Questioning Strategies for Audience Response Systems:

How to Use Questions to Maximize Learning, Engagement, and Satisfaction

Researched and Written by Will Thalheimer, PhD

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"First, interactive teaching has been demonstrated to lead to considerably larger learning gains; second, after an instructor has been exposed to the feedback this method of teaching affords, it is impossible to go back to the passive lecture format and remain ignorant about what goes on in the minds of students."

Eric Mazur, PhD
Harvard University[1]

"Based on the experimentation and [work done at IBM], interactive classrooms which use student response capabilities have been shown to improve the learning process…Much additional research is required, [but] computer-supported interactive classrooms could enhance learning by supplying the teacher with relatively inexpensive technology."

Harold M. Horowitz, PhD
IBM Corporate Education Center[2]

How This Report Is Organized

This report includes one large section sandwiched between two smaller sections. The large section provides an exhaustive overview of question types and methods—those that are particularly relevant for use with classroom audience response systems.

The introductory section describes the basic functionality of audience response systems and introduces the topic of questioning strategies. The summarizing section provides a list of general recommendations, as well as a list of references and endnotes. Again, the three main sections are:

- Introductory Section
- Question Types and Methods Section
- Summarizing Section

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Introduction

Hi. I'm Dr. Will Thalheimer. I'm a researcher and consultant in the field of learning and instructional design. I help people create more effective learning interventions by building bridges between the research side and the practice side. There is wisdom in both camps, but only by integrating research and practice can we maximize our learning outcomes.

In writing this report on classroom questioning techniques for use with audience response systems, I draw on a vast literature of research from preeminent refereed journals on learning, memory, and instruction. I also draw from the collected practical wisdom of trainers, teachers, and professors who have used audience response systems in their classrooms.

Audience response systems have enormous potential for transforming lectures from dry recitals into rich jam sessions of deeply resonant learning. The technology is widely available, but the key to success is not in the technology; it's in the instruction. To maximize meaningful learning, instructors must become adept in using questioning and discussion techniques. Unfortunately, some of us may come to believe that we can simply sprinkle our lectures with a few multiple-choice questions. This approach is emphatically inadequate, and is simply not worthy of our profession.

This report provides a near-exhaustive list of questioning strategies, and a comprehensive guide on using questions to facilitate classroom learning. No other resource exists that is research-based and comprehensive, while also being practical and useful. It has been designed specifically to provide practical guidance for trainers, teachers, and professors so that their learners—whether they are eight, forty-eight, or eighty years old—can experience deep and meaningful learning.

I would like to offer a special thank you to Dr. Steve Huff of B&H Consulting (an eInstruction affiliate) for helping me understand the technology and practice of audience response systems, for critiquing my efforts from a practical perspective, and for encouraging and supporting me as I struggled to get my head around the complexities of this topic. This paper would not be as rich and practical without Dr. Huff's insights and examples. Dr. Huff can be reached at steveh@einstruction.com and 720-261-2597.

I would also like to thank eInstruction for agreeing in advance of my research and writing to license this report for the benefit of their clients. eInstruction is available on the Web at www.einstruction.com and by phone at 940-565-0004.

Classrooms and Lectures as Inadequate Learning Designs

Today's classrooms—regardless of whether they are in primary schools, middle schools, high schools, colleges, or employee-training facilities—can create great benefits for learners, but all too often fail in a number of ways to optimize learning outcomes[3]. Here's a short list of the problems endemic to today's classrooms.

Missed Opportunities in Classrooms

1. Instructors can focus so much attention on covering material that they fail to utilize classroom time for more critical learning interactions.
2. Lectures can push students into a role of passive reception, as opposed to active engagement.
3. Learners can fail to understand what is most important.
4. Learners can have difficulty knowing how well their learning is progressing.
5. Instructors can fail to notice when their learners don't fully understand the concepts being taught.
6. Learners can think and learn in isolation—failing to benefit from other viewpoints and critical discussions—even when surrounded by hundreds of other learners.
7. Instruction can focus primarily on low-level concepts devoid of relevance.
8. Instruction can fail to engage all learners in mathemagenic (learning-creating) cognitive processing.
9. Instruction can place instructors into a "font-of-all-wisdom" role that dampens learner responsibility for actively and critically engaging the learning material.
10. Instruction can give learners a sense that information can be divided into what is true and what is not true, as opposed to helping them understand how "truth" is constructed through inquiry, exploration, data-gathering, hypothesis-testing, and social negotiation.
11. Instruction can bore the hell out of learners.

Certainly, I could list more missed opportunities, but the ones listed above are especially amenable to improvement when instructors use active questioning techniques in conjunction with classroom audience response systems. This report will describe in detail how this can be done.

The Value of Lectures

Because audience response systems are typically used as a way to augment lectures, our discussion will start by exploring the pluses and minuses of lectures.

Whether in high school, college, or employee-training situations, lectures are ubiquitous. And, while they are widely reviled for putting learners in a passive mode, they do have some advantages, such as:

- They're traditional, so learners and instructors are generally comfortable with their use.
- Lectures are relatively easy to create and implement.
- Lectures can reach a large number of learners.
- Lectures are relatively inexpensive, requiring only a room with chairs.
- Lectures can be emotionally powerful. Consider Martin Luther King Jr.'s "I Have a Dream" speech as evidence for the power that can be conveyed by a speaker's words.
- Lectures can easily be augmented with visuals, demonstrations, examples, and stories.

Instructors may prefer lectures for these reasons, as well as more personal reasons:

- Instructors may have lecture notes from previous courses that they know how to use, are comfortable in using, and require no extra work.
- Lectures are considered a time-tested success, while changing methods may be seen as risky or difficult.
- Instructors may subconsciously prefer lectures because the lack of interactivity makes conflict, confrontation, and negative feedback less likely.

While there aren't many lectures in kindergarten, by third grade teachers are talking a lot and learners are listening[4]. Despite years of reform movements in education and pleas for active learning for adult learners, classrooms are still dominated by lecture. This is true in primary schools, middle schools, high schools, corporate training sessions, conference presentations, church sermons, public meetings, elder hostels, and the local library's evening speaker series. Lectures aren't going away anytime soon, nor should they. Like all tools for learning, they provide certain unique advantages and have certain unique limitations.

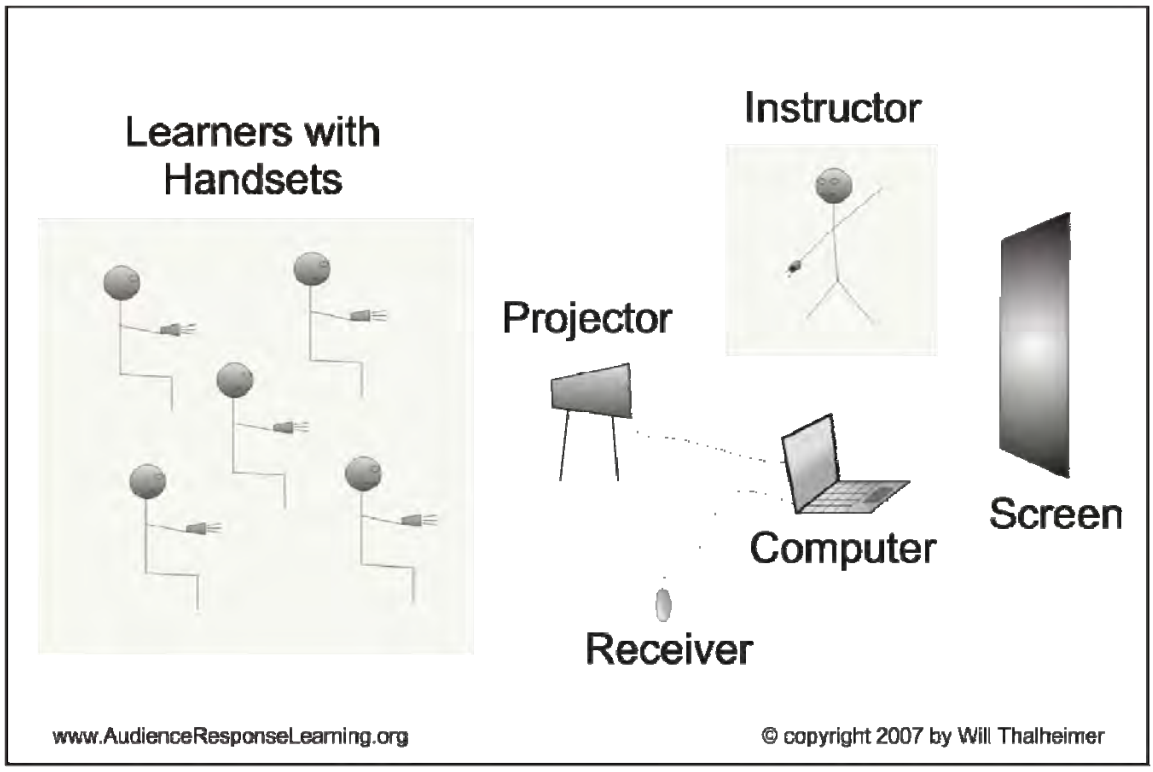
Lectures can be modified in different ways to increase the amount of active learning—to ensure that (a) learners are more fully engaged, (b) have a more robust understanding of the learning material, (c) are more likely to remember what they learned, and (d) are more likely to utilize the information later. This report will look at how questioning and discussion techniques can be used with classroom audience response systems to improve the problems endemic to the typical lecture.

Lectures, of course, aren't the only way to run a classroom. Learners can be given projects to do, exercises, group-discussion assignments, and so forth. While most of this report will be focused on how audience response systems can be used to improve situations where lectures are commonplace, it's important to be clear that the systems can be used not only to improve lectures, but in other ways as well. For example, audience response systems can be used as a way to (a) collect student test answers for grading, (b) drive project responding, and (c) give form to various types of exercises.

What are Audience Response Systems?

Classroom audience response systems[5] provide learners with handsets (or other input devices) that enable them to respond to instructor questions or other queries. Learner inputs are typically compiled in a database and are displayed through a projection system so that learners and instructors can see the results. Today's audience response systems typically include (a) handsets[6], (b) a receiver to gather learner inputs, and (c) software to compile, capture, and display learner inputs. In addition, these systems require (d) a computer, and (e) a projection system. When used for data gathering, the systems can be augmented with (f) spreadsheet software. Older response systems were often hardwired, whereas most current systems are portable and wireless.

The following diagram shows the most critical elements of audience response learning.



Although others who have diagrammed these systems often omit the instructor—probably to avoid cluttering the diagram—I include the instructor to highlight the importance of instructor facilitation, question development, and session organization. One thing that is critical, but hidden, in the diagram, is the software that runs the audience response interface. In addition, some instructors prefer using two projectors/screens—one screen to show the question and one to display either (a) the acknowledgement of handset responses and/or (b) the graph of the answer results. Note that one screen is almost always sufficient and avoids the extra logistics needed in utilizing two screen displays. Finally, due to space limitations, the graphic above does not

depict the learners working in groups or involved in discussion, a key component of the learning process.

The following photographs show typical handsets. The one on the left is a radio-frequency handset. The one on the right is an infrared handset. Note how the radio-frequency handset includes the LCD screen and provides for numeric inputs.

Radio Frequency Handset

Infrared Handset

The photo below illustrates how these systems can be easily transported to the classroom.

Note how the system looks in the classroom, for both adults and children. The RF system is depicted below, but deployment is similar for both IR and RF systems.

For Adults

For Children

Research on Audience Response Systems

There is overwhelming evidence that audience response systems are rated highly by most learners and instructors who have used them[7]. Learners not only enjoy using them, but they feel the systems improve their learning and engage their attention better than typical classroom interactions. Instructors who use the systems also see benefits for learning, engagement, and the ratings of their classes[8].

The research that tests learning outcomes with audience response systems is suggestive, but not definitive[9]. Too few studies have been done that meet the highest standards of experimental rigor. Moreover, it is exceedingly difficult to tease apart the effects of the audience response systems from the effects of questioning strategies themselves[10]. In fact, one of the difficulties in analyzing the research is deciding whether the results are driven by the audience response systems or the changes in teaching—or whether the benefits result from some synergy between the two. For analysis of research on audience response learning, see my Website at www.AudienceResponseLearning.org.

Regardless, audience response systems require instructors to utilize active-learning interactions in their classrooms—and the research is suggestive that active-learning techniques facilitate learning[11]. The studies that have been done suggest that properly implemented audience response systems improve student grades, increase scientific understanding, and improve scores on topic tests. In addition, some research shows increases in learner attendance[12] and attitudes toward school.

In addition to research directed specifically toward audience response systems, research on active-learning techniques and on fundamental learning factors offer further support for the potential of audience response systems. Clearly, what is most important is the thinking and the learning activities in which our learners engage.

Dr. Will Thalheimer

"Although I regularly produce these research reports, I earn my livelihood by consulting, speaking, and doing learning audits.

If I can help transform your organizations' learning practices, let me know."

info@work-learning.com

Can't We Get Benefits Without Audience Response Systems?

When instructors use improved questioning techniques, they create better learning outcomes, whether they use an audience response system or not. The key, of course, is ensuring that these active-learning techniques are well designed and well implemented.

Audience response systems do provide some noteworthy advantages over alternative methods of active learning. For example, handraising does not ensure anonymity[13] and it often fails to encourage all learners to respond. Response cards[14]—cards that learners hold up to indicate their response to a question—have appeal because they enable some anonymity, but they don't have the ability to capture or slice learner responses into meaningful subcategories. In addition, response cards are generally more cumbersome to implement and lack the *"cool factor"* of electronic handsets. Finally, some learners, especially adults, may be uncomfortable using response cards because they connote the oppressive infantilization of flashcard drills.

Introduction to Questions and Questioning Strategies

Questions are at the heart and soul of active learning with audience response systems. Like every learning tool, questions have strengths and weaknesses. To realize the benefits, questions have to be implemented properly and appropriately; otherwise, they may even have a negative impact. This section will provide an analysis of the benefits and dangers of questions.

Using Questions is Not Enough

Simply placing questions into lectures is not an adequate pedagogy. Questions must be utilized with thoughtfulness and a specific set of goals. Questions send messages. They tell learners where to focus their attention—not just in the moment, but in future sessions, in homework, and in their day-to-day lives. If we use questions that focus on low-level trivia, learners will use their cognitive resources to think about low-level trivia, instead of thinking about more-important high-level concepts. Questions strengthen certain memory routes and nodes while neglecting or creating interference for the accessibility of others. Questions take time, and thus represent an opportunity cost for other material or learning. In short, questions set priorities for learning. To be maximally effective, we have to know what our priorities are and then use questions accordingly.

Questions are Part of a Larger Learning Flow

In the context of classrooms, questions don't act alone. Typically, they are introduced in association with learning content. Sometimes they come before the associated content. Sometimes they come after it. In addition, questions are often followed by feedback to the learners. Finally, questions generate learning-related cognitive processing in the minds of the learners. For simplicity, throughout the rest of this report, I will refer to this as ***mathemagenic*** processing[15]—cognitive processing that gives birth to learning. To summarize, the following join together to create learning benefits: (a) questions, (b) content, (c) feedback, and (d) learner cognition. Questions don't do the work alone.

Questions Before and After, Early and Late

Questions have different effects depending on when they're delivered. Questions can be delivered before the relevant learning material or after. Questions can be delivered early in the learning of a particular topic—or after the learners have gained a substantial understanding of that topic. Instructors must recognize these distinctions to design optimal classroom sessions, placing questions where they are most appropriate.

The Inherent Learning Benefits of Questions

Questions produce cognitive effects in our learners and generate learning benefits. While it is beyond the scope of this report to delve into these benefits in depth, the following list offers a flavor of the myriad ways that questioning strategies support deep and meaningful learning. Some of these benefits are inherent to questions, while others are possible if questions are well designed and well facilitated. All of these benefits are derived from research published in preeminent refereed journals. I will explicate these in depth in my forthcoming book and on the Website www.AudienceResponseLearning.org.

#	Summary of Question Benefits
1.	Prequestions Guide Learner Attention
2.	Postquestions Guide Later Learner Processing
3.	Questions Provide Repetition
4.	Questions Provide Retrieval Practice
5.	Questions Provide Learners with Feedback
6.	Questions Provide Instructors with Feedback
7.	Questions Can Grab Attention
8.	Questions Can Activate Prior Knowledge
9.	Questions Can Provide Variety
10.	Questions Can Make the Learning Personal
11.	Questions Can Provide Spaced Repetitions
12.	Questions Can Highlight Boundary Conditions
13.	Questions Can Highlight Common Misunderstandings
14.	Questions Can Demonstrate Forgetting
15.	Questions Can Support Transfer to Related Situations/Topics
16.	Questions Can Prepare Learners for Future Decision-Making
17.	Questions Can Demonstrate Relevance to the Real World
18.	Questions Can Help Learners Identify Their Assumptions
19.	Questions Can Encourage Attention to Difficult Content
20.	Questions Can Demonstrate Learning Over Time
21.	Questions Can Provide Practice in Learning with Others
22.	Questions Can Be Utilized to Gather Experimental Data
23.	Questions Can Prompt Out-of-the-Classroom Learning Activities
24.	Questions Can Promote Thinking Skills

Question Types and Methods

Many of us may be inclined to see audience response systems only as a way to deliver multiple-choice and true-false questions. While this may be true in a literal sense, such a restricted conception can divert us from myriad possibilities for deep and meaningful learning in our classrooms.

This section provides a list of question types and methods. While no list could be exhaustive—and I encourage you to experiment with your own questioning methods—this list is based on classroom-tested practice and conceptions coming straight from research on learning and instruction.

To be successful in utilizing questions with audience response systems, you'll have to do the following:

1. Create a list of high-quality instructional goals.
2. Know your learners' competencies related to each goal.
3. Write high-quality questions tailored to each goal.
4. Facilitate high-quality conversations for each question.
5. Utilize feedback to make instructional changes.

The following material is written specifically to help you implement all five of these recommendations. The wealth and depth of information in the following section is immense. I recommend that you digest this information slowly, iteratively, and reflectively. Take time to make it your own. Take notes. Make plans for how you will use the information. Come back to the document when you're ready for more or when you want to go deeper. Share what is special to you, so that you yourself will develop keener insights about your own practices.

There is so much information within this report that some of you may find value in thinking about this as a long journey of discovery. Others may prefer a metaphorical approach, thinking of yourself walking through the document as you might walk through an enchanted forest glen, sitting in the middle, breathing in the air, gazing calmly on the entirety of the landscape. One thing you should be sure of—learning these methods will require some well-invested time.

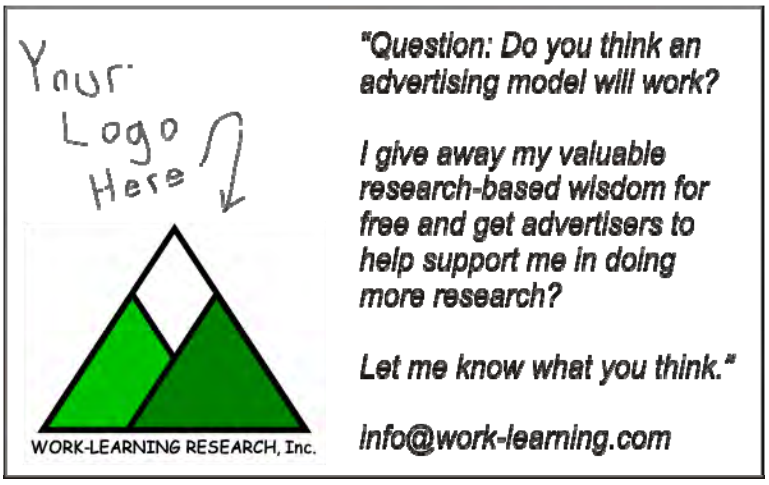
At the end of this report, I've added some general recommendations for how to approach the process of utilizing questions with audience response systems. Some of you may be more comfortable starting there. My recommendation is that you start here, because this section conveys the full richness of what is possible.

1. Graded Questions to Encourage Attendance

Questions can be used anytime during your classroom session to encourage learners to show up for class. Many college instructors have found this particularly effective in increasing their attendance rates. Typically, they count attendance or class participation as 5% to 20% of the course grade. It is generally preferable to give learners at least partial credit for answering questions regardless of the correctness of their responses.

Research shows that grading typically produces measurable learning gains. However, for some learners, grading may seem insulting or heavy-handed. You probably wouldn't want to grade a classroom of business executives, for example, especially if you wanted to keep your job as a well-paid corporate trainer.

In addition, grading can put the emphasis on the wrong learning priorities, pushing learners into habits of mind that are counterproductive. For example, research (mostly with children) has shown how learners who focus on external rewards are often less likely to approach learning situations in a way that enables deep and meaningful learning[16]. Instead, when extrinsic rewards become more important than the enjoyment or meaningfulness of learning, learners focus only on getting good grades or looking good to their instructors or peers. For this reason, it is recommended that grading be de-emphasized by giving credit for answering—not for correctness. Note, however, that such de-emphasis is probably not relevant to the next question type.



2. Graded Questions to Encourage Homework and Preparation

Questions can be used to prompt learners to prepare for classroom sessions. By grading a few questions based on prework assignments, learners are more likely to engage in valuable study time prior to class and are more likely to come to the classroom ready to contribute to class discussions. This strategy has an additional advantage—it enables classroom time to be devoted to more meaningful interactions than just information presentation.

It is often most natural to provide these questions at the beginning of sessions. This tactic encourages learners to get to class on time and provides a natural segue to new material. It also may be beneficial to get the "graded" questions out of the way early so that learners can focus on learning instead of focusing on being graded. On the other hand, this recommendation should be weighed against your other pedagogical goals. For example, you may have reason to start a session with a provocative demonstration or a group discussion on a hot topic in the news. The point is that, just as in all instruction, you need to keep your focus on your learning goals and maintain some flexibility so that you can reach them.

Catherine Crouch and Eric Mazur, professors of physics at Harvard University, have found success in asking learners to complete reading assignments before class. They have their learners use the Internet to answer questions about reading assignments they have used[17].

3. Avoiding the Use of One Correct Answer (When Appropriate)

When we test learners to grade them, credential them, or get feedback to hold ourselves accountable, we need correct answers. Questions that don't fulfill this narrow assessment purpose need not have right answers. Questions can be used for assessment, or learning, or both. When they are used for assessment, we have to be able to attach metrics to the responses learners give. We usually do this on multiple-choice tests by assigning one answer choice as correct and the other answer choices as incorrect. Of course, this need not be the case. We could give full credit for two answer choices, or full credit for one choice and half-credit for another answer choice. Most of us have computers and calculators, after all.

The point to remember is that if we're using our questions for learning, not assessment, we don't have to be hamstrung by the requirement of assigning value to answer responses. Certainly, there can be advantages to having some level of correctness. Some learners may engage more fully in the cognitive processing required to answer the question, for instance. On the other hand, pecking for a correct answer does not always produce the most beneficial mathemagenic (learning-creating) cognitive processing.

Research has found that multiple-choice questions create more learning benefits—in general—than true-false questions. Having learners rank multiple-choice options produces more benefits than selecting only one of the options. Recall questions are usually more potent than multiple-choice questions. The theme of the research is that the more learners cognitively process the question alternatives, the better the learning. Of course, we have to be careful not to take this too far. These are general results. There are times when true-false questions are perfect, and simple multiple-choice questions are preferred. The point to remember is that are potent alternatives to multiple-choice and true-false questions.

A teacher focusing on a political science unit might use a ranking question like the following.

Question: Which of the following characteristics are most important for a president or any national leader—so that they can be effective in their job to help their countries' citizens? Rank-order these and then input your top three choices in order.

A. Honesty.
B. Good ideas.
C. Likeability.
D. Good public speaking.
E. Toughness.
F. Compassion.
G. Social skills.
H. Intelligence.
I. Knowledge of issues.

Obviously, there is no ***one*** correct answer here, but the question can generate important thinking and discussion. Note that I wrote this question as a ranking question, which is likely to generate deeper thinking than just having learners pick one choice. If your audience response system doesn't allow such responding, you can do this manually by having learners rank their choices—for example on paper—and then answer three separate questions ("Which is your first choice?"…"Which is your second choice?"… "Which is your third choice?"). Alternatively, you could just ask the question as a simple pick-one-answer question, but facilitate the discussion to highlight the fact that many answers are acceptable.

Here are some examples of questions that avoid the use of one single correct answer. This first question might be used by a fifth-grade teacher to get students to think about media-literacy issues.

Question: What happens when a news program gives equal time to two people—one who is an expert scientist who voices the beliefs of most scientists, and a second scientist who voices an opposing belief that is generally dismissed by most other scientists? Suppose both speakers are equally charismatic and well spoken. What is the most likely outcome?

A. The expert will be perceived as having the better case.
B. Almost all listeners will believe the expert.
C. More people will believe the non-expert view than the data warrants.
D. Both people will be perceived as having credibility.
E. The non-expert case will gain in esteem.

Question: Which is the least likely to happen?

The questions above offer many plausible answer choices. While some are more consistent with the empirical evidence (because data clearly show that elevating non-expert arguments in this way gives them credibility beyond what those arguments deserve), at least three of the five choices (Choices C, D, and E) are empirically defendable. This question could be used as an entry point in discussing real-world examples, including media-literacy issues around debates on global warming, tobacco, and the like. Moreover, it could lead to discussions of similar credibility issues in candidate debates, presidential news conferences, news reporting, education, public relations, etc.

In a social-studies class, the following questions might be used to begin a discussion on the American civil-rights movement.

Question: In your small groups, discuss the following questions. What did both Martin Luther King, Jr. and Malcolm X have in common? In what ways did they differ? The following provides a list of some potential characteristics. These may or may not be true.

A. Was a man.
B. Was African American.
C. Was good looking.
D. Grew up in poverty.
E. Was a religious leader.
F. Knew how to attract attention.
G. Was an excellent orator.
H. Was knowledgeable and thoughtful.
I. Played football in high school.
J. Voiced opposition to violence.
K. Was seen as a capable leader.
L. Was married.
M. Had children.
N. Engaged in an extra-marital affair.
O. Argued that men are more capable than women.
P. Received death threats.
Q. Was killed by opponents.
R. Wrote a book.
S. Led a life of integrity.
T. Was able to mobilize followers to action.

After small group discussions, the instructor can comment on which of these are true. The learners can then be directed to the following question:

Question: What are the top three characteristics that made them especially effective in creating change in the lives of African Americans? Let's do Martin Luther King first. Then Malcolm X. Use your handsets to make your selections. Remember, you only get three choices, so think before you make your selections.

While some of the choices are better than others, there are many good options. This question can be used to initiate further learning. It gets learners interested in the two men personally. It gets learners thinking about the leverage points in the civil rights movement. It also prompts them to contemplate what makes leaders effective. It helps learners see that change requires brave men and women to step forward and take risks.

4. Prequestions that Activate Prior Knowledge

Questions can be used to help learners connect their new knowledge to what they've already learned. A cooking teacher could ask a question about making yogurt before introducing a topic on making cheese, prompting learners to activate their knowledge about using yogurt cultures before they begin talking about how to culture cheese. A poetry teacher could ask a question about patriotic symbolism, before talking about the use of symbols in modern American poetry. A calculus teacher could ask a question about how to compute the area of a circle before introducing the concept of how to compute the area under a curve.

In creating these questions, instructors must be adept at two things—knowing their subject matter and knowing the minds of their learners. For most instructors, the second is much harder than the first. It may take some experimenting to determine what questions work to bridge the gap between the new content and the learner's prior knowledge.

The following question is one that I've seen work in action—teaching managers why there is a benefit in asking their direct reports to help them make some decisions.

> **Question. Think back to the jobs you've had over your career. Which situations did you find most rewarding?**
>
> A. When my manager told me what to do.
> B. When my manager provided minimal guidance.
> C. When my manager asked my opinion.
> D. When my manager asked me to take on more responsibility.

This question activates managers' feelings about what it was like to be managed. They can then use this information to understand and empathize regarding how their direct reports might feel and to think about how they want to act as a manager.

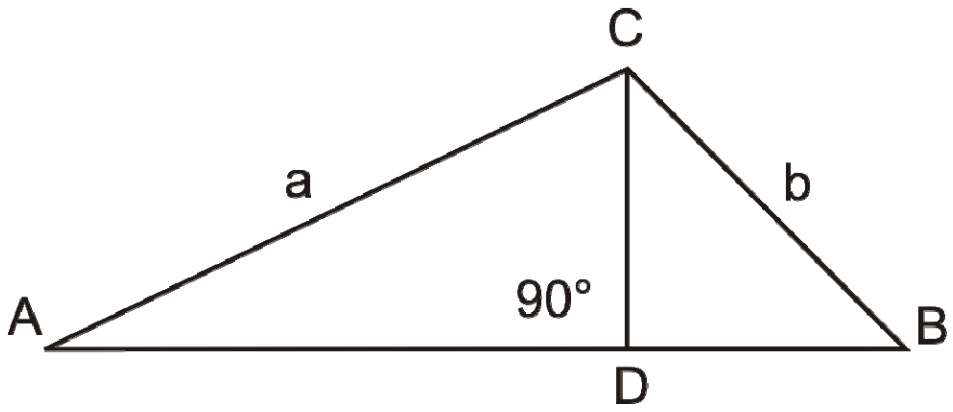
Here's a question that a fourth-grade teacher might use before introducing the concept of cultural differences.

> **Question: Write down as many names as you can—up to 10 names—of all the people you know who have Latino ancestry. Do the same for all the people you know who have European, African, Asian, or other ancestry. If you're not 100% sure about someone's ancestry, that's okay. Just make your best guess. When you're done, we'll use our handsets to answer a question.**
>
> **[After learners complete their lists]**
> **For which list was it easiest for you to come up with names?**
>
> A. Latino
> B. European
> C. African
> D. Asian
> E. Other

This question prompts learners to begin thinking about cultural differences in relation to the people they know in their lives. It also helps students begin to understand how their own experience shapes the breadth of the people they know and determines how much they know about other cultures. By activating their prior knowledge, subsequent discussions are likely to be more relevant, more enriching, and more memorable.

A college mathematics professor might use the following question when introducing concepts in trigonometry.

Question: Which of the following answer choices provide sufficient information for determining the length of Side "a" in the triangle below?



A. The angle of Angle "A"
   The length of Side "b"

B. The angle of Angle "A"
   The angle of Angle "B"

C. The angle of Angle "A"
   The length of Side "b"
   The angle of Angle "B"

D. The angle of Angle "A"
   The length of Side "b"
   The length of Side A-D

E. None of these provides sufficient information

This question helps learners activate their prior knowledge about geometry, a prerequisite for trigonometry.

5. Prequestions that Surface Misconceptions

Learners bring naïve understandings to the classroom. Let's think about the basics of learning. Aren't learners supposed to change their current conceptions? If not, why should anybody bother with this learning thing?

One of the best ways to confront misconceptions is to bring them to the surface so that they can be confronted straight-on. The Socratic Method is a prime example of this. Socrates asks a series of questions, thereby unearthing misconceptions and leading to a new and improved understanding. You've always wanted to rise to the level of Socrates, haven't you? Using prequestions is your big chance.

To write a good prequestion to surface misconceptions, you have to learn what those misconceptions are. If you've taught your subject for a while, you'll have learned what these are. If you're new, you'll have to guess, ask colleagues, or figure it out by seeing what points textbooks on your topic tend to belabor.

I use the following question when I teach learning and instructional design:

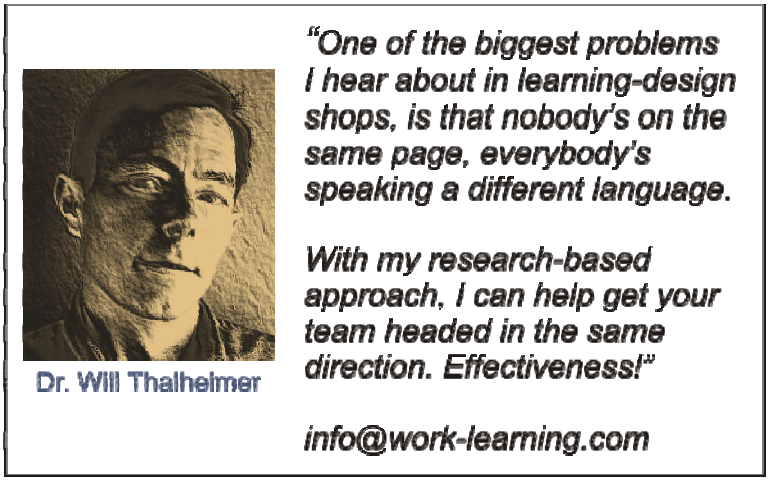
> **Question: Which form of question feedback will enable the best memory-retrieval two weeks after learners get the feedback?**
>
> A. Give learners feedback immediately after they answer each test question.
>
> B. Give learners feedback immediately after they finish the whole test.
>
> C. Give learners feedback one day after they finish the test.

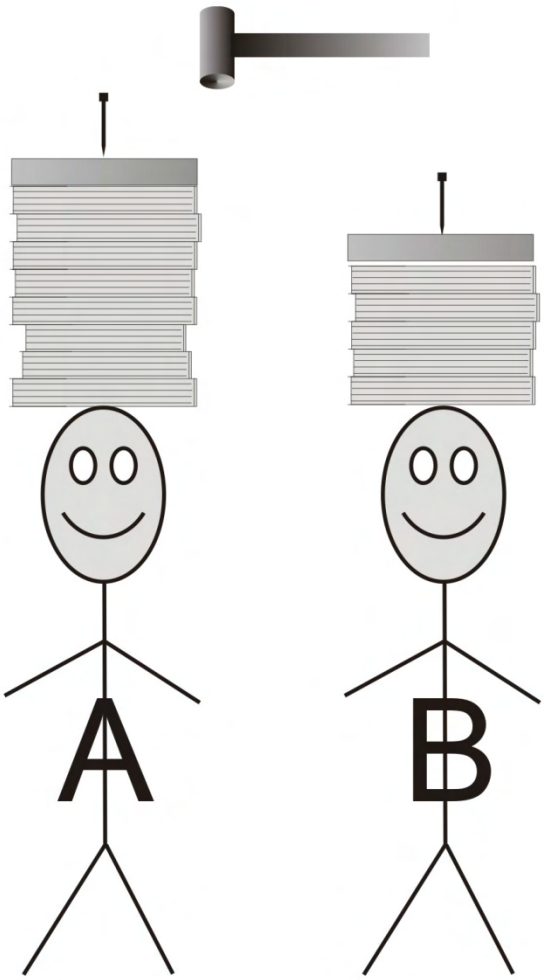
Many instructional designers, trainers, teachers, professors, and e-learning developers to whom I present this question hold the misconception that immediate feedback is always preferable. It is not. Research has shown that, in many circumstances, delaying feedback on test questions will facilitate long-term retention of the information targeted by the question.

Before I "teach" anything about when feedback should be delivered, I ask my learners the question above. Not only does it activate their prior knowledge, but it also enables me to surface their misconceptions and confront those misconceptions directly. As you might imagine, this kind of myth-busting energizes my classroom, grabs attention, and demands discussion to tease apart the boundary conditions of this new rule. I have found that using this technique requires me to be especially gracious in acknowledging challenges and respecting the opinions of those whose paradigms I've just assaulted. This is not easy, and I must admit that sometimes I have failed in balancing my advocacy for the new ideas and my demonstrated empathy and respect for those whose ideas have been challenged.

Here's an example question in teaching about the physics of inertia.

> **Question: Suppose you carefully stacked books on top of your physics instructor's head and then put a pine board on top of those books. Suppose further that you then tried to hammer a nail into the wood board with one quick powerful stroke (See Figure A in the following diagram). Finally, suppose you then took about half the books off the stack and whacked the nail again using the exact same amount of force on the nail (See Figure B in the following diagram). What is the most likely outcome? Use the diagram on the following page to answer the question.**





A. Your instructor would feel both strokes equally.

B. Your instructor would feel stroke A with more intensity.

C. Your instructor would feel Stroke B with more intensity.

D. Your instructor would feel nothing.

Many introductory physics students have the misconception[18] that force is transmitted fully through objects, regardless of their mass. In actuality—as Newton's Laws of mass and inertia describe—as the mass of an object increases, it has more inertia and will more fully resist forces acting on it. The more books in the example, the more mass, the more inertia, and the more the force of the hammer will be absorbed.

After using the question above, and perhaps encouraging learner-to-learner conversation, learners will be primed to learn about inertia. Those who struggled determining an answer will be motivated to learn why their mental models were insufficient. Because the example is so evocative of objects learners have experience with (hammer, nail, books), the concepts will resonate with learners. The humor inherent in Choice D will make the question entertaining—of course, you may want to remove that choice so that learners take the other choices seriously.

You might want to try a follow-up question to see if this changes learners' answers.

> **Question: Suppose the books are replaced with bricks. What answer would you choose then?**

Comparing or contrasting the effects of "bricks" and "books" may be intriguing. Alternatively, you might find that using "bricks" instead of "books" actually works better to surface learners' misconceptions. Learners' lay conceptions of books may have the connotation that books can absorb forces—a conception that, though true, would make the question less effective in surfacing their misconceptions. As you can see, you'll need to experiment a little to see what works best for your learners and material.

Having Learners Predict Results

You might also consider actually preparing a demonstration as a prequestion. For example, what if you set up a way to measure the strength of forces, and you asked learners to predict the results.

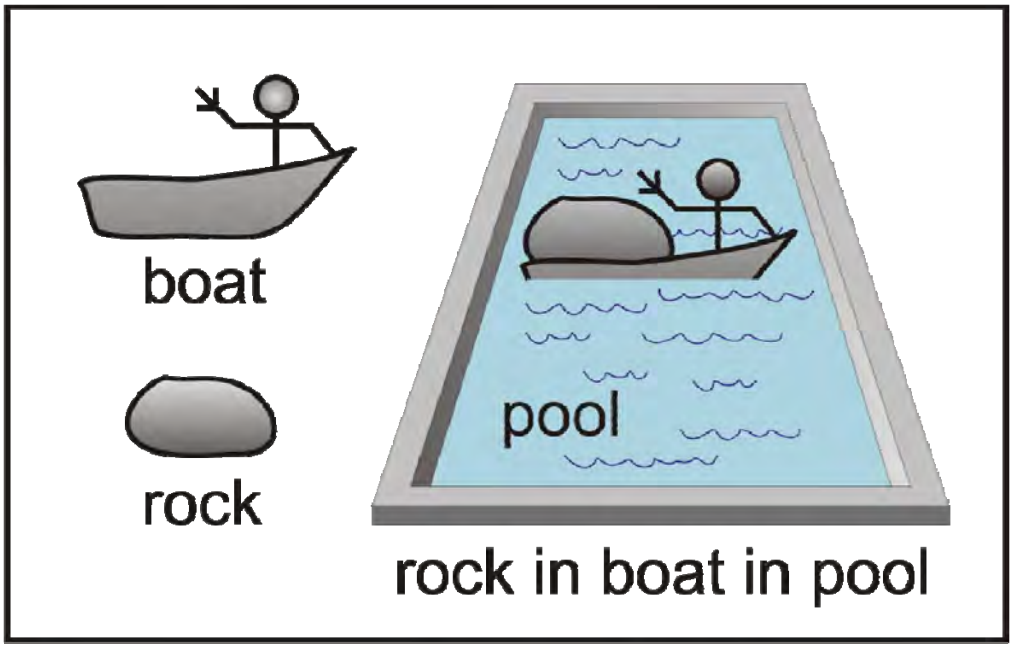
> **Question: On the table in the front of the class are two stacks of books—one significantly taller than the other stack. Both stacks have been placed on scales that will measure their weight when we drop this bowling ball from one meter above the stack. What is the most likely outcome? Turn to your partner to discuss. Then we'll take a vote.**

To summarize, prequestions to surface misconceptions can be an excellent way to confront learners' preconceptions. Using these questions to optimal effect requires both knowledge of your learners' common misconceptions and a deft hand in facilitating the discussion. While you shouldn't expect to be great at either of these things at first, with time you'll be able to master both. An additional advantage in looking to build this type of question is that it will prepare you to respond to your learners' common misconceptions.

One final point. Learners' misconceptions change with time and with each set of new students that enter your classroom. You'll need to be constantly vigilant in noticing where your learners' misconceptions lie.

Prework Misconception-Testing Prequestions

Ruben Meerman of ABC Science suggests that we assign misconception-testing questions—he calls them "conundrum" questions—as preparation for classroom sessions. His rationale is that it may benefit learners to have time to think about questions. He cites the following as a great example of a question where the answer is counterintuitive—in other words, it's a perfect question to surface misconceptions. Meerman reports that this question even stumped the famed physicist Robert Oppenheimer. I've adapted the diagram and question from his excellent materials[19].



Question: A boat with a heavy rock is floating in a swimming pool. If the rock is pushed out of the boat into the pool, what will happen to the water level in the pool?

A. Water level in pool will rise.
B. Water level in pool will fall.
C. Water level in pool will stay the same.

Why don't you try to answer the question before I provide the answer.

Meerman's suggestion of assigning this type of question as prework is intriguing. We could certainly use the question in class without first having assigned it as prework—assigning it beforehand, assuming the learners actually think about the question prior to class, has some advantages. First, it provides a repetition of the question: the learners will think about the question before *and* during class, not just during class. Second, that repetition is spaced out over time, providing learning benefits: spaced repetitions are more potent than repetitions that are not spaced[20]. Finally, if the learner shares the question with others, such as friends and family members, or thinks about the question in a study group, the social effects may spur intense engagement in thinking about the question. Moreover, because people have a tendency to bring up previous conversational items later, there is also a very real possibility for further socially-induced reflection. We can easily imagine a learner presenting a question to his family or colleagues prior to class and discussing it, answering the question and discussing it in class, and then bringing up the question and its answer after class as a way to build on the earlier conversation.

In the question above, most people choose A or C, but the correct answer is B (the water level in the pool will fall), making it a great misconception-testing prequestion.

6. Prequestions to Focus Attention

Our learners' attention wanders. In an hour-long session, sometimes they'll be riveted to the learning discussion, sometimes they'll be thinking of other ideas that have been triggered, and sometimes they'll be off in a daze. The wavering of attention is a completely natural process; and while we can't stop the wavering, we can influence it enough to create some learning benefits.

There has been a large body of research on using prequestions and learning objectives to help learners pay attention to the most important subsequent learning material. In fact, in one famous study, Rothkopf and Billington (1979) presented learners with learning objectives before they encountered the learning material. They then measured learning and eye movements and found that learners actually paid more attention to aspects of the learning material targeted by the learning objectives. Prequestions work the same way as learning objectives—they focus attention.

The prequestions we've described above are likely to focus attention during the subsequent discussions in the classroom. However, we can think more generally about the attention-focusing effect of prequestions.

Research has shown that the words we use in the prequestions should be similar to the words in the learning material on which we want our learners to focus. For example, if we want to increase the likelihood that our learners will focus on how mitosis works, we ought to use the word "mitosis"—not just related words like "chromosome," which may diffuse their attention to other non-mitosis-related learning material. So, for example, if we wanted our learners to focus on the difference between mitosis and meiosis, we might ask this as a prequestion:

Question: Which is true for mitosis but NOT meiosis[21]?

A. Chromosomes consist of two chromatids.
B. Cells divide into equal parts.
C. Cell division is a one-step process.
D. Chromosomes divide into two equal parts.

When is it appropriate to use prequestions like this? For many learners, asking a prequestion on a topic about which they have no idea could be frustrating. On the other hand, if the questions can be answered relatively easily—like most multiple-choice questions can be—learners will typically rise to the experience as long as they have some foundation for taking a guess. Prequestions for IT software training are notoriously frustrating because learners often have no idea how to make the software work before they learn at least a little about the program. You'll have to decide (or discover through trial and error) whether your content is in this rare category.

7. Postquestions to Provide Retrieval Practice

Postquestions—questions that come after the learning content has been introduced—can be used to reinforce what has been learned and to minimize forgetting. This is a very basic process. By giving learners practice in retrieving information from memory, we increase the probability that they'll be able to do this in the future. Retrieval practice makes perfect.

Retrieval practice is a powerful learning factor, so it has to be appropriately implemented or it can produce negative outcomes. For example, if we give learners practice recalling trivial information, they may become expert in remembering facts but poor in remembering higher-level concepts or in combining higher-level concepts to solve problems or to be creative. The best heuristic is to give learners practice in what we want them to be able to do later—and specifically, to give learners practice retrieving the same information in the same context in which they'll need to retrieve it later[22].

Retrieval practice creates its benefits in two ways. Successful retrieval supports long-term retention. Unsuccessful retrieval enables feedback and further mathemagenic processing. The next section will discuss using retrieval practice to surface retrieval troubles.

Note that incorrect retrieval practice without corrective feedback can strengthen inappropriate knowledge, so it's best to avoid too many incorrect retrievals on the same learning point[23]. Similarly, if we want to reinforce long-term retrieval we need to be sure to provide sufficient opportunities for correct retrieval practice.

8. Postquestions to Enable Feedback

Feedback is essential for learners and instructors. As mentioned in the section immediately above, retrieval practice enables learners to get feedback. Even if we don't directly provide them with didactic after-the-fact feedback, they're getting some feedback during the act of retrieval about how confident they are in the information they've recalled. Such confidence is probably suggestive of informational accuracy, but it's not sufficient. Corrective feedback is critical, especially when learners have misunderstandings[24].

Providing retrieval practice with corrective feedback is especially important as learners are struggling with new material, difficult material, or when their attention is likely to wander—for example, when they're tired after a long day of training, when there are excessive distractions, or when the previous material has induced boredom.

Ellen Langer (1997), in her thought-provoking book, *The Power of Mindful Learning,* wrote the following:

> *"How often do we, so practiced in how to prepare information for a lecture, continue to present a prepared lesson without noticing that the class is no longer paying attention? Presenting all the prepared content too often overtakes the goal of teaching." (Langer, 1997, p. 12).*

Instructors also benefit from feedback on how well their learners understand the material. Some feedback is available from learners' facial expressions and unsolicited questions, but such feedback is insufficient. Learners will sometimes stay quiet when they think they can figure it out after class. Introverts may not speak up at all. Learners who are completely lost don't feel entitled to having the instructor start over from the beginning.

Using postquestions enables us—as instructors—to gather feedback and then modify our teaching to better support the needs of our learners. This process is so important that Draper and Brown (2004) coined the term "contingent teaching"—and Beatty, Leonard, Gerace, and Dufresne (2006b) coined the term "agile teaching"—to advocate for its use.

9. Postquestions to Surface Misconceptions

We already talked about using prequestions to surface misconceptions. We can also use postquestions to surface misconceptions. Learners don't always understand concepts after only one presentation of the material. Many an instructor has been surprised after delivering a "brilliant" exposition to find that most of their learners just didn't get it.

Because it can be impossible to tell in advance whether learners will find a particular concept easy or difficult, it may be beneficial to develop at least one postquestion for each critical learning point. This will obviously depend upon the topic and the learners, and you probably don't want to overdo it by using a postquestion for each point that is made. Moreover, as you learn from your experience using certain postquestions, you'll be able to tailor your postquestions to topics and learning points that are especially difficult for you to make understood.

Carl Wieman, Nobel Laureate in Physics, and his colleague Katherine Perkins at the University of Colorado, Boulder, tell a great story about how audience response systems helped them discover that their classroom explanation—about how violins make sound—had fallen on deaf ears. One common misconception is that the violin produces noise from the strings. In actuality, the strings only start the process. It is the wood at the back of the violin that projects the sound. Here is how Wieman and Perkins (2005) tell the story:

> *The following example is from data collected in our own introductory physics class for non-science majors. After explaining the physics of sound in our usual incredibly engaging and lucid fashion, we brought a violin into class. We explained how, in accordance with the physics we had just explained, the strings do not move enough air to create the sound from the violin. Rather, the strings cause the back of the violin to move via the soundpost, and thus it is the back of the violin that actually produces the sound that is heard. Fifteen minutes later, we asked the students the multiple choice question shown [below], "The sound you hear from a violin is produced mostly by . . ." Only 10% gave the correct answer. We have seen that this 10% level of retention after 15 minutes is typical for a nonobvious or counterintuitive fact that is presented in a lecture, even when the audience is primarily physics faculty and graduate students.*
>
> (Wieman & Perkins, 2005, p. 37)

Question: The sound you hear from a violin is produced…

A. mostly by strings (84% selected this answer)
B. mostly by the wood in back (10% selected this one)
C. both equally (3%)
D. none of the above (3%)

(adapted from Wieman & Perkins, 2005, p. 38)

Many experienced instructors have found that it is not enough to be engaging and lucid, especially when they're covering counterintuitive information. An article by William Crombie (2006) in the Harvard University Gazette talked of Eric Mazur's use of audience response systems this way, *"His students use [the handsets] to answer questions about what he had just taught them, or thought that he taught them. The tactic revealed how much his students didn't know."* Mazur went on to say, *"I suddenly realized that many students didn't understand what I had just told them. I knew immediately that I would have to spend more time explaining the material. Before I would have gone on to the next topic and increased the number of students that I left behind."*

Beatty, Leonard, Gerace, and Dufresne of the University of Massachusetts advocate eloquently on this point, *"Correctly predicting any one student's response to an instructional stimulus is difficult; doing so for an ensemble of students in a class is impossible. An instructor must continually probe, monitor, and model students' knowledge state, progress, and difficulties on a minute-by-minute timescale, and adjust teaching behavior accordingly."*

Our first instinct might be to avoid postquestions for fear of being redundant. However, as these examples show, postquestions are critical in providing feedback to our learners and ourselves, and in correcting learners' misconceptions.

10. Questions Prompting Analysis of Things Presented in Classroom

One of the great benefits of classroom learning is that it enables instructors to present learners with all manner of things. In addition to verbal utterances and marks on a white board, instructors can introduce demonstrations, videos, maps, photographs, illustrations, learner performances, role-plays, diagrams, screen shots, computer animations, simulations, objects, animals, graphs, smells, music, sounds, etcetera. While these presentations can certainly support learning just by being observed, questions on what has been seen can prompt a different focus or a deeper understanding.

For example, suppose learners in a drama class evaluate each other's performances.

Question: What was the best aspect of the performance?

A. The actor(s) were believable.
B. The actor(s) demanded attention.
C. The actor(s) enunciated well.
D. The actor(s) had good timing.
E. The actor(s) looked the part.
F. The actor(s) exhibited authentic emotions.

Or a video is shown that shows some of the realities of war.

Question: How realistic did you think the depiction of war was?

A. Very realistic.
B. Mostly realistic.
C. Somewhat realistic.
D. Not very realistic.
E. Not realistic at all.

These types of questions can benefit learners by helping direct their attention to certain aspects of their experiences. The next section on "Rubric Questions" highlights a specific method for utilizing this type of question.

Learner performances can also be evaluated by asking audience members to share their emotional reactions. Here's just one example.

Question: How did the speaker's speech make you feel?

A. I experienced severe negative emotions.
B. I experienced mild negative emotions.
C. I didn't experience any significant emotional response.
D. I experienced mild positive emotions.
E. I experienced significant positive emotions.

11. Using Rubric Questions to Help Learners Analyze

In common parlance, the term "rubric" connotes a set of standards. Rubrics can be utilized in asking learners questions about what they experience in the classroom.

For example, if a public-speaking instructor wants to help her learners to integrate seven attributes into their public-speaking performances, she could show videos and ask her learners to answer seven questions regarding those performances.

> **Question: As you view the following speech, I want you to consider the following questions. We will rate the performance using our handsets immediately afterward.**
>
> 1. **Did the speaker project confidence?**
> 2. **Did the speaker communicate credibility?**
> 3. **Was the presentation well organized?**
> 4. **Did the speaker create rapport with the audience?**
> 5. **Did the presentation take advantage of audio-visual aids?**
> 6. **Did the speaker encourage audience participation?**
> 7. **Did the speaker emphasize and repeat the key points?**
>
> **Rating Scale**
>
> A. Clearly met the rubric.
> B. Partially met the rubric.
> C. Did not meet the rubric.

It is generally best to have only a few items on this type of rating scale. I used three in the example above, but you may even want to use two to force learners to really wrangle with the decision.

> **Another Rating Scale**
>
> A. Met the rubric.
> B. Did NOT meet the rubric.

Too many rating categories can make it difficult for audience members to distinguish between the categories. It can also make it hard to interpret the results when they are presented in a graph.

Rubric questions, if they are well designed, can give learners practice in evaluating situations, activities, and events. Such practice is an awesome way to engage learners and prepare them for critical thinking in similar future situations. In addition, if rubrics are continually emphasized, learners will integrate their wisdom in their own planning and decision-making.

Well-constructed rubric questions must be as unambiguous as possible. The more concrete they are, the more helpful they will be in helping learners understand their meaning. Rubric questions should only ask about one thing at a time. The following table shows a few good and bad examples.

Good	Bad	Rationale
Did the speaker project confidence?	Did the speaker dress appropriately and project confidence?	The "Bad" question asks about two unrelated characteristics.
Was the presentation well organized?	Was the presentation well done?	The "Bad" question uses ambiguous language.
Did the speaker encourage audience participation?	Did the speaker appropriately encourage audience participation?	The "Bad" question utilizes a qualifier—the word "appropriately"—that may not be immediately obvious.

Rubric questions can be used in a discussion sequence as well. Continuing with the example above, the public-speaking instructor could begin the topic with a simple rating exercise. "Watch the following speech, and then we'll rate it for effectiveness on the following scale."

Initial Rating Scale

A. Very effective.
B. Effective.
C. Somewhat effective.
D. Not at all effective.

The instructor could introduce the rubric questions and discuss them one at a time. She could also ask the learners to rate the video on the rubric questions. She could end the discussion of the video by repeating the initial question (the one right above) and asking learners to respond again. Finally, she could lead a discussion about how the rubric questions helped her learners notice things they would not have otherwise noticed. "Okay, I see that you've rated the presentation a bit differently than the first time—your average rating has slipped from 'very effective' to 'effective.' How did the rubric questions affect your overall ratings of the video?"

One of the difficulties of rubric questions is that they can involve a large number of questions. I used seven questions in the example above. Fortunately, many audience-

response manufacturers have developed software that enables learners to answer questions one after another without instructor initiation on each question. So, for my example above, the instructor could play the video, present all the rubric questions on one slide, and start the software so that the learners could answer all seven questions at their own pace one after another.

Note that rubric questions can be presented to learners before they experience something in the classroom, or after, or both. In the example I used, the learners were given the questions in advance, so that they knew what to pay attention to. Another common method of using rubrics is to omit them the first time and then utilize them subsequently. When this is done, learners learn the benefits of using the rubric—because it enables them to notice what they otherwise wouldn't.

12. Questions to Debrief an In-Class Experience

Classrooms can also be used to provide learners with experiences in which they themselves participate. Learners can be asked to take part in role-plays, simulations, case studies, and other exercises. It's usually beneficial to debrief those exercises. For example, after studying a business case, learners might be asked questions to focus their analysis.

Question: How would you rate the performance of the marketing manager?

A. Good.
B. Fair.
C. Poor.

Question: What is the biggest opportunity facing the company?

A. Expanding into the European market.
B. Selling the quality-assurance business.
C. Investing in better manufacturing technology.
D. Penetrating more deeply into their current accounts.
E. Using advertising to update brand image.
F. Taking the company public.

As the instructor, you might first lead a full-group discussion on the reasons for people's answer choices—or you may ask learners to have those discussions in small groups. After such discussions, you might continue by asking the learners to make recommendations. "Okay, now that you've answered some initial questions and discussed your thinking, I want you to work with the other members of your team to come up with three recommendations for this company moving forward. Prepare a two-minute presentation to make to the class."

Third-graders who have just worked on a project to estimate measurements might be asked questions about their experience.

Question: Rate the quality of your team's estimate.

A. Good.
B. Fair.
C. Poor.

Question: How helpful was your partner in conducting your experiment?

A. Very Helpful.
B. Helpful.
C. Not Very Helpful.
D. Disruptive.

Question: How helpful were you in working with your partner?

A. Very Helpful.
B. Helpful.
C. Not Very Helpful.
D. Disruptive.

The instructor might then turn the discussion back to the learners. Okay, I want you and your partner to discuss how you might work together more effectively. Remember to keep doing the things you've been doing well, and change the things that aren't working.

Did you notice that the business case example asked the learners to focus on the business, while the third-grade example asked the learners to focus on their own processes? I could have switched this around, of course. The point is that questions like these can be used to focus learner attention in many different directions. In the next section, we'll describe how questions can similarly be used to focus on learners' affective responses.

Using Learners to Grade Each Other's Performances

You might consider having learners grade or score each other's performances—whether these are individual or team performances. Audience members are more likely to stay engaged in watching their classmates if they have a role to play in evaluating the in-class performances. Certainly, care should be taken in using such a grading method (to ensure fairness and avoid bad feelings). Audience scoring could represent a non-binding recommendation to the instructor who provided the final scoring or a percentage toward the final score (say 30% based on audience score and 70% based on the instructor's score). Special care is less important when the whole class is very cohesive, trusting, or comfortable with each other; or when peer evaluation is particularly relevant to the topic, for example, when speeches are designed to persuade one's fellow classmates.

13. Questions to Surface Affective Responses

Not all learning is focused on the cold, steely arithmetic of increasing the inventory of knowledge. Learners can also experience deep emotional responses, many of which are relevant to the learning itself.

In topics dealing with oppression, slavery, brutality, war, leadership, glory, and honor, learners aren't getting the full measure of learning unless they experience emotion in some way. Learners can be encouraged to explore their affective responses by simply asking them questions.

Question: After seeing the video on the experience of the Amistad slave ship, what emotion, if any, best describes your reaction?

A. Sadness.
B. Serenity.
C. Anger.
D. Joy.
E. Disgust.
F. Numbness.
G. No Significant Emotion.
H. I'm Not Sure Yet.

Note how the wording of the question above—as well as the answer choice H—gives the learners permission not to have an emotional experience. Just as we all mourn the loss of loved ones in our own way, we all respond to learning material in ways that are uniquely personal. If you don't give your learners permission to opt out, they may feel manipulated into a response. Such manipulation kills learning and attention. Even my four-year-old daughter demands that she be given freedom of thought. Don't fool yourself into thinking that your learners are any different. Whether they're third-graders or hardened chief executives, they want to feel that their learning is theirs.

Similarly, unless you have a very special population of learners, topics with little emotional content are unlikely to benefit from questions designed to surface emotions. For example, the following topics will not generally deserve such questions: simple math topics, the geology of rock formations, the dietary habits of ants, or the balance sheet.

Dealing with Difficult Material

Switching gears almost completely to another aspect of affective responding, note that it can also be helpful to query learners on their affective responses to difficult material. This can be beneficial with complex, confusing, or complicated topics.

Question: Okay, how's everyone feeling about this material?

A. I'm feeling GREAT.
B. I'm feeling GOOD.
C. I'm a LITTLE UNSURE of things.
D. I'm feeling NOT SO GOOD.
E. I'm FREAKING OUT.

Here's another option. Remember to use wording that will work for your learners.

Question: What state of mind are you in as we discuss this material?

A. I'm completely focused.
B. My focus fades in and out.
C. My focus is mostly elsewhere.
D. I'm completely tuned out.

These types of questions give us feedback as instructors on learners' response to their progress. It also offers learners a chance to have their progress and state of mind acknowledged. Even the mere act of asking such a question may enable some learners to refocus their attention back to the learning task and away from ruminations on their frustrations and worries. If your learners are using their limited working-memory capacity to worry, they're not using it to process your content.

Finally, there are times when it may be beneficial to gauge learners' level of boredom.

Question: How's this material going down?

A. Delicious. Like my favorite dessert.
B. Good. Like a wholesome entrée.
C. Nutritious. Like my least favorite vegetable.
D. Not so good. Like eating stale bread.
E. I'd rather eat sand.

Don't be afraid to ask such questions. It's not easy to get negative feedback, but your learners will appreciate your openness and you'll be able to improve your approach. Face it. If your learners are bored, they're not getting much benefit anyway.

14. Scenario-Based Decision-Making Questions

Scenario-based questions present learners with scenarios and then ask them to make a decision about what to do. These scenarios can take many forms. They can consist of short descriptive paragraphs or involved case studies. They can be presented in a text-only format or augmented with graphics or multimedia. They can put the learner in the protagonist's role ("What are you going to do?") or ask the learner to make a decision for someone else ("What should Dorothy do?"). The questions can be presented in a number of formats—as multiple-choice, true-false, check-all-that-apply, or open-ended queries. Although users of audience response systems overwhelmingly rely on multiple-choice and true-false formats, other formats are possible as well and sometimes have advantages. I'll discuss how to think about these different formats in a later section.

Here are some examples of scenario-based questions.

Question 1 – (To teach on the topic of instructional design, etc.)
Your instructional-design team wonders about the importance of giving feedback on questions delivered toward the end of a learning unit. Which of the following designs will enable learners to remember more key learning points on the job a week or two after the instruction?

A. Provide no feedback for each question.
B. Provide brief feedback for each question.
C. Provide extensive feedback for each question.

Question 2 – (To teach topics on journalism, free speech, etc.)
You're the executive editor of your school newspaper, and one of your reporters delivers a story alleging that another student group is encouraging hate speech. She says she has three people who independently told her about the club's activities. There is no physical evidence that she could find. The teacher-advisor to the other group also advises the school newspaper. What should you tell the reporter? Select all the choices that are appropriate.

A. "We can't run the story as it is."
B. "We'll run the story in the next edition."
C. "We'll have to check with our advisor."
D. "Are the three sources credible? Who are they?"
E. "You need to get physical evidence."

Question 3 – (To teach graphic design, art, visual literacy, etc.)
You're given the following PowerPoint slide design to critique by one of your best clients—a children's toy manufacturer, known for their whimsical toy ideas. What recommendation would you make?

A. "The design is perfect."
B. "The design needs minor improvement."
C. "The design needs significant improvement."
D. "The design is completely inappropriate."

Scenario-based questions provide several advantages. First, by providing an authentic scenario and asking learners to make a decision, learners are likely to be motivated to engage the material. Second, scenario-based learning forces learners to make sense of a situation—something they will be required to do in the real world. Many times, our learning interventions evaluate situations for learners, short-circuiting the learning. As instructional professionals, we often say, "Okay, when the meat is spoiled, it must be disposed of in the following manner." We often forget to give them authentic practice in determining when the meat is spoiled[25]. Third, scenario-based questions can support subsequent remembering if the cues in the scenario are aligned with those the learners will face in the real world. Research is very clear that when the stimuli at the time of remembering are the same as the stimuli during learning, more of the learned information will be retrieved from memory[26].

In two articles I wrote a few years ago[27], I used the term "simulation-like questions" to refer to scenario-based questions. I wanted to highlight the power of these questions to spur learning, while also noting that they are relatively easy and inexpensive to create, especially as compared with full-blown multimedia simulations. Specifically, I suggested then that simulation-like questions do the following:

A. Each question presents a brief realistic scenario.
B. Each question (including its alternative answer choices, correct answer, and feedback) highlights one or more key learning points.
C. Each question shows how the world works, or should work, by outlining a real-world cause-and-effect relationship.
D. Each question asks the learner to respond in a manner that shows he or she understands the key learning point.

It's not clear that all scenario-based questions need aspire to the simulation-like question methodology. Still, it may be worth aiming high as you design your questions.

Other Formats Besides Multiple Choice

Scenario-based questions need not use the multiple-choice format. It may be best to provide the question first without any answer choices and have learners write down or discuss what they would do. Remember, when we prompt our learners to recall information, we're asking them to invest more cognitive resources in retrieval than if we only ask them to select from among multiple alternatives. We're also, typically, prompting more authentic retrieval practice—practice that is much more likely to engender long-term remembering. Here is a scenario-based question that might be used in a sixth-grade class on the environment.

> **Question: Suppose you, and your investigative team, have done air-quality measurements every day for the past two weeks at two points—one 100 yards due east and one 100 yards due south from the local auto painting shop and every day you found levels of ethylbenzene, toluene, and butyl acetate all at levels 20% or more above recommended standards. What should you conclude?**
>
> The learners could be put into pairs or small groups and asked to discuss, or they could be asked to write down a few ideas on their own. After this short period of reflection, you could simply facilitate a discussion, or you could ask learners to respond to a set of multiple-choice answer choices.
>
> A. There is a source of air pollution somewhere near the auto-painting shop.
> B. The auto-paint shop is polluting the air.
> C. Our readings indicate a source of air pollution.
> D. Our measurement instruments are flawed.
> E. None of the above.

When we provide multiple-choice answer choices, we constrain thinking. Sometimes this can be beneficial, especially when our choices force learners to distinguish between concepts. On the other hand, constraining thinking can sometimes limit the learning benefits. This is especially true in diminishing creative linkages to other information in memory and in diminishing the authenticity of the retrieval situation.

One especially effective technique for scenario-based questions is the utilization of an initial "ready vs. not-ready" decision. For example, if you present your learners with a scenario, you can ask them to evaluate whether they have enough information to make a decision.

> **Question: You and your team have been working together for three weeks on a project in your biology class. The final report on the project is due tomorrow and the teacher has said that the deadline is final. Late papers will be docked 5% for every day of lateness. There are five members on your team. Four of you have seen and okayed the team's final report, pending some minor changes that you yourself have been chosen to add. The fifth person on your team has been admitted to the hospital for dehydration due to flu symptoms and has not had a chance to view the final report. He's an "A" student and his grades are important to him. You've talked to his mother, and she says that he still doesn't feel very well. Your team has to decide whether to turn the paper in tomorrow or wait for another day. Are you ready to make a decision? Answer Yes or No.**

The "ready vs. not-ready" technique has the benefit of prompting learners to take responsibility themselves for analyzing situations and determining whether they have enough information. If the learners decide they are ready, you as the instructor can then provide them with a question. If not, you can query the learners on why they don't feel they are ready to make a decision. For example, in the question above, it might be reasonable to ask the sick teammate (or ask his mother) whether it's okay if the paper is submitted on time. If you had provided this as a multiple-choice alternative, the learners might have recognized it as a good choice—but they wouldn't have had the opportunity to come up with the idea on their own (an advantage for learning), and they wouldn't have explored other options not presented as answer choices.

15. Don't Show Answer Right Away

There's no rule that you have to show learners the correct response right after they answer the question. Such a reflexive behaviorist scheme can subvert deeper learning. Instructors have had great success in withholding feedback. For example, Harvard professor Mazur's (1997) Peer Instruction method requires learners to make an individual decision and then try to convince a peer to believe the same decision—all before the instructor weighs in with the answer.

By withholding feedback, learners are encouraged to take some responsibility for their own beliefs and their own learning. Discussions with others further deepen the learning. Simply by withholding the answer, instructors can encourage strategic metacognitive processing, thereby sending learners the not-so-subtle message that it is they—the learners—who must take responsibility for learning.

Several methods of withholding the answer have been used. While some systems of questioning dictate one flow of interaction—for example, a question followed by discussion followed by the instructor revealing the answer—many instructors have come to utilize contingent responding.

One common practice is to show the learners the answer immediately if a plurality of learners selects the correct answer, only withholding the answer when there is a more even distribution of responses. This tactic is reasonable because there is usually no sense in wasting time by deliberating the obvious (but see the section later in this report on playing devil's advocate).

When there is a distribution across multiple answers, you as the instructor have several options. You can pair people off who have come up with different answers and have them try to convince each other. You can facilitate a whole-class discussion or put learners into small groups (3-5 people) and have them discuss further. You can drop out answer choices that have few supporters and focus only on the most popular choices. You can do this if the correct choice is one of the most popular or not. We'll talk in more detail about dropping answer choices in the next section.

16. Dropping Answer Choices

There are several reasons to drop answer choices after learners have initially responded to a question. You can drop incorrect answer choices to help focus further discussions on more plausible alternatives. You can drop an obviously correct choice to focus on more critical distinctions. You can drop an unpopular correct choice to prompt learners to question their assumptions and also to highlight the importance of examining unlikely options. Each of these methods will be discussed in turn.

Dropping Incorrect Choices

Dropping incorrect choices enables the discussion to focus on the most relevant answer choices and encourages the most productive mathemagenic cognitive processing in the minds of the learners. You can drop out a modestly popular incorrect answer or a very popular one. Dropping out a completely unpopular one produces little added benefit because the learners have already dropped it out. The one exception is when you've offered more than four or five answer choices on the first question round. Imagine offering 12 choices in the first answer round. In such a case, it would be beneficial to drop out all the incorrect answer choices to get the number of choices in the second round down to a cognitively manageable amount. Less than five or six is recommended.

Dropping a very popular incorrect answer choice can have powerful effects because it explodes the learners' mental model of the content in question. It forces learners to completely rethink their reasoning. This is a great opportunity for small-group discussion, perhaps augmented with a few choice hints from the instructor—but only when learners are clearly clueless and overly frustrated with being clueless.

You might recall the "rock-in-boat-in-pool" question from earlier. See below. The most popular choice is typically Choice C. What do you suppose would happen if we took away Choice C as depicted below?

> **Question: A boat with a heavy rock is floating in a swimming pool. If the rock is pushed out of the boat into the pool, what will happen to the water level in the pool?**
>
> A. Water level in pool will rise.
> B. Water level in pool will fall.
> ~~C. Water level in pool will stay the same.~~

For all those learners who chose that answer, it forces them to re-contemplate the question and the concepts—and go beyond their initial conceptions. In short, by dropping this highly popular answer choice, it prompts the learners to learn more deeply.

Dropping a moderately popular incorrect answer choice will act in a similar way for those who chose that choice, but it also offers the opportunity for instructors to pair students

who are in-the-know with those whose answer has been dropped. As always, it is important to remember that with multiple-choice questions there is a strong possibility that at least some who got the answer right are just guessing. This is especially true in cases like this one in which many learners chose the wrong answers. So, while pairing learners may be useful, if you want to increase the likelihood that at least one person in an after-question discussion understands the concept being discussed, small groups may be preferable. On the other hand, there are times when the intimacy of the pair format and the struggle to understand can have value as well.

Dropping the Most Obviously Correct Choice(s)

Sometimes it is helpful to offer an obvious answer in your answer choices but then drop it to make the other answer choices the focus of discussion. This may seem like a strange idea, but there are times when it is a necessity. For example, I have found that with experienced instructional-design professionals, the following question requires that I add the third choice.

Question: Which will create best memory retrieval two weeks later?

A. Listening to a 4-hour presentation, followed by 2 hours listening to a review of the material.

B. Listening to a 4-hour presentation, followed by 2 hours of answering questions about the material, where the learners get NO FEEDBACK—they just answer questions.

C. Listening to a 4-hour presentation, followed by 2 hours of answering questions about the material, where the learners GET FEEDBACK on each question.

To explain why this is critical, I'm going to have to explain the rationale behind the question. The learning point for the question is that retrieval practice—answering a question and retrieving information from memory (even if you don't get any feedback)—has powerful learning benefits. In fact, if learners are getting most answers correct, the benefits of such retrieval practice outweigh the absence of feedback. I describe this learning point in detail because the first two answer choices are diametrically opposed in this regard. Choice A sees feedback as critical. Choice B assumes the power of retrieval practice. Choice C assumes that both are vital. Therefore, Choice C, while it is obviously the best choice, isn't that interesting. However, I have found that if I don't provide it, many of my learners are so distracted by not being able to respond with this obviously superior answer that they won't engage the other choices. They miss out on the learning and I miss out on the glow I get from their attention.

It took me only a few times of using the question without the third choice to find out how disturbing it was to my learners. I can't emphasize enough how all of us need to look for opportunities to improve our questions as we see how our learners respond to them.

Here's how I use the question above. I present all three choices, and then put the learners in small groups to discuss and debate the choices. I then ask them to individually rank the three choices in terms of which one they think is best, second best, third best. Alternatively, I could have them select the best answer and then drop it out and ask them to choose between the remaining two. The ranking method seems a bit more efficient. After I've given them two or three minutes to discuss, I say, "Okay, there's something you don't know about me. I'm telepathic [I shut my eyes and roll my head as if I'm channeling information from the room]. Hmmm. I'm picking up your signals. It looks like most of you have selected Choice C as the best choice. Raise your hand[28] if Choice C was your top choice…[Invariably here, I am right]. Okay, most of us agree that Choice C is powerful because it provides everything—practice, feedback, everything. Now, what's more interesting is the choice between Choice A and Choice B. Let's take a vote…" Including Choice C enables me to keep my learners focused on the learning point of the moment.

Dropping an Unpopular Correct Choice

Every once in a while, it can be fun and educational to ask a question that most people get wrong, and then drop out the correct answer after the first vote. This tactic enables two things. First, it provides instructors with a chance to focus on other incorrect alternative and process them in a Socratic dialogue to show their inadequacies. Second, it enables you to remind learners of the importance of listening to all viewpoints, not just the most popular viewpoints. If you choose to drop out the correct answer and then encourage a discussion, you'll have to circle back to the correct answer later. By surprising learners with the tactic, you'll help them realize that the most popular choices may not always be best—and that we need to encourage and examine alternative viewpoints.

17. Helping Learners Transfer Knowledge to Novel Situations

"Transfer" is the idea that the learning that happens today ought to be relevant to other situations in the future. More specifically, transfer occurs when learners retrieve what they've learned in relevant future situations. As we've already discussed, the easiest and often the most potent way to promote transfer is to provide learners with practice in the same contexts—retrieving the same information—that they'll be required to retrieve in future situations. For example, learning benefits accrue when trainers anticipate learners' future on-the-job performance situations and educators anticipate learners' future learning and real-life performance situations.

This section is devoted to a different process—preparing learners to retrieve information in situations that are not, or cannot be, anticipated in designing the learning experience. Researchers call these "novel" situations, so let's use that term. So, for example, trainers teaching Microsoft Word cannot anticipate every type of task for which their learners will utilize Word. Neither mathematics professors nor fourth-grade teachers can anticipate all the uses to which their learners may put their math knowledge. Thus, this section is focused on how questions can support retrieval in future novel situations.

Take the following situation as an example. Suppose a science teacher wants to encourage her learners to generate multiple solutions to an unstructured problem before they decide on the best solution—rather than moving immediately to a solution[29]. In her current class, she gives them the following unstructured problem, and encourages them to utilize this "multiple-solution strategy".

> "*Please develop a manufacturing strategy that would reduce the number of plastics that have to be recycled. In doing this, remember that different plastics have different characteristics, so that utilizing only one or two plastics would not be feasible—because they won't meet all the needs for which they are currently employed.*"

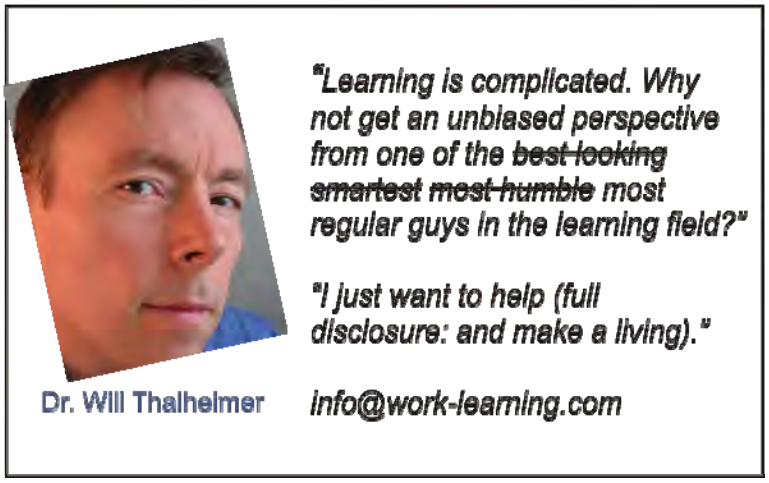
If this is the only problem that her students are given, it is extremely unlikely that they'll transfer what they've learned to future novel situations. In other words, engaging only a single instance is unlikely to help her learners spontaneously remember to use the "multiple-solution strategy" when faced with other problems. Fortunately, two questioning methods hold special promise for improving transfer to novel situations.

First, multiple questions—each with different background information—can be presented to the learners. For example, suppose you wanted to teach the same learning point as the example above—the multiple-solution strategy. To teach this, you could provide three unstructured problems and coach learners to develop multiple solutions. One problem could deal with a medical situation, another with a family dispute, and a third could deal with an argument two friends are having over how to cook a turkey using the least amount of energy. By providing multiple scenarios, you make it more likely that learners will remember to utilize the brainstorming technique in the future. In essence, using

multiple questions on the same learning point—each having a different background context—helps learners generalize their learning beyond narrow contexts.

Second, you could directly teach metacognitive strategies. For example, you could teach learners to develop multiple solutions to unstructured problems, but work directly toward a best solution for structured problems. You could then give them questions enabling them to practice identifying whether problems are structured and unstructured. The questions would prompt the learners to decide whether to generate multiple solutions or work toward one best solution.

To summarize, to maximize the likelihood that learners will retrieve and utilize what they've learned in future unrelated situations, two questioning strategies are particularly beneficial: (1) utilizing multiple varied questions and (2) providing questions that help learners practice metacognitive strategies relevant to that specific learning point.



18. Making the Learning Personal

By making the learning personal, we help learners actively engage the learning material. This also supports mathemagenic cognitive processing, making it more likely that learners will think about the learning outside of our classrooms, further reinforcing retention and utilization.

Many years ago, I taught educational psychology concepts to undergraduate education majors. One topic I covered related to different types of conditioning—classical conditioning (à la Pavlov's dogs) and operant condition (à la Skinner's pigeons). To most of my students, these topics seemed completely irrelevant to their future roles as teachers. I don't blame them for thinking that—and I think I probably did a poor job of showing them how they might be applied in the classroom. One thing I did, however, made an impression. I specifically tried to relate these conditioning concepts to their personal lives. Most of my students were young—in their early twenties—and highly concerned with dating and relationships. At the time, I didn't think to ask them questions, and instead just used the following topic as an example in my lecture. Making the learning personal improved my learning results, but I'll bet that I might have done even better had I asked them a question like the following:

> **Question: Suppose Randy and Sally have been dating regularly for three months. Randy wants to continue making Sally feel positive vibes when they are together. Which of the following might work as a classical conditioning technique to help him achieve his goal?**
>
> 1. Praise Sally whenever she tells a story about herself.
> 2. Look away when Sally stops talking about their relationship.
> 3. Look deeply into Sally's eyes when she's talking.
> 4. Cook Sally dinners consisting of delicious foods.

Note that Choice 4 is an archetypical example of classical conditioning, whereas Choice 3 might be seen as such if it is assumed that eye contact is a pleasurable unconditioned response. Choices 1 and 2 are more aligned with operant conditioning.

This question has appeal for many reasons. First, it can be used to generate a good discussion regarding the correctness of the various answer choices. Second, it can generate a discussion that teases apart the difference between unconditioned and conditioned responses (for example, related to the eye-contact issue). Third, it can prompt a further discussion about how classical conditioning might be applied directly to their real-world futures as classroom teachers. Fourth, it can generate elaborated knowledge structures that later may remind learners of what they learned in class. When our learners in their outside-of-class realities are reminded of what we taught them inside the classroom, the learning point they consider receives the powerful extra advantage of a spaced retrieval repetition.

19. Making the Material Important

Sometimes we can't make the material directly personal or provide realistic decisions for learners to make, but we can still use questions to show the importance of the topic being discussed. For example, the question below isn't a decision-making question, nor is it intimately personal, but it does highlight the relevance of learning material related to global warming.

> **Question: If the oceans continue to rise at an average rate of 3 millimeters per year as Wikipedia says they are now, which of the following is most accurate[30]:**
>
> 1. If we live to be eighty-five years old, the sea will rise about 25 inches in our lifetimes.
>
> 2. 100 acres of New York City will be underwater within about 1200 years.
>
> 3. 10 million people worldwide will be displaced by rising oceans within the next 200 years.

Even if the learners don't understand the science of rising sea levels, this question can make the topic seem quite important and relevant.

20. Helping Learners Question Their Assumptions

One of our goals in teaching is to get learners to change their thinking. Sometimes this requires learners to directly confront their assumptions.

Consider the following set of questions[31] famously used to help learners think through ethical decision-making.

> **Question 1: A trolley is running out of control down a track. In its path are five people who have been tied to the track by a mad philosopher. Fortunately, you can flip a switch that will lead the trolley down a different track to safety. Unfortunately, there is a single person tied to that track. Should you flip the switch?**

Typically, most people say "yes," it is appropriate to flip the switch, because although one person will die, five will be saved.

> **Question 2: As before, a trolley is hurtling down a track towards five people. You are on a bridge under which it will pass, and you can stop it by dropping a heavy weight in front of it. As it happens, there is a very fat man next to you—your only way to stop the trolley is to push him over the bridge and onto the track, killing him to save five. Should you proceed?**

Typically, most people say "no," it is not appropriate to push the fat man onto the track, killing him to save the five others.

As you can imagine, these questions create a great discussion. They also push learners to tease apart their reasoning and confront their assumptions.

21. Using the Devil's Advocate Tactic

The devil's advocate tactic can be used in a number of different ways. You can play the devil's advocate yourself, or utilize your learners in that role. The term "devil's advocate" was originally used starting in 1587 by the Catholic Church to ensure that those being considered for canonization to sainthood were really worthy of that esteemed position. The so-called "devil's advocate" was a canon lawyer whose advocacy balanced the evidence of miracles put forth by the "God's Advocate". In a classroom, when we play the devil's advocate, we argue ostensibly to find flaws in the positions put forth.

From a learning standpoint, when someone plays the devil's advocate, learners are prompted to more fully process the learning material. In a way similar to the Socratic Method, the intention is to get learners to fully examine their assumptions. This kind of critical examination has several learning benefits. It provides the benefits of repetition. It prompts elaborative processing, strengthening and enriching relevant knowledge structures. It helps prepare learners to argue their positions. It buffers their knowledge structures against attacks from further antagonistic information, including misconceptions and persuasive messages.

When learners overwhelmingly select some choices and not others, you as the instructor can play devil's advocate in support of the unpopular choices—even if those choices are wrong. This will not only keep learners on their toes, but can support deeper learning by encouraging learners to consider alternative perspectives.

I have used this technique to good effect in teaching managers about leadership. Take the following question, for example:

> **Question: You're a senior marketing manager for the Remodo Company. Your boss, the CEO, has asked you to coordinate a company-wide effort to break into the European market. After doing lots of research and spending several weeks reflecting on the best way to move forward, you've developed an extensive yet preliminary plan for how to proceed in entering the new market. What's the best next step?**
>
> A. Present your preliminary plan to the CEO.
> B. Develop a full plan on your own before proceeding.
> C. Work with your department to develop a full plan.

The question above is a great question, partly because all three answer choices are viable and have significant strengths and weaknesses. See the table below for an analysis of the question.

	What's Good	What's Bad
Choice A. **Present Preliminary Plan to CEO.**	It's always important to get support from more-senior managers for any significant efforts.	The preliminary plan may set boundaries for what is acceptable—boundaries that your team may not support or find motivating
Choice B. **Develop Full Plan Yourself.**	It's helpful to think through issues fully before presenting them to important stakeholders	Without getting input from others, your plan may include weaknesses or recommendations that will be unpalatable to others.
Choice C. **Work With Your Team to Develop Full Plan.**	Bringing team members into the process facilitates getting their commitment to implement the plan that is developed.	Your team and you may waste a lot of time and energy developing a plan that will not receive senior-management support.

Having strengths and weaknesses enables beneficial devil's advocacy. For example, what often happens in a class on leadership is that learners quickly understand that one of the central themes is that good managers bring their teams into the decision-making process to get their good ideas, their buy-in, and their enthusiasm for implementing any decisions that are made. Thus, given this question later in the learning, they often discount Choices A and B and gravitate to Choice C. This becomes a perfect opportunity to play devil's advocate. "Okay, so most of you have chosen C. Why?" [Learners respond with their reasoning.] "Hmmm. Well, that seems to make sense, but let me make sure I understand. You get together with your team. You spend days or weeks coming up with a plan. Your team gets really excited about the plan. You've never seen them so alive, so focused. They've really put their blood, sweat, and tears into the effort. You develop a brilliant plan. You and your team proudly present it to the CEO. [Pause] She shakes her head and says, 'No, this is good work, but it's not what we need to do.' [Pause] You and your team are devastated. Your team first reacts with sadness and frustration. Later they take their anger out on you. In fact, you're never able to get their energy and enthusiasm again. [Pause] Okay, everybody, what do you think now?"

The learning discussion is not about the correctness of the answers. In fact, the best way to end the facilitation of this question is to say something like, “Okay, this scenario sets up some false dichotomies. Let’s forget the question’s answer choices for a moment. In the real world of your workplace, what do you need to do to push an initiative forward?” The learners usually end up concluding that managers have to delicately, slowly, iteratively get input from all stakeholders; build momentum iteratively and informally; and only present a formal plan after knowing that it is likely to be acceptable to all of the stakeholders—or at least most of the critical stakeholders.

Playing devil’s advocate in this way can have powerful effects, but it is obviously something that will require planning and practice on your part.

Learners as Advocates

You won’t always want to play the role of the devil in your classroom. SMILE. Another way to get the same sort of interaction after voting is to ask learners to publicly advocate for the different answer choices. You can do this in a full-class discussion, in small groups, or by dividing learners into pairs. It can be especially illuminating to solicit advocates for the unpopular answer choices. Often—especially with more experienced learners—you’ll be able to surface boundary conditions or wisdom you hadn’t considered. Alternatively, you’ll be able to collect and understand misconceptions and provide brief remediation so that learners aren’t lost in a later learning interaction.

22. Data Slicing

Data slicing is the process of using one factor to help make sense of a second factor. Data slicing is particularly powerful in the classroom for demonstrating how audience characteristics may play a part in their own perceptions or judgments. Dr. Steve Huff told me the following story about how data slicing was used with a group of courtroom judges who were wrangling with the difficult job of determining how to certify an expert witness.

The group consisted of experienced judges from Colorado. The topic was how to certify a witness as an expert witness in your courtroom. Rather than providing boring PowerPoint slides with information that the audience already knew, the facilitator invited a professional dowser onto the stage. A dowser is a person who helps find water underground with a rod or stick. The facilitator interviewed the dowser in front of the audience of lawyers in the same way he would be interviewed in the courtroom. The dowser described his qualifications, presented evidence of his effectiveness, and cited research on dowsing. The facilitator turned to the audience and asked them the following question (paraphrased):

Question: Would you certify this person as an expert witness in your courtroom?

A. Yes.
B. No.

The audience voted with about 50% saying "Yes," and 50% saying "No." The facilitator then asked them a follow-up question.

Question: Which of the following is true?

A. I said YES, and I'm from an URBAN area.
B. I said YES, and I'm from a RURAL area. **
C. I said NO, and I'm from an URBAN area. **
D. I said NO, and I'm from a RURAL area.

The starred responses (**) were the most popular choices by a significant margin. The judges from rural areas voted in large proportions to certify the dowser as an expert witness, whereas the judges from urban areas voted in large proportions not to certify the dowser. The audience was stunned by this revelation because it demonstrated how decisions to certify expert witnesses depend not only on cool legal reasoning, but also on our previous experiences and biases. The facilitator brilliantly used this introduction to encourage further learning activities. Not only did he energize the learning, but he also provided a clear demonstration of how the subsequent discussion would be personally relevant to the judges. They'd already seen how their own judgment could be swayed. They were about to be offered a way to improve their decision-making.

The method used above can be referred to as "Manual Data Slicing." By asking four questions along two dimensions, the question itself sliced the data into subgroups.

With the advent of sophisticated software applications available with some audience response systems, data slicing can be done automatically. For example, at the beginning of a session, an instructor could ask some background questions.

Question: Are you from an urban, suburban, or rural area?
Question: What age group are you in?
Question: Are you male or female?
Question: What experience level do you have?
Question: What religion do you practice?
Question: Are you from a cultural majority or minority?
Question: What hair color do you have?

Later, as questions are asked, these discrete variables can be used to slice the data. For example, Steve Huff used the following question in facilitating a group of social workers:

Question: To what degree do you think your agency uses culturally-appropriate practices in evaluating patients during the intake process? For example, in evaluating patients for depression, are your diagnostic procedures culturally appropriate for people of different cultural backgrounds, including people like Native Americans, White Americans, Black Americans, Latinos, etc.?

A. Awful.
B. Okay.
C. Good.
D. Excellent.

The initial results showed that most thought their agency was doing pretty well. He then sliced this data based on the responses to another question.

Question: Are you from a cultural majority (for example, Caucasian) or minority (for example, Native American)?

A. Cultural Majority.
B. Cultural Minority.

The data slicing result showed that members of the cultural majority rated the agency highly in dealing with cultural minorities, while members of the cultural minority thought the agency did a poor job in this regard. A great discussion ensued about what constitutes culturally appropriate practices—a discussion that would not have been as valuable if the learners hadn't been enlightened by their own data-sliced responses.

Data slicing using audience background information has applications in educational environments as well. For example, a social-studies teacher could examine how her students' religious backgrounds affect their view of the U.S. involvement in the Iraq War, birth control, female political candidates, or any number of things. A professor of clinical psychology could look at the effects of birth order, cultural upbringing, or gender. A biology professor could look at how one's experience spending time in nature affects how people view the case for global warming. A drama teacher could examine how people's socioeconomic status affects how they feel about Shakespeare.

The opportunities are endless, yet often we fail to utilize them because we don't truly acknowledge how much our learners' previous experiences affect how they will respond to the learning environments we create. To prod ourselves in this direction, we need to embrace the reality that our learners' backgrounds affect their perceptions and views, which subsequently influence the experience they have in learning.

Data slicing need not be done only with background information as the slicing tool. It can also be done using our learners' stated beliefs, values, and perceptions.

For example, a history teacher might ask the following questions.

Slicing Question 1: How would you best describe your views about books?

A. Information found in books is generally true.
B. Information in books is more false than we may think.

Slicing Question 2: How would you best describe your views about the history you've learned in school?

A. More than 95% of what I've been taught is true.
B. At least 10% of what I've been taught is false.

Question: Which of the following statements is the most true concerning the effects of the wave of European Colonists who came to North America in the 1600s and 1700s?

A. The lives of the Native Americans of the time were generally improved by the arrival of the colonists.

B. The lives of the Native Americans of the time were not much affected by the arrival of the colonists.

C. The lives of the Native Americans of the time were largely devastated by the arrival of the colonists.

Data slicing based on learner perceptions not only engages learners in the material, but it also can highlight underlying assumptions and sets of beliefs for deeper exploration and learning.

23. Using Questions for In-class Experiments.

For some topics, in-class experimentation is very beneficial. It helps learners relate to the topic personally. It also highlights how scientific data is derived.

For example, in a course on learning, psychology, or thinking, learners could be asked to remember words, while also unknowingly being primed to think about certain semantic associates and not others. The following description of an in-class experiment describes how this might be done. Warning: You're going to have to pay attention to fully appreciate this.

> Instructor creates two sheets of paper, labels them differently, shuffles them before coming to class, and then hands them out to his or her class.
>
> **Sheet 1** (Labeled "10 Words to Remember") includes the following words:
>
> *couple, bench, two, rock, double, monkey, lovers, grass, poker, dream*
>
> **Sheet 2** (Labeled "10 Words to Remember Today") includes the following words:
>
> *fruit, bench, apple, rock, sweet, monkey, juicy, grass, ripe, dream*
>
> The difference in the lists is that the first, third, fifth, seventh, and ninth words relate semantically to different homonyms (that is, words that sound alike but are spelled differently). The Sheet 1 words relate to the word "pair." The Sheet 2 words relate to the word "pear."
>
> After the sheets are handed out, the instructor tells the learners to try to memorize the words. After a few minutes, the instructor says that there will be a distracter task before the words will have to be recalled—to ensure that the words are removed from short-term memory. The distracter task will require the learners to write down words the instructor vocalizes rather quickly. The instructor then vocalizes ten words very quickly.
>
> *book, clock, justice, pare, joint, yellow, flour, photograph, jean*
>
> The instructor then uses the audience response system to ask the following questions:
>
> **Question: What was the heading on your sheet?**
>
> A. 10 Words to Remember.
> B. 10 Words to Remember Today.

Question: On the answers you wrote down, how did you spell the following word?

A. pair.
B. pear.
C. pare.
D. Oops. I missed this one.

Question: On the answers you wrote down, how did you spell the following word?

A. flower.
B. flour.
C. Oops. I missed this one.

Question: On the answers you wrote down, how did you spell the following word?

A. jean.
B. gene.
C. Oops. I missed this one.

The instructor could then admit the deception, lead the class in an examination of the experimental results by comparing the Sheet 1 group versus the Sheet 2 group, and talk about the semantic priming effect that might have occurred. For example, past research would suggest that the learners who received Sheet 1 (having the priming words *"couple, two, double, lovers, poker"*) are more likely to have written the word "pair," and those getting Sheet 2 (having the priming words *"fruit, apple, sweet, juicy, ripe"*) are more likely to have written the word, "pear." These results could be compared to the homonyms that were not primed with semantic associates (flower vs. flour and jean vs. gene). Even if the results did not conform to expectations, the instructor could explain the rationale and ask the learners why they think the experiment failed to find the predicted results.

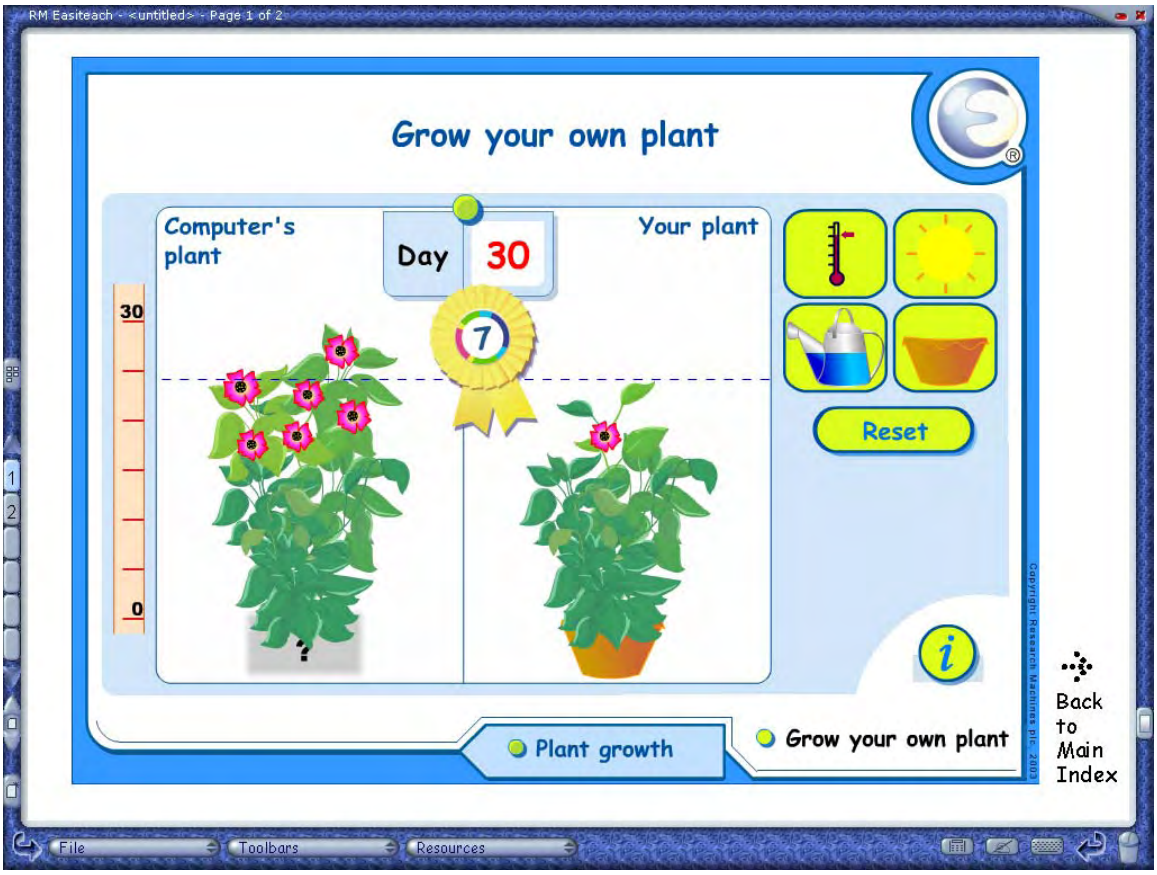
As you can imagine, these sorts of in-class experiments can open myriad opportunities for learning and exploration. Turning back to the example, the instructor need not end the discussion by talking about the learning content (the semantic priming effect); the instructor could broaden the discussion to discuss research methodology, ways of knowing, the philosophy of science, and/or applications of the scientific method to our everyday lives. By providing these special moments, you as the instructor open up parallel universes of insights and possibilities for your learners. Is teaching not a great profession?

24. Prompting Learners to Make Predictions

In the earlier section on using prequestions to surface misconceptions, we touched briefly on the benefits that accrue when we prompt learners to make predictions. When learners predict the results of a counterintuitive situation, it prepares them to attend to the most relevant information and understand the concepts uncovered in the prequestion.

Prediction-making can facilitate learning in other ways as well. It can be used to provide retrieval practice for well-learned information. It can be used to deepen learners' understandings of boundary conditions, contingencies, and other complications. It can be used to engender wonder. It can be used to enable learners to check their own understanding of the concepts being learned.

Take the following simulation as an example (created using RM Easiteach www.rmeducation.com/).



This screen shows the results of a simulation that can be run on a computer and displayed through a projector. Note how the learners' plant is not as healthy and robust as the computer's plant. The simulation asks the learners to modify different variables and then

see what happens. For example, learners can change the amount of water, sun, and the temperature and see what effect that has on their plant.

This can play out in the classroom in many ways. Learners can be asked, either individually or in small groups, to make a suggestion for what variables to change to maximize the height of the plant. The instructor could ask for volunteers and then hold a vote using the handsets on several of those choices. After the vote settles on the variables that will be in play, the instructor can ask the learners to make a prediction about what will happen.

Question: What will happen to our plant?

A. Maximum height.
B. Medium height.
C. Low height.
D. Death.

This is an excellent opportunity to utilize small-group or paired discussions before the vote to encourage multiple perspectives and in-depth conceptualization. Moreover, after the vote, but before the simulation is allowed to run and show its results, it's also a great opportunity for an instructor-led discussion asking the whole class why they predicted what they did, focusing now on causal reasoning.

Predictions can be made for out-of-class events as well, including elections, political votes, weather, sporting events, cultural events, and natural occurrences.

Question: Who will win the election, and why?
Question: How many Senators will vote for the bill on tort reform?
Question: What will the average temperature in April be this year?
Question: Who is going to win the Super Bowl?
Question: What day will the ice break in the river?
Question: Which of these movies will be nominated for an award?
Question: What color will the maple tree's leaves turn in October?
Question: How many snow days will we have this year?
Question: Who will be the fairest of them all?

25. Utilizing Student Questions and Comments

Our learners often ask the best questions. Sometimes a learner's question hints at the outlines of his or her confusion—and the confusion of many others as well. Sometimes learners want to know about boundary conditions. Students can also offer statements that can improve the learning environment. They may share their comfort level with the topic, add their thoughts in a class discussion, or argue a point because they disagree. All of these interactions provide opportunities for a richer learning environment.

Many times our learners will bring new insights into our classrooms by way of their questions. As our sessions unfold, our learners are constantly processing new information and relating that information to what they already know. With 90 learners, we have 90 parallel processors in our classroom, each creating new insights in their separate working memories. When one learner asks a question regarding his or her insight, everyone can benefit.

> *"So, we've been talking about allergic reactions and their causes in this class. In my psychology class, we're learning about Pavlov's dogs and classical conditioning. That's where if you pair a not-yet-conditioned stimulus (like a bell) with an unconditioned stimulus (like some raw meat) that the organism can be made to respond to the bell just like it would respond to the red meat (for example, by salivating). Could allergies work in the same way? Suppose someone eats some peanuts with some fungal toxin and has an allergic reaction to the toxin. Could this create an allergic reaction to peanuts without toxin? And if this mechanism really works, could allergic reactions be extinguished through desensitization training, just like people with phobias are desensitized to their fear of snakes, heights, whatever?"*

Such questions can be viewed as a derailment of the flow of material to be covered. They can also be seen as an opportunity for deep and meaningful learning. For the example above, the instructor could answer the question, of course. He could defer the question until later—after having time to think about it. "Hmmm. That's seems really insightful. I honestly don't know much about classical conditioning. Let me learn a little more and we'll talk about that in our next session." The instructor could also encourage the perceptive student to lead a class discussion on the idea. The instructor could invite the psychology professor to introduce the topic of classical conditioning to his class, either in person, through an online audio-narrated PowerPoint presentation, or through a suggested reading.

Questions from learners can be compiled by instructors for use in later classes. Questions about confusions can be used to guide subsequent lesson-plan improvements as well. Learners can simply be asked to write questions on index cards, scraps of paper, or whatever, and hand in their responses. Alternatively, if your handsets enable text-messaging-like input (most currently don't), learner questions can be gathered electronically. Capturing the questions digitally enables further distribution to learners, instructors, or assistants without the slow, painful process of transcription. On the other hand, text messaging can be cumbersome for some audiences and difficult to implement with some technologies.

Sometimes, a question or statement from the audience is perfect for use as an ad-hoc question. This is especially true when the audience members are experienced professionals or the topic relates to actions and behaviors in which the audience members are likely to engage. For example, in a class on American government, a learner might say, "Well, I don't care what the public-opinion polls say. Most people I know think the war is wrong." The instructor could quickly develop a question.

Question: Which do you most agree with, in terms of America's presence in the war?

A. The war was always wrong.
B. The war is wrong now.
C. The war confuses me.
D. The war is correct now.
E. The war was always correct.

Another question might follow.

Question: Why do our views differ from the polls?

A. The polls are wrong.
B. We are not normal.
C. The polls measure something else.
D. We're lying.
E. Poll respondents were lying.

In a different venue—say a conference session filled with instructional-design professionals—an audience member might ask the speaker, "What do you see as the future of m-learning (learning through a cell phone, PDA, or other handheld device)? Is it a fad or will it have a long-term impact?" I've been asked many questions like this, and unfortunately, I often instinctually respond by attempting to answer the question. Responding to questions is often appropriate, especially if the audience wants to know what the "expert" speaker has to say. However, many times getting the whole audience involved is beneficial. For example, instead of answering the question immediately, I might say something like this, "Well, I have some strong feelings about that, but before I give you my assessment, I'd be curious to know what you, the audience, thinks. Most of

you are experienced professionals who, like me, have been in the field long enough to see new learning technologies like m-learning. Okay, so here's the question for you."

Question: In 10 years, how many of our learners or learning interventions will utilize m-learning techniques?

A. Rarely used.
B. Sometimes used.
C. Routinely used.
D. Almost always used.

Interestingly, as I wrote this question for this paper, it took me about ten minutes to wordsmith the question into a form that worked. This highlights the challenge of creating questions on the fly. It can be very difficult in a short timeframe to develop good questions, especially under the impatient gaze of 200 learners. As Quintin Cutts, who has used audience response systems at the University of Glasgow, has recently written about ad-hoc questions, *"I have not found this method to work well in general. It is hard to come up with a good explanation for the wrong answers because there usually is not the time to determine the thought process underlying them."*

If you intend on using ad-hoc questions like these, you ought to practice beforehand. Imagine a question that might come from your audience, and then give yourself 60 seconds to write your version of that question using your audience response system. Practice may not create perfect ad-hoc questions, but they'll be better than you can do without the practice. One of the key things to figure out as you practice is what types of questions (in your domain) are amenable to on-the-fly question development and which types are not. In general, it is probably safer to use ad-hoc questions related to learner opinions, predictions, or personal background rather than questions related to fundamental concepts or misconceptions.

Going back to the example, I might follow up with my audience by saying, "Okay, so it looks like we've got a diversity of opinion on this one. For those of you who said that it would be rarely used, tell me why you think that. Anybody, just raise your hand…etc…[And after this discussion] All right, here's what I think…"

Encouraging Learners to Create Handset Questions

Another way to utilize learner input is to assign them the task of developing handset questions—questions that might be used with their fellow learners through the audience response system. Since developing good questions requires extensive subject-matter knowledge, assigning this task is particularly effective when learners are experienced with the material. Developing questions requires extensive knowledge of the topic. The task of developing a question has great value from a learning standpoint because it forces learners to deeply consider many aspects of the concepts targeted by the question. Learners have to consider how the content is understood by others. They have to think about boundary conditions, interactions, and misunderstandings.

Because of the difficulty of creating questions, you might want to assign the task as homework or as a group project. To add some extra motivation, you might utilize the best three questions in a future class, maybe even grading the answers. Finally, it might be best to seed your learners with different learning points they may choose in developing their questions. This will give them some guidance so they don't go too far astray. So, for example, the following learning points could be used as the basis for developing a question.

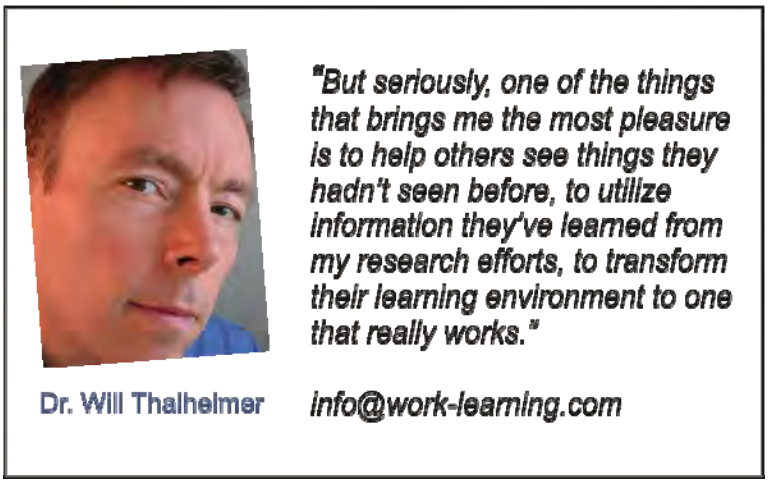
Question: Develop a question that covers one of the following learning objectives. (Note: I'm mixing domains here, but you won't.)

1. In a frictionless environment, the spin of a spinning sphere is irrelevant in the force it exerts in collisions.

2. As the price of a commodity product rises, demand for that product falls.

3. Adding interesting graphics to standard text can hurt learning.

4. Having a conversation utilizes the same brain areas as driving a car, making simultaneous talking and driving dangerous.



26. Enabling Readiness When Learners are Aloof or Distracted

Let's face it. Not all of our learners will come into our classrooms ready to learn. Some will be dealing with personal problems. Some will be attending because they have to—not because they want to. Some will be distracted with other stress-inducing responsibilities. Some will think the topic is boring, silly, or irrelevant to them. Egad! What can an instructor do but plough forward?

Fortunately, experienced instructors have discovered tricks that often are successful. One thing that works for some audiences is to acknowledge publicly that people come to the classroom with different levels of readiness and enthusiasm. If you know that you might have a difficult audience, you could try the following:

> **Question: We all come into the classroom with different levels of enthusiasm, different expectations, different distraction levels, personal problems, interest in the material, more or less coffee, etc. Let me get the session today started by asking everyone to check in. How are you feeling? How ready are you to learn?**
>
> A. I'm intoxicated with a love to learn.
> B. I'm ready to go.
> C. I'm sitting on the fence. Thrill me.
> D. My mind is somewhere else today.
> E. I don't really want to be here.
> F. I'm a caged animal. I was forced to be here.
> G. Please don't ask me about emotions again.

The follow-up to this kind of question is crucial. You'll need to say something like this, "Okay, I see we've got a good mix of reactions. For those of you who are ready or more or less ready to go, I'm going to do my best to give you something of value. For those of you who aren't so ready, give yourself permission to move in and out of focus. Some days, we just don't have it. But don't give up before you begin. Keep a little bit of your brain open for an unexpected curiosity, for a blink of insight, or simply for the benefit of sharing some special insight you might have with your fellow learners.

27. Enabling Readiness When Learners Think They Know it All

Some learners will come to your classroom thinking they already know everything they need to know about the topic you're going to discuss. There are two types of learners who feel this way—those who are delusional (they actually need the learning) and those who are quite clearheaded (they already know what they need to know). Don't delude yourself into thinking that everyone can benefit from your learning sessions. Oh, please!

So what can you do to bring both groups into the mindset of learning? For the "they-don't-know-they-need-to-learn" group, you can use prequestions to snap them out of their delirium. Prove to them that they don't know as much as they think by asking them some tough questions as you introduce the topic. These questions shouldn't be hard in a tricky sort of way. They should be difficult, fair, and important. They should directly relate to the key learning points you're going to try to get across.

Now the fun part. What can you possibly say to the know-it-alls who grace your classroom? Here's a question you can use to begin to bring them into the fold.

Question: What level of background do you have for the topic we're going to be talking about today?

A. I know the topic so well I could teach it.
B. I know the material well, but I'm eager to learn more.
C. I know the material well, but I'm open to learn more.
D. I know a modest amount.
E. I know a little.
F. I'm a blank slate.
G. I'm confused; I thought this was the Donald Trump seminar.

First, note the humor in Choice G. Humor here is critical because asking people how smart they are can make them uneasy. The humor will keep your learners comfortable. You'll know better than me what's funny to your learners, but other funny lines might be:

- I'm confused; I thought this was the Star Trek convention.
- I'm confused; I thought this was detention.
- I'm confused; I thought this was choir practice.
- I'm confused; I thought this was my AA meeting.
- I'm confused; I thought this was the model railroad club.
- I'm confused; I came here to meet Oprah.

Now to the serious stuff. First, you must realize that asking the question above provides only half the solution to your know-it-alls problem. You must also follow it up with an invitation of welcome to your know-it-alls, some hints at proper behavior, and appropriate role-modeling of openness to learning.

> *"Excellent. I see that some of you know a lot about this topic. That's awesome. Your job then is to help support the rest of us in our learning. Now don't be know-it-alls—everybody hates a know-it-all—but instead provide some thoughtful commentary when it's particularly needed. Share practical insights. Let us know what the boundary conditions might be. Let us know how you struggled when you were learning this topic; help us overcome the same obstacles you faced. I'm an expert in this topic, but one thing I've learned along the way is that I'm occasionally surprised with new insights. Those of you who know a lot about this topic should give yourself permission to think fresh about the topic, or relate it in your mind to a recent problem you've been working on, or just run with the idea in a fit of wild cacophonous creativity.*

Obviously, you'll have to tailor such a speech to your audience, topic, and your way of interacting with an audience. You certainly don't want to memorize such a vocalization, but it might not hurt you to practice the two or three things you want to get across.

Note that it may be best to combine the two strategies discussed in this section. Before you ask your learners how much they know about the topic, ask them a few prequestions so that they'll be better able to calibrate their self-assessment. You might even find it amusing to data-slice your content questions based on your learners' stated level of knowledge—to see if the know-it-alls really do know more than the more humble.

28. Enabling Readiness When Learners are Hostile

In almost every instructor's life, there will come a day when one, two, or multiple learners are publicly hostile. Experienced instructors know that such hostility must be dealt with immediately—not ignored. Even a few bad apples can ruin the learning experience and the satisfaction of the whole classroom.

If a majority of your class is hostile, it is usually best to acknowledge the hostility and try to learn where it comes from. As a young inexperienced leadership trainer, I was leading a three-day management workshop for managers at a large telecommunications company. The first day didn't go so well, but I didn't really acknowledge that reality—either to the participants or to myself. The second day sent a tidal wave across my sheltered island.

The training director pulled me aside during a break and told me the class was not going well, that the participants didn't think they were learning anything of value, and that he was considering cancelling the class but wanted to get the participants' views. He wanted to have a private discussion with the class without me present. I suggested that I ought to hear the complaints if the class decided they wanted me to continue—so that I could make the appropriate fixes.

For 45 minutes, the training director and I sat at the front of the classroom and listened to one scathing complaint after another. I was then sent out into the hall—like a bad child—so that the class could decide whether to continue the course or cancel it. I roamed the hall dejectedly, ruminating on my failings. Remarkably, the class decided to move forward with my pledge to change things up. I called my boss to ask for advice. I stayed up all night making changes. The third day went pretty well and I was thanked for listening and persevering, even though they still thought the class as a whole stunk.

As I am sure you can imagine, it was a powerful learning experience for me. I tell it here because I know that if I hadn't been in the room to hear their complaints, to acknowledge them, and to promise to make changes; that they would have decided to boot me out on my butt. Even the most hostile audiences can be turned around, if we as instructors are willing to bear the pain of their criticism.

Audience response systems cannot turn a hostile audience into a loving one—or even into a mildly receptive one. That's your job. What audience response systems can do is help you gather information to ensure you're getting good feedback. So. for example, suppose someone says, "Hey, Dr. Thalheimer, I just don't believe those three research examples you showed. And, since you based your recommendations on that research, I'm just too skeptical to take those recommendations to heart." If I get this bit of feedback from my audience, I won't be able to tell with any precision how many people feel the same way without asking for more input. One or two voices can be indicative of many, but not always. In hostile mob-like situations, the majority can become silent. This, then, is a perfect opportunity for an ad-hoc question.

Question: Okay, how many of you feel the same way? I want to make sure I've got an accurate reading of your true feelings. So, here's the question, How many of you trust the three research examples I cited?

1. Trust completely.
2. Trust mostly.
3. Don't really trust.
4. Absolutely don't trust.

Again, the follow-up is critical. "Okay, I see that 30% of you lean toward not trusting the research, while 70% lean toward trusting the research. So, let me explain to you why I trust the research. We'll then discuss it further and take another vote. Okay, here goes…"

An audience response system could also be used in such a situation to let learners vote about whether or not to continue, to decide which direction to take, or to determine which learning method to utilize. You'd have to be sure that the votes couldn't be traced to particular learners. The goal in this type of situation is confidentiality, of course, so that even the most timid learner has an equal voice in the process.

If you think about it, the above fictional example could connote failure on my part as an instructor. It certainly is a failure in the way I am perceived by my learners if I am experiencing massive hostility. On the other hand, the discussion is pure high-level learning. Shouldn't our learners be encouraged to make up their own minds, to disagree, to debate? Shouldn't we create an environment for honest interchange? I think so. In fact, if we give ourselves permission to screw things up, to make mistakes as instructors, we're much more likely to allow ourselves to create this kind of wondrous learning environment.

The discussion above assumed a massive revolt in the classroom. More often than not, only one or two people will express hostility or disagreement. This is an excellent time to use the confidential audience response methodology to get feedback on the overall satisfaction. When bad apples see that they are in a small minority, they'll often keep their comments to themselves, tone down their hostility to a more manageable level, or transform their hostility into a productive dialogue.

29. Using Questions with Images

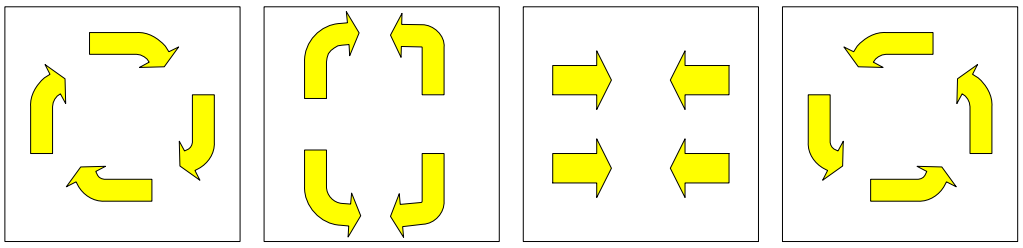
Using images as part of the learning process is critical in many domains. Obvious examples are art appreciation, architecture, geology, computer programming, and film. But even for the least likely topics, such as poetry or literature, there may be opportunities. For example, a poetry teacher may want to display poems to ask learners about the physical layout of poems. A professor teaching a course on the short story may want to show a video of an urban street scene, for example, and ask learners which of three passages best captures the mood and ambience of that scene.

Images should not be thrown in willy-nilly. They should be used only when they help instructors meet their learning goals. Images should not be used just to make the question presentation look good. Research has shown that placing irrelevant images in learning material, even if those images seem related to the topic, can hurt learning results, distracting learners from focusing on the main points of the material[32]. One easy rule: don't use images if they're not needed to answer the question.

Images can have great value by helping learners associate visual cues with what they're learning. These associations can help learners remember what they've learned when they later encounter similar visual images. For example, teaching table etiquette will be more effective if learners are asked to evaluate short video clips of people eating rather than by providing hand-drawn sketches, prose descriptions, or audio of people eating. As mentioned earlier in this document, there is a large research literature that has found that when the context of remembering is similar to the context of learning, that more information from the original context will be recalled[33].

The following question[34] is okay, but it could be improved to better support memory retention by making the background context more descriptive of what a real table might look like.

Question: Which of the pictures best demonstrates the direction food should be passed at the dinner table at the beginning of the meal?

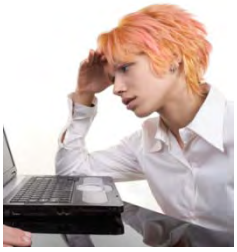


Picture A Picture B Picture C Picture D

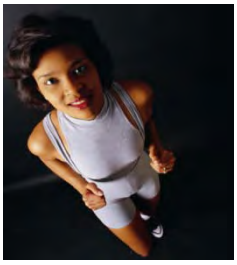
The following question[35] is appropriately delivered in a visual medium. The focus of the question is on dress codes, a content area people typically pay attention to through their visual-processing system—sometimes referred to as "their eyes."

Question: Which of the below appearances doesn't match typical corporate dress-down standards?

Picture A


Picture B

Picture C


Picture D

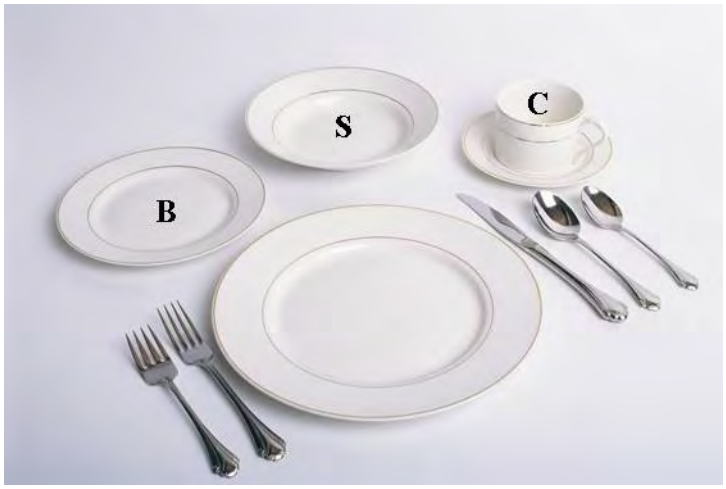
Note how Picture D (of the woman in the skin-tight athletic gear) may be too obvious of a choice. Pictures A, B, and C provide great examples of how question alternatives can help learners understand boundary conditions. Picture A presents a man in a wrinkled shirt. Picture B presents a woman with the orange hair and nose ring. Picture C presents a man in blue jeans. Each of these alternatives provides a difficult choice, depending on whether the depicted characteristic is considered appropriate or not. Gee, I hope wrinkles are okay. Ironing is so tedious and dry cleaners use such nasty chemicals.

Basics of Using Images

The description just above highlights an important element of using images. The learners actually have to be able to see what you want them to see. I know, for example, that you probably can't see the nose ring in Picture B above. My apologies—my rationale is that for this document you don't really need to see it. I can tell you about it. However, the more important point is that when you're the instructor, you have to take responsibility to ensure that the salient features can be perceived in your classroom—or at least communicated in an effective manner. If you're not 100% sure that your learners will be able to parse your visuals, you ought to test your images in your classroom under the actual conditions you'll face with real learners. Walk to the back of the classroom and take a look. If you have perfect vision, find someone with mediocre vision to take a look. If you're going to have the old projector with the dim bulb, use that projector to make your test. If the sun is going to be shining in through the windows, test your images in the sunlight.

The following question[36] is appropriately delivered in a visual medium. The focus of the question is on how to properly set the table, a content area that most people would attend to by visual means.

Question: Is the place setting below correct? If not, suggest changes in the location of (B) the bread dish, (S) the salad plate, and/or (C) the coffee cup. We'll answer one question for each dish.



Question #	The Dish in Question	Should the Dish be Moved?
1	Dish B – Bread Dish	A. Leave it where it is. B. Move left. C. Move right. D. Move up and right. E. Move left and down.
2	Dish S – Salad Plate	
3	Dish C – Coffee Cup	

Note how one image can be used to prompt learners to think about more than one issue at a time.

Note also the power of the "leave it where it is" response option. This forces learners to respond to an authentic situation. In the real world, there won't usually be someone available to tell our learners whether there is a mistake in the place setting. We don't want to short-circuit their cognitive practice by hinting that there is something wrong. It's much better to let them decide that on their own.

Graphics Quality and Production Values

Some of us may be a bit hesitant about using drawings or graphics that we create ourselves because we're afraid that our drawing skills are not very good or that our drawings will reflect poorly on our personal credibility or the credibility of our courses. These concerns have merit—even from a learning standpoint. If your audience tunes you out because your graphics are ugly, unstylish, or ill conceived, then your learning results will suffer.

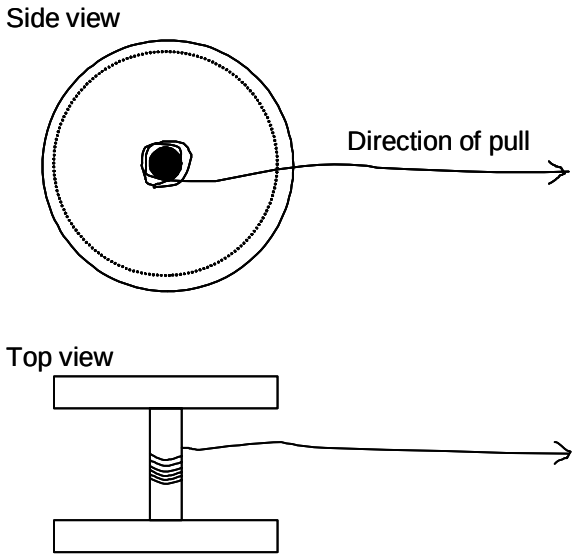
There's no single standard to be applied to all learning situations. You have to decide whether your graphics will work for your audience. When Steve Jobs of Apple introduces a new product (like the iPhone), his multimedia presentation is beautiful with relatively high production values—but it's also simple, clear, and straightforward. Jobs meets his audience's expectations with the graphics he includes in his presentation, while also supporting Apple's brand image.

Although we might not like to think about our own teaching efforts in these terms, the fact is that every time we step in front of our learners, we create an overarching perception of our course, the course topic, and ourselves as instructors and individuals. In short, our classroom performances invite our learners to draw conclusions about us. We create a brand image for ourselves. If we're interested in achieving our learning goals or receiving good evaluations, we need to influence these perceptions by the graphics we insert into our presentations.

Let's keep in mind that the key is to get our learners to pay attention to the learning materials and to think about them mathemagenically—in a way that gives rise to learning. If we've built credibility beforehand or have a special charisma in front of the room, our graphics may not be of primary significance in promoting attention, but they still must clearly communicate their meaning, be directly relevant, and enable appropriate cognitive processing.

Ill-conceived graphics can confuse; irrelevant graphics can distract. That is obvious, but a more subtle point must be understood as well. If our graphics are intended to enable our learners to mentally envision movement or interaction, then realistic images will be better than schematic (or less realistic) images. The following question has been used in teaching physics[37].

Question: Suppose you are pulling on a string wound around the center part of a spool as shown below. Which way will the spool move?



A. To the right.
B. To the left.

The correct response is "to the right." Woods and Chui (2003) report that most people get this wrong—60% in their group of teaching assistants.

Unfortunately, the diagram used is problematic for two reasons. First, people have a more difficult time using mental simulations of movement when the diagrams aren't realistic. The diagrams above are two-dimensional and so they may make it less likely that people will perform the mental simulation required to answer the question. Second, as renowned imagery researcher Dan Schwartz of Stanford told me,[38] "[this] problem probably defies everybody's imagery, because there are competing forces.[39]" The pulling force pushes the spindle to the right while the spinning force from the pull pushes the spindle toward the left. As Schwartz notes, realistic three-dimensional diagrams "lure people into a more simulation frame of mind compared to diagrammatic representations."[40]

Another problem with difficult mental tasks is that when learners are inexperienced with those tasks they'll have a difficult time performing the mental computations. If we give learners a question and they can't answer it, it could be that they need more experience with that type of mental processing. I'm not suggesting that we forgo these types of questions in our classrooms. On the contrary, because research shows that learners can improve their ability to process difficult mental imagery[41], we need to provide extensive opportunities for learning these difficult processes. If we pamper our learners by withholding important—yet difficult—concepts, questions, or challenges; we limit their competence in the long run.

The bottom line on graphic realism is this. Graphics must be drawn with enough realism to support the mental tasks required of our learners. Most of the time, simple depictions will be enough as long as the production values don't hurt our credibility and diminish learner attention. When difficult mental processing is required, realism is critical. In these cases, find someone with artistic talent to draw the pictures for you. Buy them lunch if you have to.

30. Aggregating Handset Responses for a Group or Team

Some handset brands enable responses of individual handsets to be aggregated. So for example, an instructor in a class of 50 learners might break the learners into 10 teams, with five people on a team. All 50 learners have a handset, but the responses from each team of five learners are aggregated in some way. Responses can be averaged, added, or calculated in other ways. For example, partial credit can be given on some responses, high and low scores from a series of questions can be dropped, etc.

This aggregation feature enables some additional learning benefits. Teamwork can be rewarded and competition between teams can add an extra element of motivation. Using aggregation scoring allows the instructor to encourage out-of-class activities where learners within a team help each other. Obviously, this will only work if the learning experience takes place over time. In such cases, aggregation can be used to build a learning community. Learners can be assigned to the same team or rotated on different teams, depending on the goals of instruction. Putting learners on one team encourages deeper relationships and eases the logistics for out-of-class learning. Rotating learners through multiple teams enables a greater richness of multiple perspectives and broader networking opportunities. It's a tradeoff.

You can officially grade the aggregated group responses, but you don't have to. Competition alone can have an energizing effect. Let me be clear here. By simply showing your learners aggregated results of the different groups, you can energize their learning efforts—you don't have to put a grade in a grade book. Of course, competition is a double-edged sword: while it can be energizing, it can also create problems. For example, some group members may not pull their weight, frustrating others. Cheating can result if the competition is perceived as critically important. Some learners enjoy competition, while others hate it. Competition can put the focus on the wrong thing—doing well versus learning richly.

Scoring can combine individual and group results. For example, if an individual's final score (whether graded or not) is based 70% on their own performance and 30% on the team's performance, then both individual and group learning are encouraged. This may alleviate the problems of overheated competition, cheating, and loafing (when some group members don't pull their weight).

If your audience response system doesn't automatically aggregate handsets—or you just don't want to go to the trouble to invoke that feature—you can get the same effect by passing out handsets in a logical sequence and then using that logical sequence to examine the results. For example, if you have 30 learners, you could hand out your handsets in sets of fives. Table 1 gets handsets numbered 1 through 5, Table 2 gets handsets 6 through 10, etc. After the learners input their responses, the results can be eyeballed or compiled easily by viewing the results of the first five handsets, the next five handsets, etc.

31. Using One Handset for a Group or Team

Although one of the prime benefits of handsets is that every learner is encouraged to think and respond, handsets don't have to be used only in a one-person-one-handset format. Sometimes a greater number of audience members show up than expected. Sometimes budgets don't allow for the purchase of handsets for every learner. Sometimes learners forget to bring their handsets. In addition, sometimes there are specific interactions that are more suited to group responding.

When a group of learners has to make a single response, there has to be a mechanism for them to decide what response to make. Several exist, each having their own strengths and weaknesses.

Groups can use majority rule. Individuals vote and the most popular response wins. This has the advantage of speed, but it can circumvent learning if the pre-decision conversation doesn't support learning.

Groups can use consensus. They don't make a decision unless everyone agrees to make a decision. This can be facilitated by offering an extra answer choice for each multiple-choice question, "We could not come to consensus." Such an answer choice formalizes the no-consensus option, helping to avoid group pressure to move toward a choice just because a choice has to be made.

Groups can rotate final authority on decision-making. So, for the first question, Joe is the final authority. He is responsible for leading a discussion and getting input from others. When he's ready or time is called, he makes the decision. On the next question, Sally is the final authority. On the following question, Julie will play that role. This method encourages everyone to play the role of facilitator, giving practice on this very important skill. It also has the potential to include everyone in the process of decision-making depending on whether the decision-maker does a good job of seeking input.

32. Using Questions in Games

As several sales representatives have told me, one of the first things instructors ask about when being introduced to a particular audience response system is the gaming features. This excitement is understandable, because almost all classroom audiences respond energetically to games. Our enthusiasm as instructors must be balanced, however, with knowledge of the pluses and minuses of gaming.

Just as with grading manipulations, games energize learners toward specific overt goals—namely, scoring well on the game. If this energy is utilized in appropriate mathemagenic activity, it has benefits. Games can increase the number of relevant repetitions that learners will tolerate. They can induce useful retrieval practice, especially on simple cue-and-response information (for example, "What is the synonym for occlude?"). Games can encourage team-based studying and preparation when scoring rewards learners for helping each other. Games can increase perseverance toward learning goals. Games can support the development of automatic responding when drill-and-practice schedules are utilized.

On the other hand, games can be highly counterproductive as well. Games can engender shortcuts, cheating, cramming, and a focus only on extrinsic goals. Games can make it less likely that learners will think divergently, be reflective, or stay intrinsically interested in the material. Games can encourage learners to pay attention to low-level information instead of focusing on the most meaningful concepts. Games can prompt some learners to disengage completely when they have no chance to win or compete for honors, or no hope of helping their team. Games can make it less likely that learners will help each other. Games can give instructors the impression that learners are engaged, even when learners are engaged in suboptimal cognitive processing.

There are many types of gaming scenarios. Games can be scored individually or in teams. Games can count for grades or not. Prizes can be awarded or not. Games can focus on quick-hit questions and answers or on long-and-involved problem-solving exercises. Games can be announced in advance—to encourage studying and teamwork—or be delivered periodically as a surprise. Games can reward a few learners or a multitude. Games can be hard or easy, serious or fun. Games can present questions in a simple, straightforward format or they can involve an elaborate simulation of a televised game show. Questions for games can be aligned with learning goals or completely off the mark. Questions can be well-designed or poorly-designed. Games can be delivered to receptive or hostile audiences. Games can be presented to learners who like games or learners who hate games. Games can have an urgent timing component or can be more leisurely.

Given the plethora of factors cited in the previous paragraph, there are obviously no bulletproof methods to ensure the best learning outcomes using gaming methods. The following advice may be helpful:

A. Revisit your learning goals before deciding upon a game. Then design your games and your questions accordingly.

B. Remember the dangers of games. Then design your games to minimize those dangers.

C. Be especially careful in using questions that will encourage your learners to focus on irrelevant or low-level information.

D. Facilitate the gaming event in a way that your learners stay focused on the learning at least as much as the scoring.

E. Consider non-competitive forms of scoring—especially where learners are rewarded for reaching a standard as opposed to beating an opponent.

F. If you use competitive scoring, consider methods that reward teamwork or classwork so that learners remain ready to help each other and engage each other in deep and meaningful conversations.

G. Consider telling learners ahead of time that there will be a game in a future session to encourage learning activity in the interim. Also, consider an occasional surprise game to encourage regular learning-focused attention and study.

H. When using incentives to reward "good" scores, you may want to avoid giving those incentives only to one best individual or to one best team. The rationale for this is that it is important that learners not be so focused on winning that they forget learning.

I. When using incentives, it's generally best to make them relatively low-value incentives so that learners don't forget to focus on the learning. Humorous awards can be useful as well.

J. Consider adding a timing element to your gaming activities: for example, by giving a team full credit for answering correctly in ten seconds and half credit for answering correctly in twenty seconds. Note, however, that this is likely to short-circuit deep learning, but may be especially appropriate to prepare learners for quick-response types of situations.

K. Don't get so worried from all my warnings that you avoid games altogether. An occasional game can be fun, engaging, and even meaningful from a learning standpoint. A game can also give learners a quick break from the classroom routine and so prepare them to get back to work on deeper material.

33. Questions to Narrow the Options in Decision-making

Sometimes the audience in the room must make decisions about what to do. For example, a senior manager running an action-learning group may want to take a vote about which of a slate of 15 possible projects to pursue. A professor in an upper-level seminar course might give students a vote in deciding which of the 10 possible topics to discuss in the final three weeks of the course. A supervisor might want her employees to narrow down the candidates for employee of the year. A primary school teacher might want to give her students a choice of field-trip options.

Audience response systems can be used in two ways to do this. In the first method—single-round voting—each item is voted on separately, with the top vote-getters being selected. An "A" response can represent a vote of five, a "B" four, and so on. The options with the highest number of points or the highest average point total are selected. The second method—double-round voting—proceeds in a similar fashion but enables a second round of voting for the top vote-getting options. So, for example, the top four vote-getters in the initial round are voted on again. This enables the participants to give more attention to the smaller number of options that remain.

Note that in both single-round voting and double-round voting it is generally desirable to give audience members a chance to understand the options before voting. Voting will not be seen as legitimate—nor will it fairly represent the group's true feelings—if people don't know at least a little about the options on which they are voting.

In addition to ensuring a base level of knowledge about the options, it can be very useful to make time so that audience members can advocate for the options they believe in. If they can't advocate before a vote, they may advocate after the vote, causing an interpersonal and logistical mess as the voting consensus shatters in myriad directions.

Although we may tend to see these voting opportunities as in-the-session events, the double-round voting method can be used over several hours, days, or weeks to enable audience members the time to learn more about the options and advocate for their positions.

34. Questions to Decide Go or No Go

Sometimes it's beneficial to give our learners a chance to decide whether they're ready to go on to the next topic. You might ask, "Are we ready to go ahead?" Or, "Are we ready to go ahead, or do I need to clarify this a bit more?" Using an audience response system has distinct advantages over handraising here because most learners are uncomfortable asking for additional instruction, even when they need it.

Go-or-no-go questions can be used for decision-making as well, whether or not those decisions are related to learning. Similar to questions used for narrowing options, go-or-no-go questions enable audience members to have full and confidential input into decision-making.

For example, a music teacher who wants his students to decide whether they are ready for their upcoming public performance might use the following question:

Question: Are we ready to go or do we need more practice?

A. We are ready for our performance.
B. We need more practice.

A chemistry teacher running an in-class experiment might ask this question to get learners to think about data gathering:

Question: Do we have enough observations to draw a conclusion?

A. Yes, we can now draw a conclusion.
B. No, we need to gather more data.

If the majority says, "Yes," the teacher could query the students on their conclusions. If most students say, "No," either the class could continue data gathering or those who said "Yes" could be asked for their conclusions. By putting the onus on the learners to make this kind of decision—and by having them discuss whether to move forward—it teaches them how to think like a scientist. Such decision-making interactions are a vast improvement over having learners simply run through a recipe in following experimental procedures.

A literature teacher could ask a similar question about a short story.

Question: Have we covered all the major themes presented in the story?

A. Yes, all the major themes have been covered.
B. No, there is at least one more theme of importance.

Again, this type of question prepares the learners to think for themselves after the course is done. If learners in a short-story class only have to think about the themes surfaced by the teacher or the other students, they are extremely unlikely to think about themes when they are reading a short story on their own.

A manager who is championing a change effort could utilize a go-or-no-go question to determine the level of readiness for those who will have to implement the change effort. This type of change championing may or may not be part of an action-learning project.

Question: Are you ready to support this change effort?

A. Yes, I will actively champion this effort.
B. Yes, I will support this effort.
C. No, I will stand aside and let others support it.
D. No, I'm likely to passively resist this effort.
E. No, I'm likely to attempt to actively block this effort.

While this is not a dichotomous "***go***" or "***no go***" question, it could be interpreted as one. The manager might say, "Okay, I'm willing to go ahead with the change effort if we get 80% of you who chose either of the 'Yes' responses—Choice A or B—AND we get at least three people who choose A, indicating they'll actively champion the change effort. I know this won't succeed if I'm the only one willing to champion the effort." The five answer choices enable the manager to get a better sense of the level of support for the change effort while also giving the team members a real voice in the decision.

And of course, don't forget:
www.AudienceResponseLearning.org

35. Perspective-Taking Questions

There are some topics that may benefit by encouraging learners to take perspectives of others in answering questions.

Question: How do you think a black single-parent mom from one of Chicago's worst neighborhoods would answer the following question? "What's the most important thing the U.S. government could do for you in helping you raise your children?"

A. Provide career counseling.
B. Increase the size of welfare checks.
C. Encourage businesses to locate nearby.
D. Provide affordable childcare.
E. Reduce gun violence.
F. Provide affordable healthcare.
G. Provide job training.

Question: How do you think a married double-income white mom from one of Chicago's most affluent neighborhoods would answer the following question? "What's the most important thing the U.S. government could do for you in helping you raise your children?"

A. Provide career counseling.
B. Increase the size of welfare checks.
C. Encourage businesses to locate nearby.
D. Provide affordable childcare.
E. Reduce gun violence.
F. Provide affordable healthcare.
G. Provide job training.

These two questions alone can get learners to reflect on the actual day-to-day lives of mothers from both types of situations. This kind of perspective-taking can be augmented with actual responses from poll questions or government surveys. For example, an instructor could use the results from a poll on poverty as follows:

Question: Do you think there would be a difference between the views of low-income and high-income people concerning the causes of poverty? Suppose we divided people into those significantly above the poverty line—say 200% or more above the poverty line—with those under that line. Which of the following items would the high-income people rate differently than low-income people? Specifically, which items would the high-income people rate as less likely to be major causes of poverty?

A. Drug abuse.
B. Medical bills.
C. Too many jobs being part-time or low-wage.
D. Too many single-parent families.
E. A shortage of jobs.
F. Too many immigrants.
G. The welfare system.
H. Poor people lacking motivation.
I. A decline in moral values.
J. Poor-quality public schools.
K. None of the above.

After the learners answer the question and a discussion is engaged, the instructor could show the learners actual data from the survey results (NPR/Kaiser/Kennedy School Poll, available at www.npr.org/programs/specials/poll/poverty/)[42], and then break learners into small groups to discuss further. See the following page for a table of the actual results.

NPR/Kaiser/Kennedy School Poll

The question asked:

Is the ITEM in the left column a major cause of poverty, a minor cause of poverty, or not a cause at all?

The results show the percentage saying that the item was a major cause of poverty. Note shaded gray area denotes items that were not significantly different between high-income and low-income respondents.

	High-Income (200%+)	Low-Income (<200%)
Drug abuse	68	75
Medical bills	54	69
Too many jobs being part-time or low-wage	50	64
Too many single-parent families	52	61
A shortage of jobs	27	52
Too many immigrants	27	39
The welfare system	47	45
Poor people lacking motivation	51	56
A decline in moral values	56	58
Poor quality public schools	47	46

See results: www.npr.org/programs/specials/poll/poverty/

Real data like that in the table above can be particularly energizing for audiences. Using perspective-taking questions and augmenting them with real data takes time, but the benefits can be substantial.

36. Open-Ended Questions

Some people think audience response systems lack potential because they only enable the use of multiple-choice questions. If you've been closely reading this paper from the beginning, I hope you've become convinced that (a) multiple-choice questions can be powerful on their own, and (b) variations of multiple-choice questions add to this power. I've also hinted at how open-ended questions can be valuable in conjunction with multiple-choice formats.

At the risk of some duplication, I want to again describe the power and limitations of open-ended questions, and gather all the ideas discussed so far into this section. Learning researchers have found that open-ended questions tend to support better remembering than multiple-choice questions; and similarly, learners who prepare to take exams with open-ended questions tend to learn more than learners who prepare for multiple-choice exams. Open-ended questions also tend to be more authentic than multiple-choice questions—in that most real-world retrieval situations don't provide the hints inherent in the presentation of multiple answer choices.

On the other hand, open-ended questions don't prompt learners to weigh specific options against each other. They don't always enable clear demonstrations of myths or misconceptions. They can overload learners' cognitive capacity to think productively about an issue or concept. They make data gathering problematic and the presentation of results almost impossible.

The following methods of using open-ended questions are recommended, depending on your learning goals:

A. Use open-ended questions to create a list of plausible answer choices for future planned questions. Have learners write their responses on index cards or, if the system allows, text-message them using their handsets. Analyze the responses after the session is over.

B. Use open-ended questions by asking each learner to write an answer down on a piece of paper. Then ask learners to discuss in pairs, small groups, or as a whole group.

C. Use open-ended questions in the traditional way, asking for a show of hands for those who want to respond. This is appropriate when it's not that critical that every learner is engaged in answering. No audience response system is needed for this.

D. Use open-ended questions to solicit questions from learners. "Okay, what questions do you have at this point?" You can do this by asking everyone to write down a question or two, or by simply asking for volunteers to raise their hands if they have questions. Alternatively, if your handsets enable text messaging, you can ask learners to use that function to input their questions. This can be especially valuable to plan for future sessions or to answer questions later or in an online forum, etc.

E. Have learners respond first to open-ended questions prior to providing multiple-choice answer choices. While the open-ended questions can encourage divergent thinking, following them with multiple-choice alternatives forces learners to focus more tightly on specific comparisons.

F. Similarly, pose open-ended questions first, then have group discussions about various alternatives, and only then provide multiple-choice options.

G. Similarly, pose open-ended questions first, have the learners call out alternatives and write those alternatives on a white board, then use the handsets to have learners vote to choose the top three or four answers. Then have small-group discussions, and only then present the top three or four answers for a deciding vote.

H. Open-ended questions can also be used at the end of learning sessions to prompt learners to reinforce the major learning points. "Okay, of all the things we covered today, what's the thing you most want to remember?" Many of the methods described immediately above can be utilized to process answers to this type of question.

37. Matching

Matching questions are especially valuable if your learning goal is to enable learners to distinguish between closely related items. The following is an example:

Question: Match the cooking oil with its best use:

#	Cooking Oil	Best Use
1	Olive	A. To eat raw B. For high-temp frying C. To save money D. In stir fries E. In fine pastries F. To increase Omega 3 G. None of the above
2	Canola	
3	Corn	
4	Toasted Sesame	
5	Palm	

The matching format can also be useful for logistical reasons in asking more than one question at a time.

Question: Which Spanish word best matches the English word?

#	English Word	Spanish
1	dog	A. flor B. arbol C. perro D. arroz E. sopa F. libro G. None of the above
2	flower	
3	rice	
4	tree	
5	soup	

Although this seems like one question, it actually asks five questions. Some audience response systems enable learners to answer one question after another at their own pace—a perfect solution for a "matching" question like this one.

Note that I've added more matching choices than there are items. I've also added a "none of the above" answer choice. Both of these techniques prompt learners to a deeper level of processing, and thus better learning.

Although the matching question has its uses, it is often overused by instructors who are simply trying to use non-multiple-choice questions. Often, the matching format only helps learners reinforce relatively low-level concepts, like definitions, word meaning, simple calculations, and the like. While this type of information is valuable, it's not clear that the classroom is the best place to reinforce this type of knowledge.

In both examples above, it might be better to send the learners home with flash cards or e-learning drill-and-practice programs. Moreover, neither question above gives learners authentic retrieval practice. The learners never have to recall information from memory. They only have to recognize whether the information is connected. While this may be a reasonable first step for learners, it is not sufficient to prepare them for real-world recall where they won't get any hints. Finally, in the cooking-oil question, the matching format is further flawed because learners aren't asked the question in a way that best simulates the real-world retrieval need. Typically, a person in the kitchen needs to know what type of oil can be used given a certain need. For example, cooks need to know which oils can be used for high-temperature frying. The question could be improved slightly to put the need on the left and offer multiple answer choices on the right. On the other hand, the following scenario-based question might be even better.

Question: Juan wants to deep-fry some yuca roots. If the criteria for selection encompasses health, nutrition, and aesthetics; which of the following cooking oils are suitable for this task? Feel free to select more than one of the following.

A. Corn
B. Olive
C. Safflower
D. Canola
E. Coconut
F. Palm
G. Sesame

As we noted above, by utilizing more-authentic questions with more-realistic retrieval requirements, we do a better job preparing our learners for later retrieval in their real-world contexts.

The matching question examples I used above were intentionally chosen to contain flaws, but to appear at first reading as reasonably sound. I did this because I want to discourage the matching format unless it is uniquely appropriate.

38. Asking People to Answer Different Questions

Some audience response systems enable learners to simultaneously answer different questions. In other words, Sam might answer questions 1, 3, 5, 7, and 9, while Pat answers questions 2, 4, 6, 8, and 10. This feature provides an advantage only when it's critical not to let (a) individual learners cheat off other learners, or (b) groups of learners overhear the conversations of other groups of learners.

The biggest disadvantage to this tactic is that it makes post-question discussions particularly untenable. If only half the class has seen Question 4, the other half is likely to remain disengaged or confused. On the other hand, you may be able to alleviate this problem somewhat by having your learners answer the same questions, but by putting the questions in a different order. In any case, if you do find a unique benefit to having learners answering different questions simultaneously, it's likely to be for information that is already well learned—where in-depth discussions are not needed.

39. Using Models of Facilitated Questioning

In this paper, I've attempted to lay bare the DNA of classroom questioning. I intentionally stripped questioning practices down to their essence in the hope of creating building blocks that you, my patient reader, can utilize to build your own interactive classroom sessions. For example, I talked specifically about using prequestions to focus attention, activate prior knowledge, and surface misconceptions. I also talked about how postquestions can be used as retrieval practice to strengthen remembering, provide feedback, and surface any remaining misconceptions. I didn't describe the myriad permutations that pre- and postquestions might inhabit, for example, or any systematic combinations of the many other building blocks I described. My deconstructive approach—in my thinking at least—enables you to be thoughtful, creative, and flexible in implementing questions in your classroom.

While I purposely did not present you with static models of facilitated questioning practice, I firmly believe that there is great value in studying these models. Research and practice must work together to provide wisdom, and the nascent field of audience-response learning is indebted to many pioneers who have refined their methods in the burning crucible of their own classrooms. Some of these pioneers include folks like Eric Mazur at Harvard; Ian Beatty, William Gerace, Robert Dufresne, Laura Wenk, Jose Mestre, and William Leonard at the University of Massachusetts; Louis Abrahamson of the Better Education Foundation; Harold Horowitz at IBM and at Socratec; Stephen Draper at the University of Glasgow; William Penuel and Jeremy Roschelle at SRI International; Douglas Duncan of the University of Colorado; and so many others (my sincerest apologies for missing other giants in the field and the many unsung heroes who have persevered in relative obscurity).

This is not the time or place to present all the models that have been developed, but I offer two facilitated-questioning models here to give you a flavor of how these systems work. Please keep in mind that these models have been developed for specific subject matter with specific types of learners and may not be directly relevant to your classroom. Let me note here that I expect, over time, different facilitated-questioning models will develop for each discipline, just as specific questions will become time-tested for each specific learning point[43].

Peer Instruction Method

Much of the post-wireless thinking and writing on the use of audience response systems has been based on the work of Eric Mazur, professor at Harvard University. He has popularized the Peer-Instruction methodology in teaching physics. His book, *Peer Instruction: A User's Manual*, was the first must-read book for users of audience response systems.

Peer instruction utilizes the following steps:

1. The instructor presents content.
2. The instructor asks a question and students answer individually using their handsets.
3. The instructor asks the students to pair off and try to convince their partners of the correctness of their answers.
4. The students answer the question again.
5. The instructor provides any necessary remediation.

Although this is an involved process, one basic aspect about it is that the question comes after the initial introduction of content and before a learner-to-learner discussion that enables further explanation. Note how the Peer Instruction method utilizes postquestions to provide learners with a quick opportunity to test their new understanding while simultaneously providing instructors with feedback to provide remediation. Note also how learner discussions support the learning. As Eric Mazur has been quoted as saying[44], "Standing in front of a class, I have no idea what conceptual difficulties a student faces…When you understand the material as well as I do, it's hard to figure out what students don't get, or why they don't get it. The solution is to give students the opportunity to teach each other. And technology helps me do this, to have the classroom in the palm of my hand."

Question-Driven Instruction

Also from Massachusetts, the team at the University of Massachusetts's Scientific Reasoning Research Institute and Department of Physics has developed their own model of facilitated questioning. Included on this team are Ian Beatty, William Gerace, William Leonard, Jose Mestre, Laura Wenk, and Robert Dufresne, who have written extensively about their practices[45].

Their "question cycle" has the following steps:

1. It begins outside of the classroom, with learners interacting with the material to be covered in the classroom.

2. In the classroom, learners are presented with a question that they answer individually, usually after a small-group discussion. This question acts as both a pre- and postquestion. It's a postquestion in relation to the out-of-the-classroom prework. It's a prequestion in relation to the coming discussions.

3. The instructor presents a histogram of the question results, but does not provide any information about which answer is correct.

4. The instructor prompts various volunteers in a class-wide discussion to advocate for the various responses.

5. The instructor now diverges down alternative paths depending on the previous student responses.

Note how the instructor tends to wait to resolve the tension around the correctness of the question's answer choices. The instructor may take another vote on the question, present related questions; highlight important distinctions that may not have been noticed; relate the question's learning points to the broader topic area; or present micro-lectures to provide remediation or extend the learning beyond current boundaries.

Astute readers will note the wide-ranging similarities between Mazur's *Peer Instruction* and the University of Massachusetts's *Question-Driven Instruction* models. Both utilize postquestions to solidify learner knowledge and provide instructors with feedback. Both encourage learners to take an active role in learning. Both prompt learner discussions to help clarify and deepen understanding. Both require instructors to be active, reflective, and flexible in responding to learner progress. Both focus on standard misconceptions that learners have with physics concepts.

Although we might look at these similarities and conclude that there is something inherently basic and appropriate being practiced in these models, we ought to be at least a little circumspect given the similarity in the subject matter (physics), the instructors (professors), the learners (college students), and the Massachusetts water (delicious but probably contaminated with MBTE).

Again, let me reiterate. Models like these are a great place to begin our exploration of questioning with audience response systems, but we shouldn't allow ourselves to be hamstrung by their boundaries. For example, I might ask these instructors whether they've considered using some of the following interactions:

A. Relating questions to their learners' day-to-day experiences.

B. Asking learners to make decisions of the type that real-world physicists (or engineers, etc.) have to make.

C. Examining how learners' prior experiences or education affect their learning challenges.

D. Asking learners to answer questions after having viewed an in-class demonstration of physics principles.

E. Asking learners to rate each other's in-class team presentations explaining difficult physics concepts.

F. Intentionally using questions to activate learners' prior knowledge regarding topics related to physics (gravity, electricity, magnetism).

G. Using prequestions without any prior introduction of concepts.

H. Utilizing in-depth team projects in a gaming interaction.

I. Okay, okay, you must have gotten the point. It's imperative that we all examine the full complement of building blocks in creating our own classroom learning interactions.

General Recommendations

This section will weave together research-based and practice-based recommendations for the use of audience response systems in classrooms. Because the use of classroom audience response systems has been growing over the past decade or two, more and more classroom-tested recommendations can be made. Similarly, the wealth of research on active learning and fundamental learning factors can be used to augment this formidable wealth of information.

Becoming Proficient Requires Time, Experience, and Training

Instructors who have moved from traditional formats to the more active-learning formats report that they get better with each new course that they teach[46]. Moreover, results from learning outcomes bolster the case, with greater learning improvements after audience response systems have been used more times[47], and greater learner satisfaction after instructors become more experienced using the system[48].

While this may be partly due to learning how to use the new technology, gradual improvements have been found moving from lecture to active learning even when no technology was involved. Audience response systems give instructors feedback on how well they are being understood.

Training in specific techniques seems critical as well. This is underscored by the vendors who sell audience response systems. Some vendors offer extensive training on how to use the systems to maximize learning results. For example, eInstruction offers four full-days of instruction for its customers. The first day focuses largely on how to use the technology, the second focuses mostly on how to use the audience response system to promote active learning, and the third and fourth days of training bring together experienced instructors with one or more master instructors to focus on advanced techniques. Other vendors also provide extensive learning opportunities, but not all do. Some vendors have a user-group conference where their customers can learn from each other and from the experts. Many of the manufacturing vendors offer similar training and support. Some also publish newsletters, offer online courses, distribute white papers, and/or offer other resources. To get advice about what to look for in an audience-response vendor and/or consultant, check out www.AudienceResponseLearning.org.

To put this in perspective, the acceleration in the adoption of audience response systems throughout the world is partially driven by the ease of adopting active engagement questioning practices[49].

Don't Lose What's Good about Your Current Classroom Practices

While adopting audience response technology may prompt you to change everything about how you teach, don't forget to maintain the best of what you're already doing. The idea is to focus first on what you want to accomplish and then design your classroom interactions from that set of goals. As you work through the process of developing your new classroom methodology, take stock of your current practices. Ask yourself some questions. What are your strengths and weaknesses? What exercises really seem to work? What exercises don't? What learning material is central to my efforts? What material can I exclude or push into homework?

Introduce Your Learners to These New Questioning Methods

Don't expect your learners to magically morph into active learners just because you introduce a new technology or questioning regimen into your classroom[50]. You're going to have to prepare your learners by introducing the new methodologies, selling the benefits, doing an especially good job facilitating the first encounters, hinting at discussion best practices, reinforcing the benefits of the new methods, and perhaps even by demonstrating the benefits with some pre- and posttest data.

Dr. Will Thalheimer

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Some Questions are Better Than Others

I've already described how recall questions can be more powerful than multiple-choice questions, how multiple-choice can be better than true-false questions, and how questions can drive learner attention to appropriate or inappropriate learning material. I've also highlighted the fact that these general principles don't always apply. For example, sometimes multiple-choice questions are better than open-ended recall questions.

Still, I can't emphasize enough how inadequate it is to simply sprinkle one's lectures with questions and get learners to respond. Questions can be evaluated on their clarity, brevity, level of learner engagement, and appropriateness to your topic's specific learning goals, among many other characteristics.

Following are some of the most important guidelines:

A. Utilize a question if and only if you have a reason to use the question: for example, because it helps you achieve a particular learning goal.

B. Avoid questions that encourage learners to focus on irrelevant low-level information.

C. Avoid questions that are confusing, poorly written, or overload the working-memory capacity of your learners. Pay special attention to the answer choices to ensure they are plausible and coherently presented.

D. Don't aim only for high-level learning. Aim for high-level learning that supports your learners in understanding something important.

E. Remember that questions are only as good as the mathemagenic learning-creating processing that they engender, and your augmenting explanations, discussion facilitation, and the quality of your learners' conversations are critical factors in supporting that processing.

Be Proactive in Having Your Questions Understood

It's very important, and very difficult, to write questions that will be understood as you intend them to be understood. Let me return for a moment to the question utilized by Nobel Laureate Carl Wieman and his colleague Katherine Perkins. You may recall that they asked the following question about the sound of a violin, *"The sound you hear from a violin is produced [by which answer choice?]"*

There is a possibility that the wording of the question pushed learners to the "wrong" answer. Learners may have interpreted the phrase, *"The sound you hear from a violin is produced…"* as meaning, *"The sound you hear from a violin was caused by what initiating event?"* I might rewrite the question as follows: *"The sound you hear from a violin emanates from what part of the violin?"* My guess is that this wording change would significantly lessen the number of learners who choose the "strings" answer, but that many learners would still get the answer wrong.

I use this example, not only to put a twinkle in my eye as I take advantage of this rare opportunity to critique the work of a Nobel Laureate—but to highlight three additional recommendations. First, the wording of our questions is critical. They must be clearly understood by learners for us to get accurate feedback. Second, the more expertise we have, the more likely our understandings will differ from those of our learners. We may even understand common words like "produced" differently than our learners. Third, because of this tendency for misunderstanding, we have to take responsibility for exploring our learners' understandings, by being proactive in learning what our learners mean by their audience-response answers. As Wieman and Perkins (2005, p. 40) recommend, *"By circulating through the classroom and literally listening in on the consensus-group discussions, the instructor can quickly learn particular points of student understanding and confusion. Then in the follow-up lecture or whole-class discussion, the instructor can directly target those specific items of confusion."* The bottom line is the following. It is our responsibility as instructors to narrow the distance between our learners and ourselves.

Avoid Unnecessary Mental Gymnastics in Your Questions

In addition to avoiding questions that promote only low-level rehearsal, it is also important to avoid developing questions that are difficult to answer only because they are confusing or require unnecessary mental computations. See the following as an example.

> **Overly Complex Question: Ethnic Prejudice [A] is to Parenting [B] as Birthday Cake with Trans Fats [C] is to:**
>
> A. The Baker
> B. Home Cooking
> C. Sugar
> D. Nutrition

Egad[51]. What's the purpose of such confusing mental gymnastics? It is true that the cognitive processing prompted by this question will be deeper than the processing of a more straightforward question, but deep processing is not the goal. We want deep processing that supports our learning goals and enables appropriate remembering and retrieval. Of course, it won't kill your learners if you throw a few of these in from time to time, but unless you're preparing them for standardized tests in which they'll have to do these analogies, your question time would probably be better spent elsewhere.

Questions that require irrelevant mental gymnastics are especially difficult for learners who are novice to the subject matter (because novice learners haven't yet chunked the information to enable it to be processed within the stringent confines of working memory). Similarly, questions are also unnecessarily difficult for learners with other special challenges, including those with learning disabilities, those learning in a second language, those with mental illness or impairment, and those suffering from illness or fatigue. Avoiding questions with irrelevant gyrations may be more than just a matter of learning. Your questions could also have legal repercussions if they unfairly harm the progress of certain protected groups.

Remember the Importance of Learner Discussions

As we've already discussed, asking questions in the classroom is helpful for dozens of specific reasons. Nevertheless, it is critical that we don't underestimate the importance of learner-to-learner discussions. Short-changing or limiting those discussions in the interest of time management is likely to be counterproductive. This is especially true given the difficulties most experts have in helping novices understand learning material. Experts often know so much about their area of expertise that they can't relate to the current understandings in the minds of their learners. This makes it difficult for experts to describe concepts in ways that will be understood. Many instructors who use audience response systems come to this realization only after they have begun asking the learners postquestions that they fail to answer correctly[52]. Learners have also described how they are often better able to learn from their fellow learners[53] than from their instructors.

How to Prepare for Sessions

If you want to be a really good classroom instructor (teacher, facilitator, trainer), you need to invest heavily in preparation. Practice makes perfect. You are likely to find great benefit in practicing with your audience response technology. Practice your mini-speeches and facilitation, generating ad-hoc questions under a time constraint, answering common questions, facilitating discussions, and using the technology.

In addition to practicing, you also need to prepare your questions in advance, preferably trying them out on a representative sample of your typical audience to see how they understand the question, how it works, and what they find confusing. You also will find it valuable to prepare contingency questions in advance—not just your planned questions. A contingency question is one that might be valuable if the conversation goes in one direction or the other.

How to Construct Answer Choices

A whole book could be written on how to construct answer choices. For our purposes, I hope you'll keep a few simple guidelines in mind.

Answer choices must be relatively plausible. Throw-away choices are sometimes useful to add humor, but they are mostly a waste of learner cognition. Don't mix up answer choices that have a natural progression. For example, the first is better than the second:

A. strongly disagree, B. disagree, C. not sure, D. agree, E. strongly agree

A. disagree, B. agree, C. strongly disagree, D. strongly agree, E. not sure

For questions that get at the heart of whether learners understand concepts, ensure that the incorrect answer choices are not only plausible but are common misunderstandings. In creating scenario-based decision-making questions, you might derive incorrect answer choices by providing questions to people in an open-ended form, seeing what answers they suggest, and then utilizing the most common answers as your distracter choices. Consider using index cards as you develop new questions. Show your learners the question without any answer choices and have your learners write down their responses. Collect the cards and analyze them to determine the most popular incorrect responses.

It's generally best to keep your answer choices as short as possible, while still conveying the meaning. If you do use long answer choices, you may want to add a blank line between each choice (on your presentation slides) to make reading easier. Try to make your answer choices about the same length, if possible. Be particular careful that the length of the correct answer choice is similar to that of the other choices.

Being Creative with Your Technology to Reach Your Goals

Each manufacturer of audience response systems has its own software to support your instructional activities. The software differs in quality and capability. This is partly due to the newness of the field—manufacturers are still learning what is needed. Partly this is because companies have patents that prevent other companies from implementing certain functionality in their software. The bottom line is that the software you're using may not do everything you want it to do. Your job, then, is to figure out tricks to get it to do what you want it to.

Earlier, I mentioned some of these tricks. Here are two more you might consider:

1. **To enable learners to choose more than one answer.**
   Say that your question has three answer choices. You want to enable your learners to choose any of the choices. Note that the following suggestions are more workable if you limit the number of answer choices to a small number—say three or four—because visual inspection of the results may get very messy otherwise.

   <u>For RF systems that enable numeric input:</u>
   Tell them to put in "12" to choose 1 and 2, "123" to choose 1, 2, and 3, etc. Display the results and see if they are comprehensible through a quick visual analysis. If not, you'll need to analyze the data offline and get back to the learners later with the results.

   <u>For any system:</u>
   Break the question into three questions and ask a YES-NO question. Write the results down on a whiteboard or flip chart. "23 people chose A, 54 chose B, and nobody chose C."

2. **To enable learners to rank-order the choices.**
   Say that your question has four answer choices. You want to enable your learners to rank-order the choices.

   For RF systems that enable numeric input:
   Tell them to put in "1243" if 1 is their first choice, 2 is their second choice, 4 is their third choice, and 3 is their fourth choice. Alternatively, you could focus on ranking fewer of the alternatives. For example, tell them to put in "12" if one is their first choice and two is their second choice, or "24" if two is their first choice and four is their second choice.

   For any system:
   First, give the learners the question and have them write down their rankings of the answer choices. Then ask a series of questions—one for each answer choice. For example, "Rate Choice A. Select A if it's your favorite choice, B if it's your second choice, C if it's your third choice, etc."

   Group ranking method for any system:
   First, give the learners the question and have them write down their rankings of the answer choices. Then ask a series of elimination questions. You can start from the best or the worst. "Okay, I want everyone to choose their least favorite answer choice. Okay, good. Choice C is eliminated. Let's now vote on A, B, D. Which is your least favorite of those?" This continues until one choice remains.

How to Prompt Valuable Conversations

Your learners may not automatically know how to engage in conversations that will lead to optimal learning. They'll get better over time, but you can jump-start their progress—and help them avoid bad habits—by being proactive in your facilitation.

Here is the kind of introduction that I have found particularly beneficial.

> *You should now be in groups of three or four people. Before I present you with a question, let me tell you what typically happens in group discussions like these. Why am I going to this trouble? Because what typically happens in these discussions is not good. In fact, it's usually harmful in helping you get the most out of the conversations you're going to have. Where you might want to get multiple perspectives on an issue, typical group discussions short-circuit everybody's input. Where you might want to have a rich conversation, typical group discussions move too quickly toward a resolution. Where you might want to ensure that everyone has their say, typical group discussions rely on one or two voices.*
>
> *Okay, here's what typically happens. First, you get a question, then someone starts vocalizing his or her response to the question and everyone then reacts to that initial response. After some brief conversation, the group decides to take a vote. [Augmentation: you could lead a discussion by asking your learners why this is a poor method for a group discussion.]*
>
> *Here's an alternative scenario. First, you read the question, and everyone in your group silently considers the question and writes down an answer and rationale for why that answer is correct. This is a great start because it gets everyone thinking. Then each group member tells what answer he or she likes, AND tells why they like that answer. It's usually best to rotate who goes first to ensure that everyone gets a chance to be the first to frame a response. After everyone has a chance, it can be valuable for someone to review the various suggestions and rationales to see how the conversation should continue. The group might play devil's advocate and examine the rejected alternatives, arguing for these and discussing them further. If two alternatives are still in contention, group members could advocate for each in turn. Although voting for answers at this point might be beneficial in forcing each group member to make a commitment, the group might also consider working toward a consensus if time allows.*

Sometimes it can be beneficial for groups to choose roles for each question. This is especially beneficial for questions that are expected to involve prolonged discussions. Specifically, the following roles might be assigned:

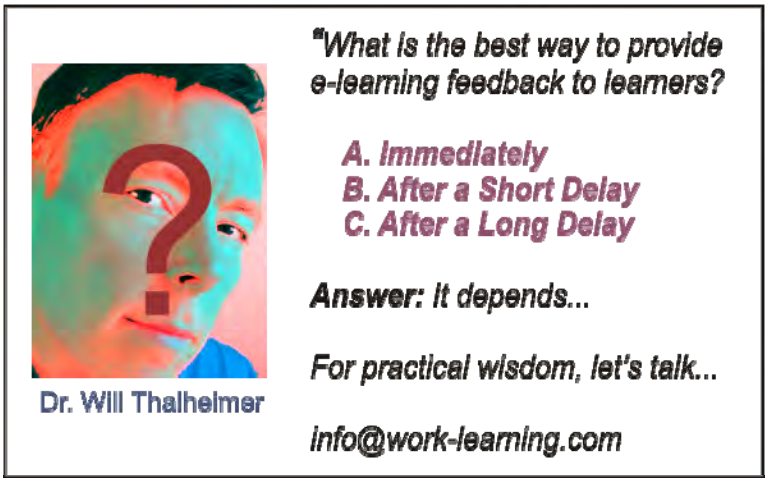
- **Discussion Leader:** Ensures that the discussion proceeds in a productive manner.
- **Notetaker:** Takes notes to document discussion points or decisions made.
- **Reporter:** Reports the group results to the full class.
- **Timekeeper:** Keeps track of the time and nudges group forward if necessary.
- **Monitor:** Keeps track of group members' affective responses and notes issues.

Dealing with Bells and Whistles of the Systems

Audience response software incorporates many features, and vendors are creating more and more capabilities all the time—for example, different gaming interfaces, team responding, timing mechanisms, display options, and many other features. There is a tendency when faced with this wealth of options for instructors to freak to the extremes—either incorporating every new option in a spasmodic cornucopia of distraction, or falling into paralytic overload and avoiding all the extras in fear of having to sift through the proverbial haystack. My recommendation is a calming middle ground. While it is a good idea to know what options are available, it's helpful to remember our instructional goals. We ought to use the technology when it meets a specific learning need, instead of using it willy-nilly to jazz up our classroom.

Use Technology as External Memory for Instructor

As an instructor, you may not remember everything or every reason for each answer choice. If audience response technology allows, you might be able to give yourself quick reminders about why the different answer choices are not correct.



Recommendations for Further Reading

Banks, D. A. (2006). *Audience response systems in higher education: Applications and cases*. Hershey, PA: Information Science Publishing.	This is the latest and most comprehensive book on audience response systems. This book is ideal for readers who want to wade through many case studies and examples. It will be too frustrating for readers who want pithy recommendations.
Thalheimer, W. (forthcoming). *Audience response learning: Using research-based questioning and discussion techniques to improve your classroom instruction.*	This is my forthcoming book. It is intended to help instructors with specific research-based recommendations for utilizing audience response systems.
Duncan, D. (2005). *Clickers in the classroom: How to enhance science teaching using classroom response systems.* San Francisco: Addison Wesley.	A basic primer on using audience response systems for science teaching. This is a pamphlet, not a book.
Mazur, E. (1997) *Peer instruction: A user's manual*. Upper Saddle River, NJ: Pearson-Prentice Hall.	The early classic on using audience response systems to teach physics.
Research Citations from Vanderbilt www.vanderbilt.edu/cft/resources/teaching_resources/technology/crs_biblio.htm	This is a great Website that contains most of the research articles on audience response systems.
Audience Response Learning www.AudienceResponseLearning.org	This is my Website, designed to be an unbiased source of information on audience response learning.

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Endnotes

[1] Quoted from the forward of the book, *Clickers in the classroom*, by Douglas Duncan (2005), San Francisco: Pearson – Addison-Wesley.

[2] Quoted from Horowitz's (1998) article, Student response systems: Interactivity in a classroom environment. *Proceedings of Sixth Annual Conference on Interactive Instruction Delivery. Society for Applied Learning Technology*, 8-15. This article has been updated in 2003 with a new title, Adding More Power to PowerPoint Using Audience Response Technology, available at: www.audienceresponseinfo.com/audience-response-info/power-to-powerpoint.html.

[3] There are many reports on the failures of lectures and traditional classrooms. For example, see Langer, 1997; Bligh, 2000; Stolovich & Keeps, 2002.

[4] Although teacher-led instruction remains ubiquitous, for the past 15 years or so primary-school education has been transforming itself toward more interactive learner-centered instruction. For example, many classrooms now use group seating as an improvement over the traditional all-desks-toward-the-front seating. Cooperative learning is well entrenched in classrooms and in research. See, for example, Chapter 5 in the National Research Council's book, *Learning, remembering, believing: Enhancing human performance* (Druckman & Bjork, 1994, pp. 83-111). See also, Slavin, Hurley, & Chamberlain (2003).

[5] Although audience response systems have a long history—going back as far as the 1950's or 1960's—it has only been in the last five to ten years that wireless capability has made them widely practical. Unfortunately, the newness of their availability has not enabled the marketplace to settle on a naming convention. There is no dominant brand name like Kleenex, Clorox, Ziploc, or Tupperware. Furthermore, until recently there was no generic label that manufacturers or users could agree on.

However, as I write this in March 2007, it has become clear that the market is rallying around the generic term "audience response system."

David Banks used the term "audience response system" in the title of the book he edited in 2006. The book includes chapters from over 50 researchers, instructors, and learning professionals who have been pioneering the use of these systems. They don't all use the same terminology, but the book title seems to have accelerated a move toward the term "audience response systems."

In addition, searching Google from among the list of candidate names in March 2007 revealed that the term "audience response system" garnered the most hits by far, almost double its nearest competitor. Moreover, while a similar search four months earlier found the same top rating for "audience response system," the gap seems to be widening. On March 14, 2007, searching Google for "Audience Response System" found 82,300 Web pages; "Classroom Performance System" got 41,800; "Student Response System" got 30,600; "Classroom Response System" got 21,400. As David Banks said in his book, using the most popular search term helps those of us who want to learn more about audience response systems.

Finally, of the 26 vendors I was able to locate (see www.AudienceResponseLearning.org), 14 used the term "audience response system" to refer in general to the type of product they were offering, three used the term "classroom response system," and the rest used various other names.

[6] While this paper only covers the utilization of handset technology, similar interactive technologies for use in the classroom include wireless laptops and PDAs, which have also been used to support active learning (Barak, Lipson, & Lerman, 2006).

[7] Many studies report that learners like using audience response systems and thought that the systems helped them learn. For example, see Judson & Sawada, 2006; Mazur, 1997; Hake, 1998; Crouch & Mazur,

2001; Dufresne, Gerace, Leonard, Mestre, & Wenk, 1996; Draper & Brown, 2004; Carnaghan & Webb, 2005; Nicol & Boyle, 2003; and Stuart, Brown, & Draper, 2004.

[8] See, for example, all or almost all of the authors of chapters in the book by David A. Banks (2006).

[9] Most of the research has been done with high school and college students, while some research has also been conducted with middle-school students and employees in training situations. Topics of all types have been covered, including the hard sciences, social sciences, business, humanities, and computer programming. Good learners and poor learners have been studied. While the research is not extensive for all audiences, all ages, and all types of curriculum; the findings seem applicable generally. Unfortunately, in doing learning research in classrooms it is very difficult to isolate the effects of individual variables. It is also difficult to prevent effects due simply to instructor enthusiasm. The research that has been most popularly referenced as demonstrating the benefits of audience response learning has significant limitations. It either (a) has methodological weaknesses (e.g., Hake, 1998; Crouch & Mazur, 2001), (b) doesn't disambiguate the effects of audience response technology from the effects of active-learning techniques (e.g., Hake, 1996), (c) doesn't measure learning—only learner opinions (e.g., Draper & Brown, 2004), or (d) has a methodology section so ambiguous as to make evaluation of the research impossible (Poulis, Massen, Robens, & Gilbert, 1998).

[10] For example, Nicol & Boyle (2003) compared two methods of active learning using audience response systems, but didn't compare these methods to traditional classroom instruction.

[11] For example, see Palinscar & Brown, 1984; Kourilsky & Wittrock, 1992. In addition, leading textbooks have also highlighted the value of active learning practices (Good & Brophy, 2002; Wiske, 1997).

[12] For example, Wit, 2003.

[13] Many instructors and learners have described the importance of anonymous responding (e.g., Draper & Brown, 2004; Stuart, Brown, & Draper, 2004).

[14] Research on response cards generally finds positive effects; however, the learning paradigms tend toward rote rehearsal strategies for relatively low-level information. The research has not tested the value of response cards on higher-order thinking skills. Some representative research on response cards includes: Marmolejo, Wilder, & Bradley, 2004; Gardner, Heward, Grossi, 1994; Kellum, Carr, and Dozier, 2001; Narayan, Heward, Gardner, Courson, Omness, 1990; and Christle & Schuster, 2003.

[15] My doctoral dissertation adviser, Dr. Ernie Rothkopf, coined the term "mathemagenic", and I continue to find the term a very helpful shorthand to use in describing our learning goals. Rothkopf (1965, 1966) coined the term while investigating the effects of questions placed into text passages. The term means "to give birth to learning." Ernie's intention was to highlight the fact that it is something that learners do in processing (thinking about) learning material that causes learning and long-term retention of the learning material.

[16] For reviews of relevant research see Dweck, 2006; Kohn, 1999.

[17] Crouch & Mazur (2001, p. 973). They cite as their inspiration for this a book by Novak, G., Patterson, E., Gavrin, A., & Christian, W. (1999). *Just-in-time teaching: Blending active learning and web technology.* Upper Saddle River, NJ: Prentice-Hall.

[18] I am NOT a physicist. In fact, I had to go to summer school in high-school to retake a physics class. So, although my question may be a perfect representation of physical reality, it could also be off the mark. I was inspired in writing this question from the following Website: Hwww.glenbrook.k12.il.us/gbssci/phys/Class/newtlaws/u2l1b.htmlH, compiled by Tom Henderson of

Glenbrook South high school.

[19] Meerman, R. (2004). Science conundrums: Get them thinking. Conundrum #1 Rock in a boat in a pool. Downloaded February 2007 from Hwww.abc.net.au/science/surfingscientist/pdf/conundrum1.pdfH. Other conundrums are available at: Hwww.abc.net.au/science/surfingscientist/teachstuff/conundrums/H.

[20] Thalheimer, W. (2006). *Spacing learning over time: What the research says*. Available at Hwww.work-learning.com/catalogH.

[21] The best answer—if my lay view of cell biology is correct—is C.

[22] While providing retrieval practice during learning in a way that simulates the future retrieval context is generally the most effective strategy, it is not the only viable strategy. For example, providing multiple contexts for retrieval is beneficial.

[23] Sometimes it is valuable to let learners fail in retrieval to spur reflection, encourage better mathemagenic processing, or simply to wake them from their daydreams. However, letting learners continually practice incorrectly is not recommended.

[24] Feedback tends to be much more critical when learners have misunderstandings than when they have appropriate understandings. If learners search memory and retrieve the correct information, giving them feedback doesn't provide much benefit. Feedback will certainly help if a learner's retrieval attempt represents a guess, but otherwise the learner has already done the best thing they can to aid subsequent retrieval—they've successfully navigated the process from cue to memory-search through to correct retrieval.

[25] Sometimes we go halfway, so in a session of meat spoilage, we say, "Pick out the tainted meat." Unfortunately, this kind of practice is not authentic and it doesn't completely prepare learners for the real world when learners are thinking about other things—not "HEY, THIS IS A CLASS ON MEAT SPOILAGE, SEE ANY!?!!" In my forthcoming book, I'll introduce the SEDA model, which provides a way to think about how to ensure authentic practice.

[26] For reviews, see Bjork & Richardson-Klavehn, 1989; Smith, 1988; Smith & Vela, 2001; Eich, 1980; Roediger & Guynn, 1996; Davies, 1986.

[27] Thalheimer, W. (2002). *Simulation-like questions: How and why to write them*. Available at www.work-learning.com/catalog. Thalheimer, W. (2003). *Research that Supports Simulations and Simulation-Like Questions*. Available at www.work-learning.com/catalog.

[28] You may have noticed that when I dropped an answer choice by anticipating which answer learners would gravitate to, I asked them to raise their hands. In this case, it's quicker and simpler than using the handsets. We should use the best technology for the job.

[29] Problem-solving can often be improved by brainstorming more than one solution to a problem before picking a course of action.

[30] I basically made up this question and answers as an example, based on a quick Web search to generate the answer choices and the question content. You should do a more thorough search to generate questions in your area of expertise. Do not use this question yourself.

[31] I copied these questions from Wikipedia on December 8, 2006. (Hhttp://en.wikipedia.org/wiki/Trolley_problemH). A good discussion of this issue can be heard as a podcast from the radio show Radio Lab (Hwww.wnyc.org/shows/radiolab/episodes/2006/04/28H).

[32] Richard Mayer and his colleagues (e.g., Moreno & Mayer, 2000; Mayer, Heiser, and Lonn, 2001) have found that adding photos, sounds, and video can produce learning decrements for the main points presented in the instructional material. I have criticized this research for being done in very short learning sessions (less than four minutes in length on average), but the negative effects are still something we should avoid when designing our learning interventions (Thalheimer, 2004).

[33] Research psychologists have found that learners will retrieve more information from memory if they try to retrieve that information in the same place in which their learning took place (e.g., Smith, Glenborg, & Bjork, 1978). Similarly, when scuba divers learn underwater, they recall more underwater than nearby on land, and vice-versa (e.g., Godden & Baddeley, 1975). For reviews see Bjork & Richardson-Klavehn, 1989; Smith, 1988; Smith & Vela, 2001; Eich, 1980; Roediger & Guynn, 1996; Davies, 1986.

[34] This question was borrowed from an adaptation created from the work of Len Scrogan, *Constructing Higher Order Thinking Questions*, Boulder Valley School District.

[35] This question was borrowed from an adaptation created from the work of Len Scrogan, *Constructing Higher Order Thinking Questions*, Boulder Valley School District.

[36] This question was borrowed from an adaptation created from the work of Len Scrogan, *Constructing Higher Order Thinking Questions*, Boulder Valley School District.

[37] Woods, H. A., & Chui, C. (2003). Wireless response technology in college classrooms. Downloaded February 2007 from www.mhhe.com/cps/docs/CPSWP_WoodsChiu.pdf.

[38] Schwartz, D. (2007). Personal communication on February 12, 2007. Dr. Schwartz's suggestions for further reading on this point: Schwartz, D. L. (1995). Reasoning about the referent of a picture versus reasoning about the picture as the referent: An effect of visual realism. *Memory & Cognition*, **23**, 709-722; Schwartz, D. L. & Black, J. B. (1996). Analog imagery in mental model reasoning: Depictive models. *Cognitive Psychology*, **30**, 154-219; and Schwartz, D. L. & Moore, J. L. (1998). The role of mathematics in explaining the material world: Mental models for proportional reasoning. *Cognitive Science*, **22**, 471-516.

[39] Schwartz, D. (2007). Personal communication on February 12, 2007. Dr. Schwartz also noted this was also discussed in diSessa, A. A., Gillespie, N., & Esterly, J. (2004). Coherence vs. fragmentation in the development of the concept of force. *Cognitive Science*, **28**, 843-900, which actually shows that younger learners do better than high-school students.

[40] Schwartz, D. (2007). Personal communication on February 12, 2007.

[41] Schwartz & Heiser (2006).

[42] This Web page was retrieved in February 2007.

[43] It would be a shame if we couldn't figure out a way to share our questions and approaches with each other.

[44] From article in *Harvard University Gazette*, February 23, 2006, by William J. Cromie. Title: Harvard launches wireless classroom: Lessons in the palm of your hand. Retrieved December 14, 2006 from Hwww.news.harvard.edu/gazette/2006/02.23/05-eclassroom.htmlH.

[45] Beatty, Gerace, Leonard, & Dufresne (2006a; 2006b); Dufresne, Gerace, Leonard, Mestre, & Wenk, 1996.

[46] For example, see Crouch & Mazur, 2001; Draper & Brown, 2004; Boyle, 2006.

[47] Crouch & Mazur, 2001.

[48] Draper & Brown, 2004.

[49] Crouch and Mazur (2001) suggest that the increasing adoption rates for Peer Instruction methods are due in large part to the ease of adapting Peer Instruction to the local context.

[50] Many instructors have mentioned the need for supporting learners in moving to the use of audience response systems. For example, see Crouch and Mazur, 2001; Duncan, 2005; Mazur, 1997; Penuel, Abrahamson, Roschelle, 2006; Beatty, Leonard, Gerace, and Dufresne, 2006; Boyle, 2006. Even when a new active-learning approach is introduced without introducing audience-response technology, learners need to be prepared for the process and given time to adjust (Hansen, 1998; Langer, 2001).

[51] Home cooking is the correct answer. Why? Because ethnic prejudice is instilled by parents who think that they are doing their children a favor by instilling such prejudice. In actuality, they are harming their children because such prejudice usually limits opportunities and thinking, confines their children to a lifetime of anger and animosity, and is potentially dangerous as it may put their children into violent situations. Home cooking is also done with good intentions and with love, but when it creates food that is unhealthy (like food with trans fat), the effects on children are harmful. Egads!

[52] Mazur, 2006; Duncan, 2005.

[53] Nicol & Boyle, 2003.