 2 \frac{1}{2} \times \frac{5}{2} = \)
IWSS

• Example of implementing the IWSS strategy into Algebra Homework.
• Students must be prompted to study the solution
Directions: Solve these problems by combining like terms and isolating the variable.

1. $3z + 5 + 2z = 12 + 4z$
   - $5z + 5 = 12 + 4z$
   - $5z = 12 - 5 + 4z$
   - $5z = 7 + 4z$
   - $5z - 4z = 7$
   - $z = 7$

2. $5z + 2 + 4z = 7 + 8z$
   - $5z - 4z = 7$
   - $z = 7$

3. $5y - 3 = 3y + 5$
   - $5y = 3y + 5 + 3$
   - $5y = 3y + ____$
   - $5y - 3y = 8$
   - ____ = 8
   - $y = 8/2$
   - $y = ____$

4. $12 - x = 3x + 2$

5. $9x + 3 = 8x + 19$
   - $9x = 8x + 19 ______$
   - $9x = 8x + ____$
   - $9x ______ = 16$
   - $x = ____$

6. $6x + 3 = 2x + 27$

7. $15 - x = 4x$
   - $15 = 4x + x$

8. $24 - 2x = 6x$
   - $24 - 2x = 6x$
   - $24 = 8x$
   - $x = 3$

9. $25 + z = 50$

10. $15 + z = 38$

- **One Complete Solution #1**
- **Solution begins to fade in #3 and #5**
- **Only one Step is provided in #7**
- **No solutions are provided**
Recommendation #1: Interleave Worked Solution Strategy

1. The amount of guidance and annotation accompanying the worked-out, completed examples varies depending on the student and instructional needs

2. Gradually fade examples into problems:
   - Provide early steps in a problem
   - Students then solve increasing amounts of later steps

3. Use examples and problems that involve greater variability from one example or problem to the next
   - Changing both values included in the problem and the problem formats.
Recommendation #1: Interleave Worked Solution Strategy

• During Whole Class instruction
  1. Begin discussion around a solved, completed example
     • Point out critical features of the problem solution
  2. After discussion have students pair off in small groups or work individually to solve a problem (JUST ONE!) on their own
  3. Then students discuss their solutions and have others students attempt to explain
  4. Then students are given another problem to try on their own.

Implementation Ideas-IWSS

• Have students alternate between reading already worked solutions and trying to solve problems on their own

• As students develop greater expertise, reduce the number of worked examples provided and increase the number of problems that students solve independently

Classroom Application Activity-IWSS

• Discuss which part of your math lesson would best fit with the IWSS.

• After identifying the part of you math lesson that best fits IWSS, discuss how you could modify that part of the lesson to incorporate the IWSS technique.

• Then, during the extended instructional planning time, develop 3-5 activities that incorporates the IWSS techniques.

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Strategies/Techniques

1. Background

2. Interleave Worked Solution Strategy

3. Spaced Learning Over Time

4. Conclusion
Recommendation #2: Space Learning Over Time

• Arrange for students to have spaced instructional review of key course concepts through the SLOT Strategy
  – At least 2 times/year
  – Separated by several weeks to several months

• Why:
  – Helps student remember key facts, concepts, and knowledge

# Space Learning Over Time

*Spaced Instructional Review Planning Sheet*

<table>
<thead>
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<th>Block (Date)</th>
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<th>Problematic Areas</th>
<th>Problematic Areas Targeted for SIR</th>
<th>Date and Instructional Time Allotted (30-40 minutes)</th>
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Notes: Use assessment data from Teacher assessments (formal & informal), Progress Monitoring data sources, State Assessments, and other sources of information (teacher’s experience). Table abbreviated for space considerations.
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<td>Fast forward 4-6 weeks from when identified skills were taught &amp; list date here to revisit</td>
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Recommendation #2-SLOT (con’t)

- Make sure important and essential curriculum content is reviewed at least 3-4 weeks after it was initially taught.

- Benefits of a delayed review is much greater than the same amount of time spent reviewing shortly after initial instruction (Rohrer & Taylor, 2006).

Recommendation #2-SLOT (con’t)

- The delayed instructional review of the material can occur through:
  - In-class reviews
  - Homework assignments
  - Cumulative midterm and final examinations

Recommendation #2-SLOT (con’t)

1. Use class time to review important curriculum content
   - For example, every other week a 4th grade teacher spends half the class reviewing an important math skill taught in the previous 3-4 weeks (i.e., estimation, LCD, fractions)

2. Use homework assignments as opportunities for students to have spaced practice of key skills and content
   - For example, in every homework assignment a math teacher intentionally includes a few problems covering material presented in class 1 or 2 months ago

3. Give cumulative midterm and final exams
   - Provides student incentives to study all course material at widely separated points in time.
Implementation Ideas-SLOT

• Identify key concepts, terms, and skills taught and learned during each 6 week unit
• Arrange for students to be re-exposed to each Big Idea on at least two occasions, separated by a period of at least 4-6 weeks.
• Arrange homework, quizzes, and exams in away that promotes delayed reviewing of important course content

Classroom Planning Activity-SLOT

• Using the spaced instructional review sheet, divide the school year into 6 week units starting at the beginning of the year through the end of the year.

• List the Big ideas taught during that first 6 week unit and identify which are often problematic and very important for students

• Then, during the extended instructional planning time, complete the rest of the SLOT planning chart for the remainder of the school year.
Strategies/Techniques

1. Background

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4. Conclusion

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Conclusion

• The learning needs of students with disabilities in mathematics is extremely challenging for teachers.

• The research base addressing the specific instructional strategies and interventions clearly suggests the importance of Explicit Instructional Techniques
  1. Interleaved Worked Solution Strategy (IWSS)
  2. Spaced Learning Over Time (SLOT)
QUESTIONS?

Additional Resource