

## Cross Content Strategies

# Organizing Instruction and Study to Improve Student Learning

Grades K–12<sup>th</sup>

### RECOMMENDATION 2

Interleave worked example solutions and independent problem-solving exercises.

### RECOMMENDATION 3

Assist students in monitoring and reflecting on the problem-solving process.

### RECOMMENDATION 4

Teach students how to use visual representations.

### RECOMMENDATION 5

Expose students to multiple problem-solving strategies.

### RECOMMENDATION 6a

Use delayed judgment of learning techniques to identify concepts that need further study

### RECOMMENDATION 6b

Use tests and quizzes to identify content that needs to be relearned..

### RECOMMENDATION 7

Help students build explanations by asking and answering deep questions

This document provides a summary of recommendations from the WWC practice guide Organizing Instruction and Study to Improve Student Learning (Pashler, 2007).

| Content Area  | Level of Evidence                                                                          | Grades                                                                                                                                                                                               |
|---------------|--------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cross Content |  Moderate | K 1 <sup>st</sup> 2 <sup>nd</sup> 3 <sup>rd</sup> 4 <sup>th</sup> 5 <sup>th</sup> 6 <sup>th</sup> 7 <sup>th</sup> 8 <sup>th</sup> 9 <sup>th</sup> 10 <sup>th</sup> 11 <sup>th</sup> 12 <sup>th</sup> |

## RECOMMENDATION 2

# Interleave worked example solutions and independent problem-solving exercises.

When teaching problem-solving, teachers can interleave worked example solutions and problem-solving exercises—literally alternating between worked examples demonstrating one possible solution path and problems that the student is asked to solve. Research has shown that this interleaving markedly enhances student learning.

## Strategies

1. Revisit, re-practice, and reinforce classroom behavioral expectations.

Students learn more by alternating between studying examples of worked-out problem solutions and solving similar problems on their own than they do when just given problems to solve on their own. The amount of guidance and annotation will vary depending on the situation and the student. Consider varying the amount of guidance and support.

2. Use partially solved problems to transition to independent problem-solving.

As students develop greater expertise, decrease the use of examples and increase independent problem-solving. Try using partially solved problems by giving early steps in a problem and requiring students to provide more and more of the later steps as they acquire more expertise with the problem type.

3. Vary the requirements between worked examples and independent problems.

As students develop greater expertise, ask students to independently solve problems that vary from the worked example (e.g., changing both the values included in the problem and the problem formats).

## Potential Roadblocks



Curricular materials do not often provide teachers with large numbers of worked example solutions.

**Suggested Approach.** Teachers can work together on teams to prepare homework sets that interleave worked examples with problems for students to solve. Teachers can take worked examples included in the instructional section of the textbook and interleave them into the assigned homework problem sets.



Teachers may be concerned that by providing large numbers of worked-out examples to students, they will memorize the solution sequences and not attain mastery of the underlying concepts being taught and reinforced through this interleaving technique.

**Suggested Approach.** By having problems to solve in between the worked examples, students are motivated to pay more attention to the worked example because it helps them prepare for the next problem and/or resolve a question from the past problem. Having problems to solve helps students recognize what they do not understand. Students are notoriously poor at identifying what they do not understand (see Recommendation 6 for a discussion of learners' "illusion of knowing"). By interleaving worked examples with problems to solve, students are less inclined to skim the example because they believe that the answer is obvious or they already know how to solve this type of problem.

| Content Area  | Level of Evidence                                                                          | Grades                                                                                                                                                                                               |
|---------------|--------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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### RECOMMENDATION 3

## Combine graphics and descriptions.

Combining graphical presentations (e.g., graphs, figures) that illustrate key processes and concepts with verbal descriptions of those processes and concepts facilitates student learning. Adding relevant graphical presentations to text descriptions can lead to better learning than text alone. Studies emphasize that it is important that text descriptions appear near the relevant elements in visual representations to best enhance learning. Students learn more when the description is presented verbally rather than in written text, probably because a learner cannot read text and scrutinize an accompanying graphic at the same time. Also, verbal descriptions allow students to use visual and auditory processing capacities of the brain separately rather than potentially overloading the visual processing capacity by viewing both the visualization and the written text.

### Strategies

#### 1. Combine verbal descriptions with graphical representations to illustrate the key steps of processes and procedures.

Visual representations of the key steps of a process should be integrated with verbal descriptions. The verbal description should help students focus on where to look and on what is being illustrated. It is important to make regular connections between steps in the procedures and how they are represented in visual representations. Verbally describe the objects and processes while simultaneously indicating the relevant parts of the visual representation.

#### 2. Use labels and text to describe visual representations.

When visual representations are used in text materials or written handouts, they should include brief text that labels unfamiliar objects and describes steps in the process being illustrated. These descriptions should be positioned as close as possible to the parts of the visualization being described and help students identify what specifically they should be looking at.

**3.** Use relevant graphics to illustrate the main points of the process or concepts.

Use relevant graphics to illustrate the main points of the process or concepts.

**4.** Use multiple graphical representations of the same abstract concept.

Use multiple graphical representations (e.g., symbols, graphs, pictures, or real objects) of the same abstract concept to demonstrate how the concept can be depicted in many different ways. Authentic situations can be portrayed through stories, real world problem scenarios, or movie clips and used to convey abstract concepts. When using multiple visual representations of an abstract concept, draw students' attention to the components of the visualization that are relevant to the abstract concept so that students understand that the same core idea is being expressed in multiple ways.

## Potential Roadblocks



Instructional materials may present verbal descriptions of a graphic or figure on a different page of the text, or alternatively not include a verbal description that aligns with the graphic or figure.

**Suggested Approach.** Teachers should preview the instructional materials that their students will be learning from and make sure to draw the students' attention to the verbal description that maps onto the graph or figure. In addition, when preparing instructional materials or homework assignments, teachers should attend to the physical alignment of the graphs or figures and their matching verbal description.

| Content Area  | Level of Evidence                                                                          | Grades                                                                                                                                                                                               |
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#### RECOMMENDATION 4

## Connect and integrate abstract and concrete representations of concepts.

Teachers can connect and integrate abstract representations of a concept with concrete representations of the same concept. Connecting different forms of representations helps students master the concept being taught and improves the likelihood that students will use it appropriately across a range of different contexts. Research suggests that introducing and using only abstract or concrete representations of concepts inhibits students from applying the knowledge in new and unique circumstances. Rather, teachers could start with concrete representations to reinforce initial learning, and then fade into more abstract representations to encourage more flexible knowledge use.

### Strategies

#### 1. Connect abstract ideas to relevant concrete representations and situations.

When presenting an abstract idea to students, highlight the relevant features across all forms of the idea. An abstract idea can be expressed in many ways. By showing students the same idea in different forms, teachers can demonstrate that although the “surface” form may vary, it is the “deep” structure—what does not change—that is the essence of the idea.

#### 2. Use a variety of representations and explicitly discuss the connections between them.

When students first encounter a new idea, they may pick up on the wrong features of the examples. For example, they might think that averages are about sports if only sports examples are used.

They may also develop misconceptions about the concept, for example, that an average is a ratio between two numbers (e.g., hits to at-bats) rather than a ratio of a sum of measures to the number of those measures (e.g.,  $(2 + 6 + 4)/3$ ). Teachers should use a variety of representations and explicitly discuss the connections between them to help students avoid such misconceptions.

**3.** Apply new knowledge across multiple examples that vary in their relative concreteness or abstractness.

Help students to acquire a more flexible understanding of the key concepts by providing multiple examples that vary in their relative concreteness or abstractness. Moving students quickly through memorizing new terms and symbols only allows students to use the knowledge in limited contexts.

**4.** Connect or “anchor” new ideas in stories or problem scenarios that are interesting and familiar to students.

Introduce students to new ideas or concepts by anchoring them in stories or problem scenarios that are familiar to the student. Then, use a variety of successively more abstract representations of the new idea to support the student in developing conceptions that get beyond the surface features of those early examples and get to the deep features and core concepts that are the essence of the idea.

## Potential Roadblocks



Explicit connections between abstract concepts and their concrete representations are not always made in textbooks, nor in instructional materials prepared to support teachers.

**Suggested Approach.** When preparing examples and instructional materials, textbook publishers and teachers should clearly identify which aspects of an abstract representation and its concrete instantiation are connected. We believe that having these relationships clearly identified ahead of time can support the use of this recommended technique during instruction.

| Content Area  | Level of Evidence                                                                         | Grades                                                                                                                                                                                               |
|---------------|-------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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## RECOMMENDATION 5

# Use questions to introduce new content and to provide additional exposure.

Questioning is a tool that can be used to introduce students to new content as well as provide additional exposures to already learned content. Pre-questions (or pre-tests) help students identify what material they do not yet know, and primes students for what they need to learn. In addition, responding to pre-questions automatically activates any relevant prior knowledge in the student's mind. These processes contribute to improved student learning.

Use quizzes or games to re-expose students to key course content. A delayed re-exposure to course content helps students remember key information longer. In addition, quizzes or tests that require students to actively recall specific information (e.g., questions that use fill-in-the-blank or short-answer formats, as opposed to multiple-choice items) directly promote learning and help students remember information longer.

## Strategies

### 1. Use pre-questions to introduce a new topic.

The pre-questions should address a few of the important concepts that are covered in the new material. Because one purpose of pre-questions is to direct students' attention to key facts and concepts, teachers should avoid creating pre-questions that highlight extraneous information.

Provide students with questions that are readily available upon entering class and starting a lesson. These questions should be relatively quick to answer but should require students to describe or explain their responses to the questions allowing students to preview classroom instruction for the day. Engagement with pre-questions allows for students to activate prior knowledge and make connections with key concepts and topics.

2.

## Use quizzes or games to provide additional exposure to material.

Use closed-book quizzes between the initial exposure to content and the final assessment to provide additional exposure to the content. These quizzes can be both formal quizzes and informal assessments, such as playing a Jeopardy-like game. Requiring students to actively recall information gives them opportunities to practice recalling or retrieving that information, and this practice helps to solidify that knowledge in the student's memory. It is not necessary to grade these activities. It is important to provide feedback on the correct answers so that the student is exposed to the correct information.

## Potential Roadblocks



A teacher might wonder how they will get their students to attend to the non-questioned as well as the pre-questioned material, particularly when quizzes and spaced study also focus on key concepts.

**Suggested Approach.** To avoid students' attending to only pre-questioned material, teachers can emphasize (emphatically) that it is important for the students to attend all of the daily lessons and all of the reading. This idea could be reinforced by noting that the pre-questions could not cover all of the important concepts that students would be expected to learn.



Some teachers might object that this is 'giving students the answer' before they have even covered the new material—that no mental work is left for the student, and that this is simply feeding into the frenzy of, 'Just tell me what I need to know so I can do well on the test,' with little regard left for sparking a student's intrinsic motivation to learn.

**Suggested Approach.** To foster students' involvement in learning, teachers could focus class discussion on explaining correct and incorrect alternatives to the pre-questions. For example, a pre-question used in a middle school social studies class on ancient Egypt was "What were the ancient doctors NOT able to do?" with the alternatives "give shots," "cure illnesses," "measure heartbeats," and "fix broken bones." The teacher could use the alternatives to stimulate discussion on why some medical practices in ancient Egypt were possible and others not.

Further, to encourage learning of a complex fact, rather than learning of a particular answer when given a particular question, teachers could change the wording of test items from those used for pre-questions. A concept from a college-level course covered by the quiz question, "All preganglionic axons, whether sympathetic or parasympathetic, release what neurotransmitter?" could be tested with the question "What axons, whether sympathetic or parasympathetic, release acetylcholine as a neurotransmitter?"

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## RECOMMENDATION 6a

# Use delayed judgment of learning techniques to identify concepts that need further study.

Metacognition refers to the ability to judge how well one has learned new knowledge or skills. Without training, most learners cannot accurately judge what they do and don't know, and typically overestimate how well they have mastered material when they are finished studying, called the "illusion of knowing."

A key technique for breaking the illusion of knowing and being able to more accurately assess whether or not one knows the information is known as the cue-only delayed judgment of learning procedure. This technique has three critical features: (1) students should test their mastery of a set of concepts, not right after they have finished studying the material, but after a meaningful delay (an hour, a day, or a week); (2) when testing whether they know the concepts or not, students should only have access to the cue and not the correct answer; and (3) students should judge how likely they are to get the correct answer on a quiz, rather than only attempting to generate the answer.

## Strategies

### 1. Teach and use the cue-only judgment of learning procedures during class time.

Teach the cue-only judgment of the learning process after you have taught a new section of new-learned material. Prepare a selection of about 10 key questions that capture the central meaning of the material.

Give the students the questions, one at a time, without the answers, and ask the students to try to answer the question. Then, ask them to rate how likely they think it is that they will be able to get the answer to this question right, on a scale from 0 to 100, when given a test the next day. Teachers should remind the students that people forget, and that their judgments should reflect the chance that they might forget the answer by the time of the test.

After making these judgments, students should be told to review the material and find out the answers for every question that they did not give a score of 100. If they do not know the answer, they can ask the teacher or look for the answer in their texts. They should write these answers down on a separate piece of paper and think about them, and, if necessary, discuss them with the teacher for clarification. This “cue-only delayed judgment of learning” procedure should be used repeatedly, on the same materials.

## 2. Teach students how to use cue-only judgment of the learning procedure when studying on their own.

Students can also use the cue-only judgment of the learning procedure when they are studying independently. When students are preparing for a test, they should assess the likelihood of correctly answering the question on a test on a 0–100 scale. Students should focus additional study on any item that they score less than 100. Have students document their use of the technique.

## 3. Teach and use the delayed-keyword technique to assess understanding of reading.

Have students use the delayed keyword technique to assess understanding of what they read. After completing a reading assignment, students should move on to other classwork. Then, after a break from the reading, the student should try to write the main points and keywords from what they read. If they cannot generate the main points of the reading, they should go back and reread, reassessing after a break.

| Content Area  | Level of Evidence                                                                         | Grades                                                                                                                                                                                               |
|---------------|-------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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## RECOMMENDATION 6b

# Use tests and quizzes to identify content that needs to be relearned.

Learners typically cannot accurately judge how well they will remember information they have previously studied (e.g., content read from texts). Being unable to accurately predict what has been learned negatively affects students' ability to implement effective study strategies.

Quizzes may help students identify which items are not well learned, and thus enable more effective allocation of study time. For example, quizzes improve the learning of foreign vocabulary words better than extra study or review time. Similarly, rereading material produces more gains in learning when a test is interposed between the reading sessions.

## Strategies

1. Teachers should provide “closed-book” quizzes after presentation of material to provide students with the opportunity to check their learning.

Use a quiz right after the presentation of new material. Quizzes can be either oral or written; in addition, they can be formal or informal (e.g., games in class). These quizzes do not need to be graded; they are being given for the purpose of student self-assessment. Ask students to rate their confidence in their answers (see the cue-only delayed judgment of learning procedure) and then provide the answers, allowing students to assess how well they not only know the material, but how accurate their judgement is. Then ask students to identify the areas that need to be studied further. Provide opportunities for students to personalize further study based on the results.

2. Use “spot checks” at the beginning of a class session with a very short quiz on the previous night’s reading assignment or on material covered during prior class sessions.

Administer a quiz at the beginning of a class session to assess content from homework or from the previous class session. This can be done as “board work” (work for students to do when they first enter the classroom), or as a formal first activity. Immediately following the quiz, the teacher should elicit correct responses from the class and explicitly tell students that if they did not know the correct answer, they should study specific pages in their text where the answers can be found. Spot checks can also include a question that was previously covered several weeks ago.

Even though the spot check is a closed-book quiz, teachers can identify the pages in the text that pertain to the question so that students can easily find the material that needs to be studied. The basic principle is to use quizzes to help students more accurately identify the material and concepts that they need to study further.

## Potential Roadblocks



A teacher might object that there is not enough class time available for quizzing and testing—that content will have to be sacrificed in order to make time for this.

**Suggested Approach.** Some of this quizzing can be completed as homework. Students can be encouraged to make use of online self-checking quizzes that are frequently available on websites tied to textbooks. These websites grade the quizzes immediately, and often identify pages in the text where the concept, principle, or skill was taught, or where the students can locate a worked example.



A teacher might object that there is already an overemphasis on testing in the school system.

**Suggested Approach.** Typically, testing in schools involves using tests to assign grades or using standardized tests to assess students' achievement. That is, tests are used to assess what a student knows. The testing recommended here is to help students better identify what they have not learned, so that students can more effectively guide their study for material not yet mastered. It is important for teachers to help students re-envision quizzes as tools to help them learn, rather than as tools used to evaluate their performance.

| Content Area  | Level of Evidence                                                                        | Grades                                                                                                                                                                                               |
|---------------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cross Content |  Strong | K 1 <sup>st</sup> 2 <sup>nd</sup> 3 <sup>rd</sup> 4 <sup>th</sup> 5 <sup>th</sup> 6 <sup>th</sup> 7 <sup>th</sup> 8 <sup>th</sup> 9 <sup>th</sup> 10 <sup>th</sup> 11 <sup>th</sup> 12 <sup>th</sup> |

## RECOMMENDATION 7

# Help students build explanations by asking and answering deep questions.

When students have acquired a basic set of knowledge about a particular topic of study and are ready to build a more complex understanding of a topic, teachers should find opportunities to ask questions and model answers to these questions in order to help students build deep explanations of key concepts. Deep explanations mean explanations that include causal mechanisms, planning, well-reasoned arguments, and logic. Examples of deep explanations include those that inquire about causes and consequences of historical events, motivations of people involved in historical events, scientific evidence for particular theories, and logical justifications for the steps of a mathematical proof. Examples of the types of questions that prompt deep explanations are why, why-not, how, what-if, how does X compare to Y, and what is the evidence for X? These questions and explanations can occur during classroom instruction, class discussion, and during independent study.

## Strategies

### 1. Model the asking and answering of deep questions.

The quality of self-explanations improves when students are exposed to high-quality explanations provided by teachers. Teachers should model the asking and answering of deep questions during read-alouds or in other opportunities to interact with text. Model the use of question stems to train students on asking these kinds of questions. These stems may include questions like: why, what caused X, how did X occur, what-if, what-if-not, how does X compare to Y, what is the evidence for X, and why is X important?

## 2. Encourage students to “think aloud” by asking and answering deep questions.

Explanations can be elicited in a classroom environment when the teacher assigns a challenging text and invites a student to think aloud by asking questions about the content as they read. The think-aloud encourages the student to develop subjective explanations that go beyond the explicit material and that link the material to personal knowledge and experiences. As students find answers to their own questions, they should construct an answer for their own questions and explain how they derived that answer. Students can engage in peer feedback by responding to other students’ explanations and give explanations of their own. Students can also be asked to write questions and answers and share them with other students for feedback. It is important to give a student enough time to think and prepare responses rather than quickly providing the correct answer.

## 3. Provide opportunities for peer feedback on explanations.

Students can engage in peer feedback by responding to other students’ explanations and give explanations of their own. The quality of self-explanations improves when students are exposed to high-quality explanations provided by peers. These examples give students feedback and guidance on appropriate content. Allow students to explore multiple explanations, viewpoints, and paths of reasoning.

## 4. Ask deep questions when teaching, and provide students with opportunities to answer deep questions.

After modeling the asking and answering of deep questions, teachers should take every opportunity to ask deep questions and allow students to grapple with the response. Teachers should ask questions that stimulate deep explanations, such as questions about causal mechanisms, and answers that require logical thought, a well-crafted argument, and evidence to support the argument. Teachers should also ask questions that challenge students’ beliefs or assumptions about the content.

## Potential Roadblocks



Some students do not have sufficient subject knowledge to construct an explanation, ask a deep question, or answer a question. Consequently, the learning is disappointing and/or the student loses motivation to learn.

**Suggested Approach.** Teachers will need to determine when their students have acquired sufficient subject knowledge in order to benefit from participating in the deep question-asking and answering process. Teachers can use the quizzing techniques described in Recommendations 5 and 6 to help with ascertaining how well foundational subject knowledge has been acquired. Teachers should also provide ample opportunities for students to observe modeling of the question-asking and answering techniques described in this recommendation prior to asking students to use these techniques independently.



In response to teacher prompts, some students may generate explanations, questions, or answers that are shallow or tangential to the problem at hand.

**Suggested Approach.** When the student generates shallow content, the teacher or learning environment can give feedback or present examples that model the desired explanations, questions, or answers.



Some students are not motivated to invest the cognitive effort to generate deep explanations, questions, or answers.

**Suggested Approach.** Teachers can present problems that challenge students' beliefs. Another approach is to present problems that are anchored in the real world for which there is some obvious utility in solving the problem. For example, students in a high school chemistry course may be challenged to figure out how to reduce the calcium, chlorine, or pollutants in a water system. They would need to know why such substances are a hazard, how to measure the concentration of the chemicals, and methods for lowering the concentration. Identifying the potential hazards and solutions would motivate some students because it solves a problem in the community and/or may challenge the government, a corporation, or some authority.

## Reference

Pashler, H., Bain, P., Bottge, B., Graesser, A., Koedinger, K., McDaniel, M., & Metcalfe, J. (2007). *Organizing instruction and study to improve student learning* (NCER 2007-2004). Washington, DC: National Center for Education Research, Institute of Education Sciences, U.S. Department of Education. <https://ies.ed.gov/ncee/WWC/PracticeGuide/1>