CHAPTER ONE

# ENGAGING STUDENTS WITH CLICKERS



Classroom response systems are instructional technologies that allow instructors to rapidly collect and analyze student responses to questions posed during class. Systems are typically used in the following manner. First, an instructor poses a question, often a multiple-choice question, to the students. The students think about the question and submit their responses to the questions using handheld wireless transmitters, usually called *clickers*, which often look like television remote controls, and beam signals to a receiving device attached to the instructor's classroom computer. Software on the computer produces a bar chart showing the distribution of student answers. Instructors then use these results to decide how to proceed during class: having students engage in small-group or classwide discussions on the question at hand, moving on to the next topic if the results indicate students are ready, or something else entirely.

For example, I once displayed the question in Example 1.1 in a course on probability. After giving students a minute or two to think about and respond to the question without discussing it with each other, I had my classroom response system generate the bar chart shown in Figure 1.1 as a summary of the student responses. Since the correct answer to the question is ''one boy and one girl,'' an answer that only four of the sixteen students selected, I then had the students discuss the question in pairs. After a minute or two of lively discussion, the students voted again using their clickers. The system then produced the bar chart shown in Figure 1.2, indicating to me that the small-group discussion time

was productive and that most students had a better understanding of the question.

I then asked for a student who changed his or her mind from ''all are equally likely'' to ''one boy and one girl'' to share with the class the reasons for doing so. One of my students volunteered and offered an explanation of the question. I listened to the explanation and responded by drawing an appropriate diagram on the chalkboard, offering a supplemental explanation, and then asking for student questions. In less than ten minutes, most students came to their own understanding of the question at hand.

*Example 1.1*

Your sister-in-law calls to say that she's having twins. Which of the following is more likely? (Assume that she's not having identical twins.)

A. Twin boys

B. Twin girls

C. One boy and one girl

D. All are equally likely

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The use of small-group discussion in the manner described is usually called *peer instruction*, after Mazur (1997), and is described in more detail later in this chapter. The choice of the instructor

FIGURE 1.1. SAMPLE RESULTS FROM FIRST VOTE.

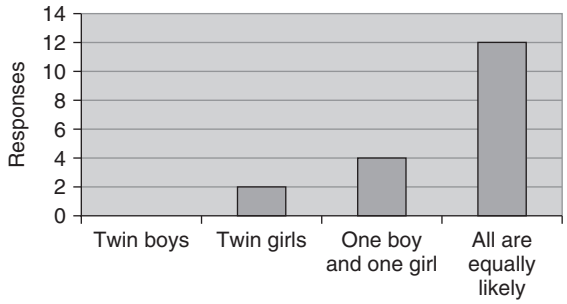
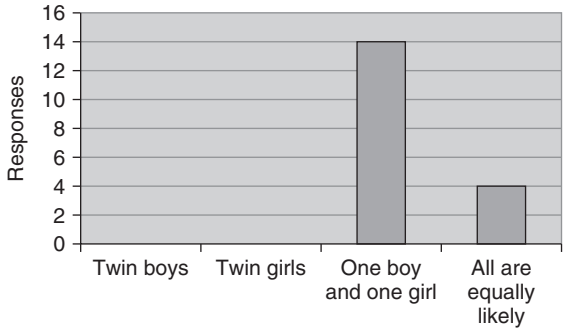


FIGURE 1.2. SAMPLE RESULTS FROM SECOND VOTE.




to have students engage in peer instruction after seeing the results of the first vote is an example of what is sometimes called *agile teaching* (Beatty, Gerace, Leonard, & Dufresne, 2006), an approach to using classroom response systems explored in Chapter Two. The question in Example 1.1 might be classified as an application question since it requires students to apply the notion of a probability space to a particular situation. The example question, activity, and results described are drawn from my own teaching, but many other instructors use similar questions and similar techniques in their own disciplines. As the remainder of this book makes clear, however, there are many ways to use clickers in the classroom.

Since classroom response systems rely on students' submitting their responses to questions with handheld clickers, using these systems requires some way of distributing clickers to students. At some institutions, students purchase clickers sold at the campus bookstores, right alongside textbooks and graphing calculators. A clicker usually costs between twenty and sixty dollars. Some textbook publishers bundle reduced-cost clickers with their textbooks. At these institutions, students bring their clickers with them to class and use them in multiple courses. Instructors often have students register their clickers to allow instructors to track and sometimes grade individual student responses. For example, students might enter their clicker serial numbers in their local online course management system, allowing instructors to import

those serial numbers along with student names to their classroom response system software. After each class session in which clickers are used, instructors can assign participation grades to the students in the class based on their responses to questions.

On other campuses, schools or departments purchase sets of clickers for instructors to use. An instructor brings a box of clickers to class, and students pick one up on their way into the room. They use the clickers during class to respond to questions and return them to the box on their way out of the classroom. This method of distribution makes it easy for students to use clickers anonymously. If instructors using this method are interested in tracking student responses, the clickers might be clearly labeled with numbers and students instructed to pick up the same clickers in each class session. A spreadsheet that matches student names with clicker numbers can then be used to track and grade individual responses.

Instructors using classroom response systems also require receivers and appropriate software. Some instructors borrow receivers from instructional technology or classroom media offices or their departments. Other instructors use free or reduced-cost receivers from vendors or textbook publishers. The software for these systems is usually available for free download from vendor Web sites. Many vendors' software programs include gradebook tools allowing instructors to track and manage student clicker grades and export them to commonly used online course management systems. Getting started using response systems can take some instructors some time. Chapter Five provides more on this issue, as well as information on the technical and logistical features of various systems.

Classroom response system technology dates back at least to the 1960s. Early systems used transmitters and receivers connected by wires instead of the infrared and radio frequency wireless connections of today's systems. Many of the ways today's systems are used to engage and assess students were described in the literature on these early systems. ( Judson and Sawada, 2002, provide a review of this literature, as well as some historical information on early systems. Historical information is also provided in Abrahamson, 2006, and Judson and Sawada, 2006.)

Classroom response systems are known by many other names, including *student response systems, audience response systems, personal response systems, classroom communication systems, group response*

*systems*, and *electronic voting systems*, and others too. I use *classroom response system* in this book as a popular and fitting term for these systems. *Audience response system* is another popular term (Banks, 2006), but some instructors who use clickers to engage students during class dislike the idea of describing students as audience members given the passive role audiences usually play in other settings. *Student response system* is also a useful term, but it can be used to describe online as well as classroom response systems. This book focuses on the use of these kinds of systems in face-to-face classrooms, although some of the principles and strategies for using classroom systems are likely to apply in online settings.

Some instructors interested in teaching with classroom response systems are curious to know what research studying their effectiveness has been conducted. The consensus of several literature reviews (Caldwell, 2007; Fies & Marshall, 2006; Judson & Sawada, 2002; Roschelle, Penuel, & Abrahamson, 2004; Simpson & Oliver, 2007) seems to be that the use of clickers often increases student attendance, participation, and enjoyment of classes and provides students and instructors with useful feedback on student learning. Most students and instructors like using clickers, which they find fun and enjoyable to use. There also seems to be consensus regarding the impact of classroom response systems on student learning. The impact depends in large measure on the instructional methods by which clickers are used. Teaching methods that use active learning, such as small-group and classwide discussion methods, typically result in improved student learning over methods in which students play more passive roles. It is not clear from the literature the extent to which classroom response system technology plays a role in these learning gains. It is possible that the methods themselves are responsible for learning gains, and clicker technology merely facilitates and supports those methods. This finding motivates much of the discussion of teaching choices found in this book since it appears that how instructors choose to use classroom response systems is the most important variable in their impact on student learning. Most literature reviews call for further research into the effects of clickers on student learning. I hope that this book, particularly the reasons for using clickers outlined in Chapter Six, will provide future researchers with useful frameworks for their investigations.

One reason to use classroom response systems is that they have the ability to allow every student to respond to a question and the ability to display the distribution of student responses for all students to see. These abilities can make a classroom response system an effective tool for engaging students during class. Here the term *engagement* refers to more than just participation in class. Engaged students are those who are actively involved in class discussions and thinking intentionally about course content during class. Classroom response systems can be used to engage students in a variety of ways, including classwide and small-group discussions, that can foster active learning in the classroom.

## Generating Classwide Discussions

One common use of classroom response systems is generating and fostering classwide discussion. A typical structure for doing so might be called ''think-vote-share,'' after the ''think-pair-share'' classroom engagement technique first proposed by Lyman (1981), which many instructors use without clickers. Instructors using clickers in this way first pose a multiple-choice question to their students. Students think about the question and submit their answers using their clickers. The instructor then displays the bar chart generated by the system showing the results of the question, indicating how many students selected each answer choice. These results, along with the thinking that students do prior to submitting their responses, inform and enhance subsequent classwide discussion facilitated by the instructor.

### *Case Study: Communication Studies*

Michael Dorsher teaches a course on mass media ethics at the University of Wisconsin at Eau Claire. Each section of the course has between thirty and forty students. In the past, section sizes tended to be smaller, and the sections were oriented toward discussion. As enrollment in the course grew, Dorsher found it more difficult to have the kinds of discussions in which he wanted his students to engage. He now uses a classroom response system to help generate these kinds of discussions. For example, he presents his students with the following ethical dilemma: Suppose you are an editor at the *Washington Post*, and the Unabomber

has demanded that you print his thirty-thousand-word manifesto or he will continue sending mail bombs as acts of terrorism. Dorsher then poses the first two questions in Example 1.2, asking his students to identify the values and loyalties that would be most important to them in this situation and leading a classwide discussion after each question. He then poses the third question in Example 1.2, asking them to identify the ethical philosophy and course of action that best matches the most important value and loyalty identified in the previous two questions.

*Example 1.2*

Question 1. As *Post* editor, which would you value most?

A. Upholding First Amendment independence from government

B. Increased readership

C. Maintaining credibility

D. Possibly helping save lives

E. Informing readers

F. Not acquiescing to terrorists

G. Possibly helping capture a criminal

Question 2. As *Post* editor, to whom do you most owe loyalty?

A. The terrorist, who's threatening you

B. Future potential victims of the terrorist

C. The surviving victims and families of dead victims

D. The government

E. Your readers/the public

F. Yourself and other journalists

Question 3. With a top value of _____ and a top loyalty of _____, which ethicist would you follow?

A. John Rawls: Protect the vulnerable; print the manifesto.

B. John Stuart Mill: The greatest good for the greatest number; don't print it to uphold press independence.

C. Aristotle: The golden mean would be to excerpt it in the paper and publish it all online.

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Dorsher's third question can be particularly challenging for students since it may not have a single right answer depending on the value and loyalty selections the students chose in the first two questions. Students are required to select the one answer they feel best matches the responses to the earlier questions. On a quiz or exam, this kind of ambiguity would be a problem in a multiple-choice question. However, for a question used to foster in-class discussion, this ambiguity is a strength: it creates the opportunity for students to share and discuss the reasons they have for selecting particular answer choices, thereby encouraging critical thinking.

Dorsher finds that without clickers, often the vocal minority of students in his class ends up making the decisions on the first two questions. With clickers, more student voices are heard, and the majority makes the decision instead. One danger he finds in this process is that sometimes the minority can be silenced by the fact that they know they are in the minority, a fact made evident by the display of the clicker results to the entire class. Dorsher is careful to encourage the minority to express and defend their reasoning, playing the role of devil's advocate as necessary to keep the discussion going.

## Why Use Clickers for Classwide Discussions?

Although classwide discussion is a frequently used instructional technique, it is worth mentioning a few reasons to have students engage in these discussions. Since students are often better able to make sense of ideas and concepts when they are given the chance to process those ideas and concepts in some way as they are learning about them, classwide discussion can be a useful way to help students learn during class. A lively classwide discussion can

also help students pay attention and stay engaged during class. Classwide discussions also help instructors leverage the social aspects of the community of learners that constitutes a classroom. For instance, students often appreciate the chance to hear from and get to know each other, a process that can occur during a classwide discussion. Furthermore, sometimes students are better able to follow an explanation given by a peer than one given by their instructor. Classwide discussions provide opportunities for students to hear each other describe and grapple with course content.

Classroom response systems can augment classwide discussions in several ways. For example, instructors not using clickers often pose a question to their students, then ask for student volunteers to share their answers to the question. This approach has the disadvantage that students who do not volunteer answers need not engage seriously with the question. Some do, of course, but some may not, preferring to wait and hear from their peers before thinking deeply about the question at hand. Since students are more likely to learn when they do their own thinking, it is useful to encourage as many to think independently about a question as possible. Clickers can help make that happen since each student is asked to respond to a question before hearing other students' answers. This gives all students a chance to thoughtfully respond to a question, setting the stage for a productive class discussion that involves more students who are ready to share their diverse thoughts and perspectives.

Clickers give all students the chance to respond to a question independently, including shy students who might be hesitant to speak up in front of their peers, students who take more time to compose responses than might be provided otherwise, and students who simply would not be heard due to time constraints. This gives more students a voice in the classroom, as Dorsher observes, and helps these students prepare to participate more fully in a class discussion.

Since clickers allow students to respond to a question without their peers knowing their answers, they provide students with a level of anonymity that can encourage participation. Students who might not voice their opinions about a topic publicly for fear of being in the minority are given a chance to register those

opinions with their clickers. When responding to questions with right and wrong answers, some students are hesitant to volunteer their responses publicly out of fear of being wrong in front of their peers. Clickers allow these students to answer questions honestly and risk being wrong.

Furthermore, although students cannot use a classroom response system to identify the individual responses of their peers, instructors may do so after class. This allows instructors to hold students accountable for their participation in a class session. It can remove the students' ''cloaks of invisibility,'' a phrase used by Lee Shulman (quoted in Merrow, 2007) to describe the anonymity that students can use to avoid participation and engagement. Each student's responses to clicker questions can be viewed by instructors after class and factored into participation or other course grades. Knowing the system has this capability, students are often more likely to participate constructively in class.

The results of a clicker question can be displayed for an entire class to see, and this feature can help encourage discussion as well. For instance, students can learn that some classmates have different ideas and opinions, encouraging some students to want to hear more from those with different views. Also, students can learn that they are not alone in their ideas and opinions, which can encourage them to voice their thoughts during a discussion. This feature of classroom response systems can be a challenge as well, as Dorsher noted. Sometimes students who find themselves unexpectedly in the minority can be less eager to participate in a classwide discussion. Instructors often need to be careful when facilitating discussions in these situations. In addition, the display of clicker question results can demonstrate to students who answer a question correctly that many of their peers do not understand the question as well as they do. This can help justify to these students the use of class time devoted to exploring the question further.

### *Case Study: Biological Sciences*

Adam Rich teaches a sophomore-level course in anatomy and physiology at the State University of New York College at Brockport that typically enrolls about 170 students. He uses clicker questions to generate classwide discussions that focus on the reasons for

right and wrong answers to those questions in an effort to help students learn to build arguments.

Rather than using the think-vote-share activity, Rich poses a question to his students and has them submit their initial answers using their clickers. Instead of displaying the results to the students, he facilitates a classwide discussion of the question while allowing students to change their answers at any time. The classroom response system Rich uses allows him to monitor the distribution of responses as they change, providing him with information about how students are changing their minds during the discussion. He can use this information to continue the discussion until the students converge on the correct answer. Since the students cannot see the distribution of responses as they are submitted, they tend not to change their minds out of any kind of peer pressure. Instead, Rich finds that they consider and respond to the arguments their peers make during the discussion.

Rich has occasionally left the bar chart showing the real-time distribution of responses on the classroom projector screen for the students to see. When he did this, there was almost immediate convergence to a single answer choice, demonstrating what can happen when students do not respond independently to a classroom question. Instead of making sense of the arguments their peers put forth in favor of various answer choices, many students simply changed their responses to the most popular response, likely assuming that the popular answer was the correct one. Rich's clicker questions count toward 5 percent of his students' course grades. By not showing students the current responses to a clicker question but allowing them to change their responses during the discussion, he uses his students' interest in performing well in the course to motivate them to engage productively in his classwide discussions. He finds that students do so as long as they have the chance to change their answer choice to the correct one.

### *Case Study: Language Instruction*

Karina Kline-Gabel teaches intermediate- and upper-level Spanish courses at James Madison University in Virginia, many of which have around forty-five students. She uses clickers frequently for oral exercises in her classes. For example, she might display a piece of artwork on her classroom projector screen and make

a series of statements about the artwork. She asks her students to use their clickers to label each statement as correct or incorrect based on the grammar and vocabulary used in the statement. Often she makes the first few statements rather comically incorrect, probing students' vocabulary, before moving on to more challenging grammar issues. Clicker questions focused on grammar and vocabulary function to warm up students for more complex, subsequent tasks, such as discussing their opinions of the artwork.

Many of Kline-Gabel's clicker questions are correct-incorrect or true-false questions. Although students are likely to guess at correct answers to these questions half the time, Kline-Gabel almost always follows such a question with another question that asks students for reasons for their answers. For instance, she might ask, ''The sentence was not correct. What was the mistake in the sentence?'' and provide students with several possible choices. Kline-Gabel also often leads a classwide discussion of the correct-incorrect or true-false question that elicits reasons for student answers. Since her students know that they will be asked to supply reasons for their responses, she finds that they tend to take the questions seriously and not guess randomly. Her clicker questions, then, function to have students commit to answers to questions before a classwide discussion. This commitment can help them engage more actively in that discussion since they have a more vested interested in defending their answer choices.

Kline-Gabel finds that these exercises help students improve their second-language listening skills, in part because they isolate those skills from reading, writing, and speaking skills. She often conducts clicker-enhanced listening activities in lieu of activities in which students work independently on reading and writing activities. She finds that her students ask more questions about a clicker question they miss than they will about a reading exercise they do not understand. She believes this is because the clicker questions are discussed as a class, whereas a student with a question about a reading exercise has to raise his or her hand to ask it. Discussing difficulties as a class somehow makes it more acceptable for students to ask questions. Furthermore, she finds that when students are engaged in individual work in or out of class, they often move too quickly through that work, not engaging in it as seriously as they could. Clicker questions allow her to slow down

her students' pace, encouraging them to engage in the work more seriously and ask more questions. She also finds that her clicker activities help her students stay on task more than small-group activities.

## STRATEGIES FOR LEADING CLASSWIDE DISCUSSIONS

Many instructors have experience effectively leading classwide discussions. However, since classroom response systems provide each student in a class the opportunity to think about and respond to a discussion question and display a bar chart showing the distribution of student responses to the instructor and often the entire class, leading a discussion after a clicker question is a somewhat different task from other kinds of discussion leading. Following are some strategies for leading a classwide discussion following a clicker question.

1. *Have students share the reasoning behind their answers to the clicker question.* For many questions, those reasons are more important for students to understand than a particular answer. Also, students are sometimes able to understand their peers' explanations more quickly than those offered by their instructors.
2. *Make sure to hear from students about each of the more popular answer choices.* Some classroom response systems allow instructors to see how each student responded to a question, allowing those instructors to call on students who chose particular answers. More typically, however, instructors might say something like, ''Can I hear from a student who chose answer A?''
3. *If no student volunteers to defend or explain a particular answer choice, instructors might step in and suggest some reasons for that choice.* They might also ask students to hypothesize why someone might find that choice reasonable. Since it is often useful for students to think through wrong answers as well as right ones, spending some time on wrong or unpopular answers can be important.
4. *Encourage students to respond to and challenge each other's comments during the discussion.* A discussion in which students reason

with and debate each other can often lead to deeper learning than one in which the instructor does all the challenging and debating.

5. *Refrain from making important points during the discussion if those points can be made by the students.* The understanding that students gain by discovering the points themselves is often longer lasting. If students miss a few key points in their discussion, an instructor can always make them at the end of the discussion.
6. *Sometimes students have trouble hearing each other's comments during a classwide discussion.* Instructors who observe this should repeat student comments loudly enough for the entire class to hear.
7. *Do not reveal the correct answer to a clicker question, if there is one, too soon.* This can stifle discussion. (See Chapter Four for more on this choice.)

Beatty, Leonard, Gerace, and Dufresne (2006) elaborate on some of these strategies and provide additional ones. Their focus is on teaching science with classroom response systems, but their advice for leading clicker-based discussions should be useful to instructors in many disciplines.

## GENERATING SMALL-GROUP DISCUSSIONS

Perhaps the most common method of engaging students in the learning process with a classroom response system is the use of peer instruction (PI), a method popularized by Harvard University physics professor Eric Mazur in his book *Peer Instruction: A User's Manual* (1997). Most instructors implement PI by first posing a multiple-choice question. Students think about the question silently and independently and submit their answers with their clickers. The instructor then displays a bar chart showing the results. Instead of moving to a classwide discussion at this point, the next step in PI is to have the students discuss the question in pairs or small groups. This is the essential feature of PI: having students share and discuss their answers with each other in small groups. Each student helps instruct his or her peers. After this discussion time, students again answer the same clicker question, this time submitting answers informed by their small-group discussions.

Often the results of the second vote are different from those of the first, and for questions with correct answers, often there is some convergence to the correct answer in the students' responses.

*Case Study: Physics*

Steven Pollock uses PI to engage students in the physics courses he teaches at the University of Colorado at Boulder. After the vote that follows the PI time, if the students are split among more than one answer choice, he usually asks for volunteers to share reasons for their answers. Occasionally he polls his students again after this brief classwide discussion. He usually allocates two or three minutes for PI and typically asks four to six PI clicker questions during a fifty-minute lecture.

Most of the questions Pollock uses with PI are conceptual in nature, after the ones Mazur (1997) describes. (See Example 3.3 for a sample conceptual question that Pollock uses.) He also likes to ask application questions to help students extend concepts to new contexts. For instance, he might ask students, ''How many controls in your car are designed to modify your acceleration?'' He and his physics department colleagues have developed question banks for many undergraduate physics courses and made them available online (Pollock, n.d.).

Some of Pollock's colleagues in the physics department have undergraduate teaching assistants who circulate among students during PI time, answering questions and prompting students to think more deeply about the questions. They have large enough teaching staffs and ask enough clicker questions so that each small group of students interacts with at least one member of the teaching staff during each class period.

Pollock finds that physics students, particularly those who are not science majors, expect physics to be about solving computational problems correctly. Pollock believes that physics is more often about conceptual understanding and scientific reasoning, not exclusively computation. Thus, the small-group and classwide discussions of reasons behind answers to clicker questions, particularly those that are conceptual or applied in nature, are the most important parts of class from Pollock's point of view. Students, however, do not always see the value in these discussions given their understanding of the discipline of physics, at least not initially.

## Why Use Clickers for Small-Group Discussions?

There are a number of reasons that having students engage in small-group discussions during class can enhance their learning experience. Perhaps the most important of these reasons is that asking students to discuss a given question with their peers is a way of actively engaging them in course material. When students are actively making sense of course material, they tend to learn the material more deeply and more quickly. Small-group discussions allow more students to participate actively than is possible in classwide discussions.

Another reason was expressed by Anthony Crider, who teaches astronomy at Elon University. He believes that if he had an infinite amount of time, he could talk to each of his students individually about a given question, assessing the student's understanding, diagnosing the student's misconceptions, and responding in ways tailored to that student's particular learning needs. Because he does not have an infinite amount of time, he uses PI to encourage this process to happen between students. Student-to-student instruction is perhaps not as effective as instructor-to-student instruction, but it can be very useful and practical, particularly in large courses.

Small-group discussions, such as those used in PI, also help prepare students to participate more fully in subsequent classwide discussions because students have the opportunity to develop and test their ideas before being asked to share them with the entire class. There can be strength in numbers too. It is one thing to speak up in class and say, ''I think the answer is . . .'' It is another thing to speak up and say, ''*We* think the answer is . . .'' Small-group discussions can encourage students to voice their thoughts during a classwide discussion since students can develop allies in other students who agree with them.

A classroom response system can foster these positive effects of small-group discussion. Having students respond individually and independently to a clicker question before engaging in PI time can improve the quality of that time since doing so gives students a chance to develop some thoughts to bring to the small-group discussion. This can be particularly important for shy students and other students who might not otherwise participate

in a discussion, even one conducted in a small group. Since classroom response systems allow instructors to track student responses, having students respond to a clicker question before or after a small-group discussion creates some accountability that can encourage students to engage more seriously in that discussion. Some instructors require students in a small group to agree on a common answer to a clicker question before submitting their responses. This forces students to work toward consensus and can focus and energize small-group discussions and help prepare students for other life experiences in which building consensus is important. Furthermore, since a classroom response system can display the results of pre- and postdiscussion clicker questions, any convergence or divergence in student viewpoints caused by the small-group discussions is made visible to the students. This can show students that small-group discussions have an impact on their learning.

A variety of studies have been conducted investigating the effects of PI on student learning. Crouch and Mazur (2001) share data from ten years of teaching physics with PI at Harvard University, and Fagen, Crouch, and Mazur (2002) report results from eleven higher education institutions. Both reports argue for PI's positive effects on student learning. (See the literature reviews mentioned earlier in the chapter for other studies.)

*Case Study: Language Instruction*

Parvanak Fassihi uses clickers in the course on academic writing for international students she teaches at Boston University. Her students speak a variety of first languages and are learning to write in a second language, English. Most classes have around fifteen students. As a second-language course, the focus of the course tends to be on grammar and sentence-level writing issues.

Fassihi uses clickers to generate small-group discussions. A typical lesson might be on run-on sentences. She starts by giving a brief lecture on the topic. Then she has her students identify and fix run-on sentences listed on a worksheet in groups of three or four. She then reviews the sentences with the entire class by asking her students to respond to the question, ''Is this a run-on sentence? Yes or no,'' for each sentence. The students respond individually using their clickers, and Fassihi displays the results.

If the results are mixed, she has the students return to their groups to discuss the sentence again, then leads a class discussion about the sentence.

Since Fassihi finds that only 5 to 10 percent of her students volunteer to speak up during class at the start of a semester, she feels she needs groups of three or four students to encourage group discussion. If she were to pair students, she would likely have several pairs of shy students who would not talk within their pairs. With slightly larger groups, there is a greater chance that each group will have at least one student willing to talk.

Each of Fassihi's students responds individually to each question, but each group receives points equal to the number of correct answers submitted by members of that group. This encourages the students to try to convince each other of the correct answer during the group discussion time. Each group's score is tallied by the classroom response system Fassihi uses, and at the end of class, she presents the scores. These scores are not factored into the students' course grades, but they add an element of friendly competition to class. Fassihi often has some kind of prize, usually chocolate, for the winning group.

Fassihi finds the PI element of her lessons to be an effective way to encourage interaction among her students and with her. This is often a difficult goal to achieve in second-language courses. Also, since the students see that they have a voice in the course with their clickers, they are encouraged to have a literal voice in the course as well.

### *Case Study: Veterinary Medicine*

Holly Bender teaches a 110-student course in veterinary pathology at Iowa State University. The course features a large number of case studies designed to teach students to interpret laboratory data. Her approach to teaching this course is based on the work of Larry Michaelsen, a proponent of team-based learning (Michaelsen, Knight, & Fink, 2004). She uses a three-class sequence for most topics. On the first day, she lectures about the topic, asking clicker questions along the way to help students engage in the lecture. Then her students complete two complex case studies on the topic as homework prior to the next class period. On the second day, she presents her students with a third case, similar to one of

the two assigned as homework. The students answer a series of multiple-choice questions about the case, first as individuals and then as teams. She uses the team responses to lead a classwide discussion of the case. On the third day, she provides the students with a fourth case, this one featuring several erroneous claims that are not supported sufficiently by the case study data. The students have to identify these claims, first as individuals and then as teams.

Given the technological limitations of the classroom response system that Bender initially used, she gave each team a single clicker, forcing her students to decide on a common team answer. The system she uses now does not force any limitation on the number of clickers in use at any one time. However, she still gives each team a single clicker since she finds the resulting class dynamic highly effective. As a result, her students answer the quiz questions on class days 2 and 3 individually using answer sheets and as teams using clickers.

Bender finds that her students are initially overwhelmed by this course structure since it is so different from the ones to which they are accustomed, but by the start of the last third of the semester, her students have learned how to work effectively within this structure. In fact, by that point in the semester, it is rare that a team answers a question incorrectly since the students develop such effective working relationships within their teams.

For the class sessions focused on case studies, Bender has students read and analyze a case study and respond to multiple-choice questions about the case study first as individuals. When all the team members complete their quizzes, a team representative brings their answer sheets to the front of the room. Once the first team does so, Bender gives the other teams five minutes to complete their individual quizzes. After those five minutes, the team members discuss the questions among themselves. Once the first team has arrived at its collective response, Bender gives the remaining teams five minutes to conclude. Then she has the teams respond to the questions using the clickers. After each vote, she selects a team at random to explain its answer, which initiates a classwide discussion on the question, sometimes resulting in vigorous debates among teams. By the end of the class, she attempts to make the reasoning behind the correct answers to the questions clear.

The six-member teams Bender uses last throughout the semester and are designed to be as heterogeneous as possible, particularly in terms of small- or large-animal specializations. Half of a student's grade in her course is determined by the in-class quizzes. Each team decides how to apportion that grade among three components: the individual quiz responses, the team quiz responses, and an online peer assessment each team member completes. Most teams choose to weigh the team responses more than the other two components, since they know they are more likely to be correct as a team. However, they also want individual accountability, so they usually allocate at least 15 percent of their quiz grades to each of the other two components.

Bender recognizes that team dynamics can sometimes cause problems. For instance, some teams often have an overly assertive team member, one who discourages or ignores the sharing of multiple perspectives during team discussions. However, Bender finds that if that team member answers incorrectly a few times, then the other team members start to ignore that member's assertiveness. As a result, many team-dynamic problems are self-correcting. Her students are older and typically more self-motivated than undergraduate students. They are also very competitive and put pressure on themselves to achieve. Bender finds her team-based learning process works in spite of that, and it helps to teach the students the cooperation and communication skills that employers often identify as important.

The advantages of the team-based learning structure outweigh any problems in Bender's opinion. For instance, she has seen students vigorously debating sodium balance, a very dry topic, after class. Bender sees her role in this process as setting up the right cases and questions for students to answer, providing feedback along the way, and letting students learn.

## FREQUENTLY ASKED QUESTIONS ABOUT PEER INSTRUCTION

**Should students respond to a clicker question individually before engaging in PI?**

There are advantages in having students answer a question individually before discussing it with their peers. Some instructors consider this step an essential component of the PI process since it

encourages students to think independently and provides students a chance to formulate a few thoughts they can bring to the PI time, creating the possibility of more productive small-group discussions. For example, Anthony Crider, who teaches astronomy at Elon University, has his students respond to a few questions designed to surface their misconceptions about the phases of the moon and the causes of the seasons at the beginning of units on those two topics. He feels that having students respond to these clicker questions motivates them to commit to their ideas on these two topics, preparing them to participate more fully in subsequent small-group discussions.

The results of a first, individual set of responses can also affect the pace of the class. If a large majority of students answer a question correctly on the first try, an instructor might choose to skip the PI time entirely, saving some class time. For this reason, some instructors find it particularly useful to have students respond individually to questions they suspect students will find relatively easy. For similar reasons, when asking a question instructors suspect students will find very difficult, they might skip the individual vote and proceed directly to the PI time.

Ivan Shibley teaches chemistry at Penn State Berks, and he usually does not have his students think about and respond to his clicker questions individually prior to PI time. He chooses not to do so in part because of limited class time, but more because he feels that his chemistry students often do not have preconceived ideas about questions and topics in his course. As a result, he finds his students often need PI time in order to get started answering a question. Matthew Mulvaney, who teaches statistics courses for psychology students at the State University of University at Brockport, often skips the individual response phase of the standard PI process as well. He does so because the course material is challenging and students often need group work time to get any traction on the questions he asks given the constraints of class time. There is also some evidence (Len, 2007) that students who self-identify as not particularly skilled in math and science prefer to collaborate when answering clicker questions when given the chance.

If students are fairly enthusiastic about discussing course content or a particular topic during class, instructors may find that they welcome the chance to jump right into small-group

discussions. Kristen Hessler teaches philosophy at the State University of New York at Albany. She allows her students to confer with each other prior to answering clicker questions if they so choose. Some students take advantage of this opportunity and work regularly in the same small groups to answer questions. These students find PI an energizing component of class.

**Under what conditions should instructors skip PI after students respond individually?**

If a clicker question has a single correct answer and that answer is clearly the most popular one, an instructor might choose to move on to the next question or topic without having students engage in PI since these results likely indicate a high level of understanding among the students of the question at hand. However, sometimes students answer a question correctly without having thought deeply about their responses. If an instructor suspects that to be the case, then PI time may be appropriate. It is important to note that if an instructor shows students results such as these, students are likely to assume that the popular answer is the correct answer, which can reduce their participation in PI time. (See Chapter Four for a discussion of the choice to show students the results of a clicker question.)

If a clicker question has a single correct answer but one of the incorrect answers is clearly the most popular one, then the question is likely one that the students find challenging, and engaging the students in PI is likely to be productive. Sometimes two students with wrong answers will help each other discover the correct answer (particularly if they have different wrong answers and can make arguments against each of their original answer choices), so PI time can be fruitful in this case. However, instructors might find that even more students are convinced of the popular wrong answer after PI time, particularly when instructors show them the results of the initial vote, results that could lead students to believe that the popular answer is the correct one. (See Chapter Two for suggestions for handling this kind of situation.)

If two or more of the answer choices turn out to be popular among students' individual responses, then the stage is set for productive PI time. Each small group of students is likely to

contain students with different perspectives on the question at hand, so the small-group discussion is likely to be lively and productive. Many instructors strive to write clicker questions that produce results of this sort not only because they lead to more engaging PI, but also because split decisions like these imply that the question is of an appropriate difficulty level for students—not so challenging that very few of them can answer it correctly, but not so easy that most of them answer it correctly. Showing students the results of the initial vote in this case is often helpful in encouraging discussion since the mixed results of the vote let students know that the question is one worth addressing.

See Chapter Two for further discussion of responding to the results of clicker questions.

**What instructions should students be given for PI time?**

Instructors can instruct students how to form pairs or small groups in different ways. An instructor might say, ''Pair up with a student nearby,'' or give a more specific instruction: ''Find a student nearby who answered differently from you.'' The latter option requires a little more time and student effort, but if students are split among more than one answer choice, more productive small-group discussions may ensue. Bill Hill, who teaches psychology at Kennesaw State University, often uses the latter instruction, particularly when the results of the individual responses to a clicker question are mixed. He points out that when students follow this instruction, at least one student in each pair of students is incorrect, setting the stage for more productive PI time. He often sees convergence to correct answers on the post-PI set of responses to his clicker questions.

Instructors can also specify the task in which the pairs or small groups should engage. An instructor might say, ''Share the reasons you have for your answer with your partners,'' or, ''Convince your partners that you have the correct answer.'' The latter option assumes that the question at hand has a correct answer, of course, and it fosters a somewhat more competitive class atmosphere than the former option, which may or may not align well with the goals of some instructors, but it also provides focus for PI time. Given that some students might be discussing the question with other students who answered similarly, instructors might add, ''If

you and your partner agree on the answer to the question, go ahead and explain your reasons since both of you may be wrong.''

Instructors might also say, ''Come to a consensus with your partners on an answer choice.'' This provides more focus to the small-group discussion time and a framework for more engaged discussions. Building consensus often takes some time, however, so this instruction has an impact on the pace of the class. Instructors need not actually require consensus answers from each group as Holly Bender does in her team-based learning courses. Instead, they can instruct students to attempt to gain consensus but answer individually after the PI time.

Adam Lucas, who teaches mathematics at Saint Mary's College of California, is interested in the effects of seating arrangements, group dynamics, and classroom management choices on student participation and learning, particularly the role of what he calls ''high-status'' students—those who are perceived by their peers as doing well in the course—in dominating small-group and classwide discussion (Lucas, 2007). He often monitors student discussions in class and moves students who are not working well together. He finds that social dynamics can be a serious issue and that he needs to be proactive with seating arrangements and instructions for class discussions. The first time he used clickers, he says class was a bit of a ''free-for-all.'' By interviewing his students about their experiences in his class, he learned they needed more structure. One approach he uses is to say, ''Even if the two of you agree on your answer, go through the steps and check your work.'' This works better, in his opinion, than the ''convince your neighbor that you're correct'' approach.

**Should each small group submit a single response following PI time?**

Holly Bender of Iowa State University has her students work in small groups during class to answer clicker questions, and each group is required to submit a common group response to these questions. This gives each group a specific goal for their discussion time that can help students focus their attention and energy. Students who must come to a consensus often have more motivation to engage in the critical thinking necessary to analyze

each other's arguments and defend their own arguments. Not requiring consensus makes it a little easier for students to step back from this process and not try to integrate their perspectives with those of their peers. Also, in their future professional and personal interactions, students frequently have to come to consensus with friends and colleagues. Structuring PI time in this way provides practice for students in consensus-building skills. Furthermore, students are more likely to speak up during subsequent classwide discussion if they know that they have the support of their fellow group members in their answer choices, and they are also more likely to be interested in hearing an instructor's explanation of a question if they and their group have come to consensus around an incorrect answer. Building consensus takes time, however. Peer instruction that leads to a single response per group is likely to take more class time than PI without single responses per group. This class time, of course, could be time well spent.

Instructors who grade group responses on accuracy provide additional motivation for students to engage seriously in group discussion and consensus building. But graded group responses can also lead to some unproductive social dynamics within groups. Edna Ross teaches psychology at the University of Louisville and is cautious about the use of graded group responses. She has known minority students to take issue with the use of graded group assignments in other courses. They find that sometimes majority students ignore or minimize the input of minority students when grades are on the line. This can happen for a variety of reasons, some of which can be related to the student's status as a minority in the classroom. The minority student can experience fairly intense pressure to answer a question correctly every single time as a way to prove his or her ''worth'' to the group. As Holly Bender points out, the issue of students who dominate the group decision-making process and are wrong can often correct itself rather quickly. It would seem that difficulties can arise when a student dominates the group and answers questions correctly. This can lead to problematic group dynamics and likely calls for the kinds of intervention Adam Lucas uses in his mathematics courses.

**What should instructors do during PI time?**

Many instructors find it useful to circulate among students as they discuss a clicker question during PI time. Instructors might do so in order to eavesdrop on student conversations to get a better sense of how students are answering the question and the reasons they are giving for their answers. This information can be helpful for preparing for subsequent classwide discussion of the question, since it provides insight into why students make certain answer choices. It also provides instructors with students on whom they can call during the classwide discussion to share reasons for their answers.

Instructors might also stop and interact with a group of students, asking questions of them in order to prompt them to consider issues and cases not already discussed in the group. Simply providing them with hints or answers is not likely to be as useful as asking them questions designed to help them think through the question more deeply themselves. This tactic can be particularly helpful with groups in which the students quickly agree on the answer to the question at hand. Instructors can play the devil's advocate role in helping them consider other answer choices.

Teaching assistants, when available, can be instructed to circulate among students too. It can be helpful to give assistants specific instructions for their role. In particular, teaching assistants, who typically have limited experience teaching, are often more likely simply to give answers as they interact with students instead of asking them questions designed to help them discover the answers on their own. They might need guidance from their supervisors on this issue.

Circulating among students is not always possible, however. The ability to do so largely depends on the students' seating arrangement in a classroom. If it is not possible to walk among and interact with students during PI time, instructors might stand at the front of the classroom and observe students to get a sense of how quickly they analyze the question at hand and submit their answers and a sense of how many of them are staying on topic in their small-group discussions. This is also a useful time for instructors to review the answer choices to the clicker question and plan a strategy for discussing them with students.

**How might an instructor lead a classwide discussion following PI time?**

The strategies for leading more general classwide discussions apply equally as well to classwide discussions that follow PI time. One difference is that in traditional peer instruction, students answer a question twice: once on their own and once following a small-group discussion. Instructors can use this structure to enhance a classwide discussion by asking, for instance, for a student who changed his or her answer during the PI time to share with the class the reasons for that change. Instructors might also ask for a student who did not change his or her answer to share with the class reasons why he or she did not find peers' arguments persuasive. Instructors might also ask to hear from a group about the arguments shared during the group discussion time that were most persuasive.

## CREATING TIMES FOR TELLING

Many instructors use classroom response systems to prepare students for ''times for telling,'' a term Schwartz and Bransford (1998) use to describe moments in a learning experience when students are ready and interested to learn from a lecture or reading. Instructors usually pose a question with an answer choice that students with a particular common misconception are likely to select. Students think about the question and submit their answers using their clickers. If the question has its intended effect, more students choose the misconception-based answer choice than any other answer choice. The instructor then reveals the correct answer to the student, often by demonstrating the answer's veracity in some way. The students are then surprised to find out that so many of them answered incorrectly, which leads them to want to hear the instructor's explanation of the question and its correct and incorrect answers.

### *Case Study: Chemistry*

Dennis Jacobs uses clickers in the introductory chemistry courses he teaches at the University of Notre Dame. These are large courses, often with around 240 students per section. Many of the

questions he uses are tied to classroom chemistry demonstrations, the kind often performed in the front of chemistry lecture halls to show students chemistry in action. His clicker questions ask student to predict the results of these demonstrations.

For example, he has shown his students that running a circuit through a beaker of pure water does not light an attached light bulb since pure water does not conduct electricity. He then replaced the water in the beaker with a weak acidic solution, 2 percent $CH_3CO_2H_{(aq)}$. This lit the light bulb dimly, demonstrating that the acidic solution was a poor conductor of electricity. He then posed the following clicker question to his students: ''Predict how well pure $CH_3CO_2H_{(l)}$ will light the light bulb. Will the light bulb be bright, dim, or dark?'' Many students erroneously selected ''bright,'' not realizing that the conduction of electricity requires both water and acid molecules. He then had his students discuss the question in pairs and respond to the question again. This second time, the majority of students chose ''dark,'' the correct answer. He then engaged the students in a classwide discussion of the question, giving students the chance to share their reasons for their answers with the class. Then he repeated the experiment with the pure acid, demonstrating students that the pure acid did not conduct electricity and the light bulb remained dark.

Jacobs finds that by the time his students respond to the question individually, discuss the question with their peers, respond to the question again, and participate in a classwide discussion, they really want to know how the experiment turns out. He uses the experiment to show why a particular answer is correct and, after the experiment, revisits the arguments students make during the discussion in the light of the results of the experiment. Jacobs feels that if he performed the experiment first, then had the students discuss it, many students would focus their efforts on memorizing his explanation of the experiment. The process he uses focuses their attention on thinking critically.

One limitation of this approach is that it relies on experiments Jacobs designs to surface student misconceptions. When possible, Jacobs gives his students the chance to design their own experiments to test hypotheses. For example, many students think that boiling water means converting water molecules into hydrogen and oxygen gases, not changing the phase of the water from

liquid to gas. Jacobs might ask his students a clicker question in which they have to identify the components of water vapor. Many choose incorrectly, indicating that water vapor consists of hydrogen and oxygen gases. He then asks his students to suggest a way they might test their hypothesis. Inevitably some student suggests burning the water vapor. If it really consists of hydrogen gas, burning the vapor should result in an explosion. Jacobs then performs this experiment in front of the class, playing up the possibility of an explosion for dramatic effect. Nothing happens, of course, leading students to conclude that water vapor must still be $H_2O$. He then prompts them to determine if they could have ruled out the hydrogen hypothesis on the basis of their past experience. Usually some student realizes that the fact that many people boil water for tea or coffee on gas stoves rules out their hypothesis. This helps his students start connecting their real-world experiences to the course content.

## WHY USE CLICKERS TO CREATE TIMES FOR TELLING?

Students' intrinsic interest in learning in a particular discipline or course can vary dramatically. When students answer a question incorrectly, however, they are often more likely to want to know the correct answer and to hear an explanation of the question than if that same explanation is offered prior to the question. Not only are students more likely to want to understand the question, but they are also more likely to make sense of the explanation of the question since they have had a chance to think about it on their own. Thus, having students attempt to answer a question on a particular topic can be an effective way to create a time for telling, that is, a moment when students are ready and able to understand an explanation about that topic. The learning experience is all the better if the question is one that many students answer incorrectly due to some important misconception they have. That sets the stage for them to engage in the difficult process of resolving that misconception.

A classroom response system can play several important roles in this process. Having each student respond to a clicker question designed to surface some particular student misconception engages all, not just some, students in a process that helps

prepare them for a time for telling. Moreover, by having students respond independently to the question prior to any small-group or classwide discussion, each student has a chance to consider his or her own ideas about the question and make connections between the question and his or her own set of prior experiences and knowledge. Furthermore, instructors using clickers to ask these kinds of questions are asking students to commit to their answers. Although that commitment merely takes the form of pressing a button on a clicker, that act can help students become more engaged with the question. This means that they will be all the more surprised by the correct answer and all the readier to hear an explanation. Also, the results from a clicker question of this sort can show students just how common a particular misconception or misunderstanding is. Students are surprised to find out that so many of their peers answer a question correctly. Finding that out can further motivate students to listen to and understand an explanation of the correct answer.

*Case Study: Psychology*

Edna Ross teaches psychology at the University of Louisville. Her courses tend to be very large, enrolling as many as 350 students each. Ross often uses clicker questions to create times for telling. For example, she finds that her students usually have difficulty distinguishing between classical and instrumental conditioning. She once told her students to take a five-minute break in the middle of her seventy-five-minute class session. She told them that she would play relaxing music and display some calming images on the classroom projector screen to help them get the most out of their break. She then displayed images of the ocean and played the ominous theme from the movie *Jaws*. Her students' supposed break was really a setup for a clicker question asking whether the use of the *Jaws* theme in this instance was an example of classical or instrumental conditioning. She had the students respond to the question with their clickers; as she expected, most selected the incorrect answer: instrumental conditioning. At this point, she did not tell the students the correct answer. Instead, she let students who chose instrumental conditioning volunteer their reasons, followed by the students who chose classical conditioning. This led to a spirited debate between the two groups of students, in part

because the majority assumed they were correct. She then revealed the correct answer, not through a classroom demonstration but by using the correct answer indicator provided by her classroom response system. (The bar on the results bar chart belonging to the correct answer turned green.) At that point, the class ''went wild'' in Ross's words.

Ross feels that this question was particularly effective because her students had read about the two types of conditioning in their textbook but had not yet fully understood them. This meant that those participating in the classwide discussion of the question were not just relying on their intuition; they were drawing on their partial understanding of the preclass reading. Once Ross explained the correct answer to the students, she could see that they began to complete that partial understanding.

Ross finds that the act of clicking an answer choice is a way of committing to that answer, which hooks the students into the learning process. No commitment means no potential for change in understanding.

## STRATEGIES FOR CREATING TIMES FOR TELLING

Creating moments in a class session when students are ready to get the most out of a lecture or an explanation takes a certain set of circumstances. The strategies provided next can help instructors create conditions favorable for times for telling:

1. *Design questions that trap students around common misconceptions and ideas that are intuitive but not accurate.* This requires knowing what those common misconceptions and intuitions are. Instructors with experience teaching a particular topic likely have some idea what those misconceptions are. The more that instructors interact with students around the topic, the more they will learn about ways in which their students' understanding of the topic is incorrect or incomplete. For a more systematic approach to determining common misconceptions, instructors might analyze student responses to a free-response question to determine common misconceptions and misunderstandings. Instructors might also find information about common misconceptions in the educational literature in their fields. (See Chapter Four for more ideas

on constructing answer choices to clicker questions that surface common misconceptions.)

2. *Demonstrate to students that they are wrong about the question in as dramatic a way as feasible in order to increase their surprise at being wrong*. In a science class, that might mean performing an experiment in the classroom that concretely shows students the correct answer to the question. In other classes, a social experiment using the students themselves might provide proof of a particular result. If nothing else works, most clicker systems allow instructors to designate the correct answer to a question with a check mark or smiley face or some other visual indicator. Showing students the result of their vote and then having one of these indicators appear next to the correct answer can elicit some gasps of astonishment from students when they realize that the popular answer was the wrong one.

3. *Plan for an explanation that is as helpful to the students' understanding as possible*. This usually means explaining not only the correct answer but also why the popular answer is incorrect. Instructors might ask a few students to volunteer their reasons for choosing an incorrect answer prior to the actual explanation. This allows students who are frustrated at answering incorrectly a chance to voice their thoughts on the question. It also provides instructors with information on their students' thoughts about the question, perspectives to which instructors can respond in their explanations.

4. *Having student volunteers share their reasoning for choosing the correct answer to a question can be productive*. This gives the minority of students who answered the question correctly a chance to shine. Also, students are sometimes better able to understand their peers' explanations than the ones that instructors provide.

## Structuring Class Time

A classroom response system can be used to structure a class session in ways that help students learn. The think-vote-share activity helps to focus students' attention on a particular question and introduce a time of class discussion. The peer instruction method can provide a useful way to structure an active learning

exercise for students, whether that exercise takes two minutes or twenty. Even creating a time for telling provides a certain rhythm in a class session. Some instructors use classroom response systems in other ways to structure portions of class sessions and even entire class sessions.

*Case Study: Biological Sciences*

Instructors using the case study method of instruction (Barnes, Christensen, & Hansen, 1994; Herreid, 2007) typically provide students with a description of a real or fictional problem or situation. Students are given time to read this case study and respond to a series of questions about it, typically questions that require students to apply knowledge and skills gained in the course thus far to the contextualized problem in the case study. Often students read the case study and respond to the questions prior to class, and class time is spent discussing the case study and associated questions.

Herreid (2006) proposes the use of classroom response systems to facilitate ''interrupted case studies.'' In an interrupted case study, students read and respond to a case study during class. They are initially given only part of the case study and then asked a series of application and critical thinking clicker questions about this first part. Once these questions have been asked, answered, and discussed, they are given another portion of the case study and asked another set of questions. This process continues until the entire case study has been analyzed in class.

Brickman (2006) describes her use of interrupted case studies in a three-hundred-student, introductory biology course. She has students work through case studies in permanent six-person teams. Each team is given a single clicker with which to respond to the questions embedded in the case study. Case studies used in more traditional ways often involve ill-defined problems with multiple reasonable solutions; part of the challenge of the case study is determining what those possible solutions are and evaluating their relative merits. Brickman finds that in her large-enrollment course, less open-ended case studies are more appropriate. As a result, her case studies focus on conceptual understanding and the data analysis skills used frequently in the biological sciences.

## Why Use Clickers to Structure Class Time?

Most research on attention span (Hartley & Davies, 1978; Middendorf & Kalish, 1996) indicates that undergraduate students are able to pay attention for ten to twenty minutes before losing that attention for some amount of time, although some researchers (Wilson & Korn, 2007) dispute this finding. Many instructors see value in structuring a class session into a sequence of activities (mini-lectures, small-group discussions, large-group discussions, individual writing exercises, and so on) as a way to help students maintain their attention during an entire class. The simple act of picking up a clicker and responding to a question can provide the ''change-up'' in a lecture Middendorf and Kalish (1996) argue is often needed to hold students' attention. Furthermore, some students respond well to kinesthetic activities, which involve movement and tactile sensation. Clickers can facilitate such an activity in a minimal way. Since a quick clicker question can help focus students' attention on the classroom activity in which they should be engaged, clickers can be used several times within a class period to keep students on task. Classroom response systems can be used in a variety of ways to structure class time beyond simply asking quick clicker questions, and are thus often useful tools for helping students maintain attention during a class session.

Structuring a class session helps students pay attention, and structures that include activities can also help focus their attention in productive ways on particular tasks. Students who know that they will be asked to respond to a specific question or complete a specific task in the next five, ten, or fifteen minutes are often more likely to engage seriously with classroom activities during that time frame, particularly if they have some indication as to how they will be asked to respond. This can be more productive for some students than the task of taking notes on a sixty-minute lecture with the goal of doing well on an exam three or four or more weeks away. Because all students are asked to respond to a clicker question, they are more likely to be engaged with the activity at hand. Since those responses can be tracked by instructors and tied to student participation grades, students are more likely to take the activity at hand seriously, increasing their focus and engagement.

Clickers can be used as well to gather information from students in order to determine the direction of a class session, giving all students a voice in determining that direction. For example, Robert Bartsch, who teaches psychology at the University of Houston at Clear Lake, likes to ask what he calls ''class process'' questions. He might ask his students at the start of a class whether they would prefer a lecture or a small-group activity. Hinde and Hunt (2006) suggest a class structure that one might call a ''question tree.'' They give the example of a lesson on government policy options in an economics course. By directing students' attention to a particular policy problem and then asking students to vote on several possible policy choices that might be used to address that problem, an instructor can invite students to determine the focus of subsequent class discussions. Class time is spent exploring the ramifications of the policy choice selected by the most students. Students then vote on other policy choices to explore as time allows.

Hinde and Hunt's question tree is fairly simple, but one can imagine an instructor posing an initial challenge and providing students with a few options as to how to proceed. The instructor then asks the students to vote on their preferred response using their clickers. The most popular choice is then used to shape the next portion of the class session as the instructor and students begin to respond to the challenge in the way suggested by this choice. At some point, another choice is presented to the students, asking them their preference as to the next phase of the analysis of the challenge at hand, and this process repeats itself until the challenge is sufficiently explored. Depending on the nature of the challenge, students might choose responses that lead to dead-ends, requiring the instructor to return to earlier questions and have students select other responses. It would be challenging for an instructor to design a question tree of this sort with branches within branches, but students might find such a tree rather engaging.

## MAKING CLASS MORE FUN

Many classroom response systems include features that can be used to add an element of competitive fun to a classroom. For instance, many systems allow instructors to set up teams and track

team performance on clicker questions during a class session. Students respond to a clicker question at the start of class that asks them to designate their team number. Then during the class session, students respond to subsequent content questions, typically ones with single correct answers, perhaps conferring with their teammates prior to answering. At the end of class, the system displays the score for each team: the number of correct answers submitted during class by members of that team. The instructor might offer some kind of prize such as candy or extra credit to the team scoring the highest.

*Case Study: Mathematics*

Meredeth McCoy teaches mathematics courses at Columbia State Community College in Tennessee that students take in preparation for college algebra. Each course typically has between twenty-five and thirty students. McCoy first learned about classroom response systems at a technology fair, and her department purchased a set of clickers for instructors in the department to use. She initially used them for graded quizzes, but this did not seem to engage her students very well. She then tried asking some ungraded clicker questions during her lectures, but this did not quite work either.

What really engaged McCoy's students was one of the competitive games her clicker system facilitated. In each round of this game, each student is assigned one of several questions printed on a handout. Students complete their assigned questions as quickly as they can and submit their answers using their clickers. Then the system displays the fastest responder for each of the questions asked. Students score points for correct answers, and they score bonus points when they are the fastest responders. McCoy finds that this game engages her students because it is competitive but not punitive: students compete to be the fastest responder with a correct answer, but they also receive full points for a correct answer even if they are not first to respond. The fact that students are answering different questions helps prevent cheating, as does the competitive aspect of the game. She finds this game works especially well when helping students prepare for tests.

The description of Parvanak Fassihi's classroom games earlier in this chapter provides another example.

## WHY USE CLICKERS TO MAKE CLASSES FUN?

Although the primary goal of a college or university course is student learning, not fun, a little fun can help students maintain attention and engagement with course activities. As long as any activities designed to add a little fun to a class session are also helping students learn, students are likely to find them enjoyable and productive. Many instructors use these kinds of games to make exam preparation sessions more engaging, for instance.

Also, instructors who help their students enjoy their classes a little more often find that this helps establish a useful rapport with their students. Positive interpersonal interactions can increase students' interest in the subject of a course, interest in engaging productively in course activities designed by their instructor, and willingness to forgive their instructor when he or she makes a mistake or plans an activity that does not turn out well.

Some students find competition motivating. These students engage more seriously with a task when they know they have a chance at outperforming their peers publicly and so enjoy participating in classroom games in which they compete. Other students respond more positively to collaboration and team experiences. These students can thrive in team-based classroom games. Classroom response systems can provide useful technology for supporting these kinds of games. Some students react negatively to high-stakes competition, however, so keeping these kinds of activities low stakes, with no penalty for performing poorly or where the award for performing well is minor, can help make them motivating for more students.

Clickers allow instructors to incorporate elements of popular television game shows into a college or university learning experience. Many game shows use multiple-choice questions or contestants clicking buttons to answer questions quickly, components that can be replicated by clickers. An element of many television game and reality shows is the dramatic ''reveal,''

when the results of some game element, round of voting, or transformation are first displayed to the audience. An instructor with a little flair for the dramatic can use clickers to create similar reveals in the classroom, surprising students with the summary of student responses that clicker systems provide on screen. Furthermore, clickers also provide instant summaries and scoring of student responses. This allows for a more lively and faster-paced game-oriented class sessions.