Why should students learn science? How should students learn science? How do we know when they learn science? Helping future teachers to find answers to these questions is a goal that appears in the mission statements of science pedagogy courses around the world. Once out of the college classroom and into our own, however, it becomes clear that finding the answers is a lifelong and not just a semester’s journey. Our goal in this regular feature of Cell Biology Education is to provide insights that come from educators at various stages and from various perspectives along the journey. To inform decisions about science teaching and learning and classroom practice, we present philosophies and research findings that underlie the practical tips that we offer.

The online format of Cell Biology Education invites a reader response. We encourage you to contact us: 1) to ask questions about what you have read; 2) to tell us about specific examples of when you have tried an approach highlighted in the column, and whether it did or did not work; or 3) to share additional tips or resources that would be useful to others. We begin each new feature by sharing some of these comments, with your permission, of course. Please include your name, institution, and e-mail on all correspondence. We look forward to hearing insights and stories from you.

ANSWERS WORTH WAITING FOR: “ONE SECOND IS HARDLY ENOUGH”*

In teaching students of any age, on any topic, questions are a teacher’s best friend. Questions provide insight into what students already know about a topic, determining points for teaching. Questions reveal misconceptions and misunderstandings that must be addressed to move student thinking forward. Questions challenge students’ thinking, leading them to insights and discoveries of their own. Perhaps most important, questions are often an instructor’s only tool in checking for understanding during an explanation of organelles to middle-grade students or during a lecture on the machinery of protein translation to undergraduates.

Questions play such an important pedagogical role that student teachers are encouraged to ask them from the moment they first set foot in a classroom. The anecdote below from a student teacher (quoted from an article about reflective practice in teaching) points out just how hard it is, however, to put into practice such a seemingly simple act: asking a question. As he was encouraged to do in his pedagogy courses, the apprentice teacher telling the story opened his first class by posing a provocative question. And then he waited . . .


(Loughran, 2002, p. 37)

Most of us, no matter how long we have been teaching, can vividly recall such an excruciating moment of silence, which seemingly stretched on into years, as we waited for students to respond to our question. Teachers of all levels attempting to increase wait time in their own teaching practice describe it as “uncomfortable,” “awkward,” or even “painful,” at first. Is it worth the wait? Mary Budd Rowe’s ground-breaking papers introducing the concept of “wait time,” are also enduring, having influenced teachers at all levels of education for the last 30 years (Rowe, 1969, 1974, 1978, 1987), and suggest that the answer to this question is a resounding, “Yes!”

Working with an audio-recorder and a chart-plotter as her primary scientific tools, Rowe examined hundreds of elementary-school classrooms asking the question, “How long do teachers wait after asking a question of their class, before receiving an answer or speaking again themselves?” Surprising to many, including the teachers themselves, Rowe found that on average, teachers waited only 1.5 s after their question for a student response (Rowe, 1974). If no student response came in that time period, teachers either asked a follow-up question or answered the question themselves. Rowe coined the term “wait time,” more recently referred to as “deliberate silence” or “think time” (Stahl, 1994), to describe the time window after a question has been asked by an instructor. Additionally, Rowe found that teachers allowed the most wait time for high-achieving students in their classes (an average of two seconds) and the least wait time for low-achieving students (an average of nine-tenths of a second), providing strong evidence that teachers’ expectations of a student influence the time they allow that student to attempt a response to a question (Rowe, 1978).

Surprised by the briefness of classroom wait times, Rowe collaborated with 50 teachers to study what would occur when instructors deliberately waited 3–5 s after asking a question. The discovered effects of extended wait time are impressive. Rowe and colleagues found that waiting 3–5 s,
just 1.5–3.5 s longer after asking a question, resulted in dra-
matic changes in student responses. Students gave longer,
more complex answers, on average increasing their response
length from 7 to 28 words (Rowe, 1974). Indeed, the num-
ber of students answering “I don’t know” or refusing to an-
swer declined (Rowe, 1974). In addition, more students were
willing to respond to the question, increasing the number of
students offering responses from 3 to 37 in one classroom
studied (Rowe, 1974). Classrooms became less teacher cen-
tered, promoted more dialogue between students about their
ideas, and raised the caliber of the discussion in general. The
effects of increased wait time were not limited to student be-
haviors, however, but also altered teachers’ behavior. Rowe
found that when implementing wait times of greater than 3 s,
teachers’ decreased the percentage of class time they spent
talking. When they were talking, teachers asked more chal-
 lenging and cognitively complex questions. In addition, the
differential wait times for high- and low-achieving students
was reduced (Rowe, 1978).

Upon reflection, however, it should be unsurprising to cell
biologists, especially, that longer periods of time following a
question could have these dramatic effects. For what is cog-
nition but cellular communication, and cellular communica-
tion takes time. Extending wait time allows the brains and
minds of students to engage completely in all of the cell bio-
logical wonders of considering and answering a question—
auditory sensation, synaptic transmission, memory retrieval,
multisensory cognitive integration, and the neuromuscular
coordination required to speak. All things considered, 3–5 s
still seem “hardly enough.” One thousand one, one thousand
two, one thousand three, one thousand four, one thousand
five. Try it out yourself. Five seconds is longer than you think!

If insufficient wait time can discourage student participa-
tion and decrease the potential for quality responses, then
the remedy seems simple—just wait, and wait some more.
Rowe’s and others’ studies on wait times in typical classrooms
suggest, however, that it is not all that easy. Perhaps unlike
the student teacher quoted above, most of us tend to abhor
the vacuum of silence our questions inadvertently create. If
students perceive this discomfort and sense that we do not
have the tenacity to wait, the majority of them will remain
knowingly silent until we move on, or worse, until we rush
in to fill the silence with our own answers. Fortunately, al-
ternatives to simply waiting do exist, and many instructors
found that when implementing wait times of greater than 3 s,
teachers’ decreased the percentage of class time they spent
talking. When they were talking, teachers asked more chal-
 lenging and cognitively complex questions. In addition, the
differential wait times for high- and low-achieving students
was reduced (Rowe, 1978).

Another classroom strategy (Lyman, 1981) to structure wait
time is commonly known as “Think-Pair-Share” (National In-
stitute for Science Education, 1997). Although more complex
than Multiple Hands, Multiple Voices, it nevertheless is a rel-
avely easy activity to integrate within an existing lecture or
laboratory course framework, and takes relatively little time
to plan and implement (as little as 10 min). Think-Pair-Share
is a cooperative learning (Johnson and Johnson) strategy, where
student pairings are informal and brief, eliminating the need
for monitoring strategies recommended when groups work
together for extended periods of time. The basic steps for car-
rying out a Think-Pair-Share activity go as follows:

1. Pose a question at the same point during the class discussion
in which you would ordinarily ask that question or would choose to open up a topic for discussion.
2. Allow time for individuals to think independently. Give
students about 30 s (or longer if the question is more com-
plex) to think about how they would answer the ques-
tion. Ask students not to say anything out loud until you
give the cue for Step 3. Often, charging students to jot down
their ideas on paper helps maintain both the silence and
the independence of the thinking.
3. Form the pairs. Invite students to discuss their ideas with
a classmate seated nearby and allow several minutes for
pairs to share their ideas with one another and perhaps pre-
pare a composite response. If the class is large or students
unacquainted with one another, some may need your as-
sistance in finding a discussion partner.
4. Invite pairs to share their ideas with the whole class. Ask
for volunteers or call on pairs. The number of pairs that
it is most beneficial to hear from typically depends on the
complexity of the question. A tip for concluding the class
discussion when time is at a premium is to listen for the
point at which pairs begin to repeat the same answers. At
that point, ask if there are any pairs who have different
ideas to contribute.
5. Provide summative commentary on the responses.

Although it is tempting to use the time when pairs are
discussing the question to organize your thoughts, walk-
ing around the room to monitor the discussions has many
advantages. Listening in on the conversations will give you
a sense of when the class is ready to move on to Step 4 (the whole
class discussion). It allows you to preview student ideas,
which can help with flow of the whole class discussion—you can call on pairs whose choice comments you overhear if the discussion later stalls or responses seem to lack the wished-for depth or insight. An acknowledgment to the class that you heard some good ideas during the pairs’ discussions can help some students overcome their reluctance to reveal their thoughts in front of the whole class. Most important, listening to the pair discussions is an opportunity for assessing what concepts students have understood, where they are still struggling, and what misconceptions may have arisen during the class.

By structuring wait time, Think-Pair-Share allows students time to both think on their own and have an opportunity to try out their ideas with another person in a low-stakes discussion. This not only promotes greater class participation and higher quality responses, but it also actively engages students in recalling, processing, and communicating what they have learned. A last, but not trivial benefit is that it gives students a chance to meet each other, which can help to lessen the sense of isolation that they commonly report feeling in large enrollment science classes (Seymour and Hewitt, 1997).

One-Minute Paper

Another strategy for structuring wait time is the “Quick Write” or the “One-Minute Paper” (Mazur, 1996). As a variation of Think-Pair-Share, the One-Minute Paper is suited for more complex questions or when the instructor wants to collect more in-depth information from all students about their individual understandings of the course material. In this classroom strategy, a brief writing period (more than just jotting down ideas) is allowed after a question is posed during class. This writing period can also be inserted between the thinking and pairing steps of Think-Pair-Share. Students write down individual comments on an index card or half-sheet of notebook paper and turn them in to the professor. For more complex questions or when the instructor wants to collect more in-depth information from all students about their individual understandings of the course material. In this classroom strategy, a brief writing period (more than just jotting down ideas) is allowed after a question is posed during class. This writing period can also be inserted between

strategies increase the likelihood that waiting will actually occur, optimizing the possibility for the positive outcomes documented in the original studies—more responses, longer responses, and responses from more students. But do these strategies always work as intended? Well, not always. But when they do not, it may be that the problem lies not with the strategy, but with the original question that was asked. In the next “Approaches in Cell Biology Education” feature, we will explore how to construct and ask questions worth answering.

REFERENCES


Additional Reading


