Uses of clickers:

1. Attendance
2. Verify understanding (quiz)
3. Practice knowledge/application
4. Cue knowledge (not yet introduced) / misconceptions / awaken interest
5. Goose discussion
6. Controversies

General Best Practices for Using Clickers

Ensure that the system is used regularly in classroom activities.

Classroom response systems appear to be most beneficial when used on a regular basis, rather than intermittently. In fact, a survey of physics courses in Hong Kong found that students who used the classroom response system consistently in their course had more positive responses to the system and reported attending class more often than students who used the response system only once a week (Cue, 1998).

Build extra time into your lecture to handle technical issues.

Using a classroom response system during a class lecture inherently requires extra time, as the system can run slowly on occasion and technical problems sometimes occur. Additional time is also often needed prior to the start of the lecture for setup of the system. Instructors need to consider this when creating their lectures and classroom activities (Stuart, Brown, & Draper, 2004).

Consider using a textbook publisher that supports classroom response systems; doing so can ease the development of clicker-enhanced classroom activities.

Some textbook publishers provide multiple-choice items on their website that can be used for in-class activities that utilize the classroom response system. This can make the task of creating items much less challenging for the instructor (Lightstone, 2006).

Use the system not only to improve student-faculty communication in large classes, but also to enhance student-student interaction.

The goal of using a classroom response system in a large class is often to improve faculty-student communication by allowing all students to share their knowledge of course topics with the instructor. Student-student interaction in these classes can also be enhanced, however, by encouraging students to individually use the clicker to answer in-class activities and then to discuss these answers with other students ("Clicker Pilot Program Continues," 2006; Draper, Cargill, & Cutts, 2002). The discussion/debate following their initial responses can help students to verbalize the rationale for their answers in addition to facilitating group discussion of course

topics. Alternatively, students can be encouraged to discuss their answers with other students prior to submitting an answer (Woods & Chiu, n.d.), which can help reduce the initial variability in student responses.

Consider using the clickers to obtain feedback on your performance during class and on student understanding of the class material.

Instructors can use the classroom response system to gain immediate feedback on student satisfaction with the course, in addition to feedback on student comprehension of course concepts (Draper, Cargill, & Cutts, 2002). For instance, they note that instructors could periodically include questions such as "How am I doing?" to evaluate their performance during class to which students could respond: a) The lecture is very clear so far, no questions; b) I have a question or two; c) I have a lot of questions; or d) I am so confused, I don't have any questions. Feedback given "real time" to the instructor could be used to direct the flow of the course, as information that is not understood could be further elaborated and repeated to ensure adequate comprehension.

Think about making clicker responses part of the overall grade but also consider the consequences on the classroom environment.

Research has found that including clicker responses as part of a student's overall grade increases student attendance and class preparedness. In particular, Burnstein and Lederman (2001) found that when student clicker responses counted for more than 15 percent of their overall grade, attendance increased to approximately 80-90 percent and students made significantly greater attempts to come prepared for class. A downside of grading student responses during class, however, is that it can change the dynamic of the class from one that encourages learning (in which mistakes are okay) to one that focuses on evaluation (Beatty, 2004).

Best Practices for Creating Questions and In-Class Activities

Find creative ways to use the multiple-choice response options to assess different types of thinking and learning.

Although the classroom performance system requires framing questions in terms of multiple-choice responses, this response format can be adapted to assess different types of thinking and learning. For instance, multiple-choice questions could be used to measure knowledge of facts or processes, problem-solving skills, and opinions or beliefs (Woods & Chiu, n.d.). Thus, it is important for instructors to remember that although the multiple-choice format appears limiting, it can resourcefully be used to evaluate many aspects of student learning and thought processes.

Include response options that reflect commonsense misconceptions of the material within your multiple-choice answers.

Including response options that include commonsense misconceptions of course material can help instructors determine which topics are most confusing for students and would benefit from further discussion. Instructors are likely to find that response patterns are more normally

distributed when response options include commonsense misunderstandings rather than skewed towards one particular response (Judson & Sawada, 2002; Wit, 2003).

Include a "do not know" response option.

Allowing students to say that they do not know an answer to a question can prevent guessing during class and help the instructor to determine which topics are not well understood (Wit, 2003).

Keep in mind that each question can be reworded to create a different question.

For each item you create, there is an equivalent question that can be created. For example, you can ask: "What is the definition of this concept?" The opposite of this question is, "What concept is defined by this definition?" In addition, you might ask, "Which of these statements are correct about this plot?" The opposite of this question could be, "Which of these plots can you associate with the following statement?" By asking questions in various forms, you can assess whether students truly understand the subject matter. Moreover, as Wit (2003, p. 16) points out, asking questions in different ways, "also keeps the types of mental demand on the students fresh, even if one is in fact sticking to the same topic."

Try not to go beyond five response options when creating in-class exercises.

It is often difficult for students to read and compare more than five options during an in-class activity. Limiting the number of options to five, therefore, helps students to respond quickly and accurately during classroom exercises (Wit, 2003).

If you plan to use a demonstration in your course, consider having students use the clicker to make predictions about what they think will happen.

Having students use the classroom response system to predict the results of a demonstration before they watch it has been shown to improve learning outcomes. In fact, Crouch, Fagen, Callan, and Mazur (2004) found that compared to a group that only watched in-class demonstrations and listened to the instructor's explanation of what occurred, students that were asked to predict what would happen during a demonstration performed twice as well on an end-of-semester test designed to measure their predictive abilities and four times as well on a test assessing their explanation of what happened. Moreover, having students predict the results of the demonstration only added minimally to the amount of time required for each demonstration (i.e., approximately two minutes).

Best Practices from Educause Center for Applied Research

Use Appropriate Pedagogy.

Technology doesn't inherently improve learning; it merely makes possible more effective pedagogy, and only when it is consonant with an instructor's educational philosophy and beliefs and reinforced by other components of the total course. An instructor cannot and should not

explicitly address in class every topic, idea, fact, term, and procedure for which students are "responsible." Instead, use class time to build a solid understanding of core concepts, and let pre-class reading and post-class homework provide the rest. Use exams and other performance metrics that support, not contradict, the concept- and reasoning-centered focus of the class.

Effective CCS [Classroom Communication System-another term for Classroom Response System] use requires us to design for "multi-pass learning," in which an idea or technique is developed through multiple visitations in varying contexts spread over time. We must also appreciate, and convince our students, that confusion is an inevitable part of learning and that no lecture or lesson plan is so perfect that students will fully understand what is taught at first encounter.

If a CCS-using class is to be more than an endless series of quizzes, we should focus on the reasoning behind answers and not on their correctness, and students must be convinced that the questions are for learning and not for evaluation. How we respond when right or wrong answers are offered is crucial. A full spectrum of answers should be drawn out and discussed before we give any indication which (if any) is correct. Even the notion of "incorrect" should be downplayed; it is more enlightening to students, and more conducive to discussion, to say something like "that would be correct if...," identifying the circumstances or assumptions under which the answer would be right. Instead of offering the wrong answer, students often offer the right answer to the wrong question.

Avoid the "Instructor-Centric" Classroom.

As teachers, we are accustomed to being the focus of attention in our classrooms. To use a CCS effectively, we must learn to give up control and allow learning to occur without constant micromanagement. When we present a question, we should resist the temptation to read the question out loud or clarify it. If it contains ambiguities, it's better to allow class discussion and student questions to bring them out; it can be beneficial to be quiet and wait while students read, discuss, and answer a question. During class-wide discussion, it often pays dividends to be tolerant of silences while students ponder and make up their minds to speak out. It is at times appropriate to paraphrase a student's statements for the rest of the class or to help a struggling student express an idea, but it may also be best to confirm our accuracy with the originator. Rather than jumping on errors or flaws in an argument, it often works well to allow other students to find them, even if this appears inefficient.

Empirically, two to four questions per 50-minute class is optimal. If we cannot fill a class with that many, it probably means we aren't sufficiently cultivating discussion or posing sufficiently divisive questions. When deciding how long to allow for small-group discussion, sound can be a clue: the noise level in the room tends to rise as students finish reading and assimilating the question and begin discussing it, and then drops as they reach resolution and enter their answers. If too much more time passes, it rises again as small talk ensues.

Use Question Wrap-Up.

The transition period that wraps up class-wide discussion of one question and either transitions to another question or ends class is an important opportunity. We can summarize the key points or arguments students have put forth, possibly adding additional ones that students missed. We can also make connections to related questions and topics, pose "what if' alternative questions to be pondered but not answered, or segue into the next question. Before we've revealed which answer is "right" (or which answers are right), we may ask for a show of hands indicating how many students have changed their minds as a result of the discussion. If the count is significant, we can resend the question to see how the histogram differs.

If student answers and discussion have revealed a fundamental gap in knowledge or understanding that discussion did not resolve, a mini-lecture on some piece of subject matter may be appropriate. Students will learn far more from it than they would without the preceding CCS question because the presentation is now motivated and contextualized. Alternatively, the instructor may help students structure their knowledge and avoid getting lost in details by communicating about how material just covered fits into the larger picture of the subject as a whole or of learning in general. Although this phase of the question cycle is necessarily instructor centered, take care to keep it relatively short and directly tied to students' recent and upcoming learning activities and do not slip into extended lecturing.

Engineer Questions Deliberately.

In CCS-based pedagogy, question design replaces lecture note preparation as the focus of class planning. The criteria for an effective CCS question are quite different from those for exam, quiz, or homework questions, and question design should be given great care. Each instructor must discover what kinds of questions suit his or her own subject and style; however, a few broad principles apply.

Every question should have a clearly identifiable pedagogic goal, not just a topic to address. The goal indicates the action we hope to induce in students' minds. Some general types of goals include

- Drawing out students' background knowledge and beliefs on a topic
- Making students aware of their own and others' perceptions of a situation
- Discovering points of confusion or misconception
- Distinguishing two related concepts
- Realizing parallels or connections between different ideas
- Elaborating the understanding of a concept
- Exploring the implications of an idea in a new or extended context

In general, avoid computational or simple factual questions or those that probe memory rather than understanding. Comparison questions are powerful, as are predictions and causal relationships (for example, "What would happen to X if Y were increased?"). Strive for questions that get students to reason qualitatively and to draw conclusions from a conceptual model. If the instructor can anticipate likely misunderstandings and points of confusion, he or she can design questions to "catch" students in those and thus draw them out for discussion and resolution.

Ambiguity is a good quality of a CCS question. It sensitizes students to the ambiguous point's implications, trains them to pay attention to subtleties in a situation, and motivates a discussion about what aspects of a question statement are important and how they matter. All this may not help students reach a correct answer to the question at hand, but the answer isn't the goal: it helps students learn to reason and think defensively and to answer future questions, especially the vague, fuzzy kind often encountered outside the classroom.

A broadly spread histogram of student answers, indicating several popular choices, is a signature of an effective question. It provides good material for discussion and argument among students and is likely to result in significant learning all around. Conversely, a histogram with a single peak at the right answer accomplishes little except to indicate that students can answer that particular question and that it warrants no further time.

Sequences of related questions can build on each other to develop a complex idea or set of related ideas. One tactic is to present a concept in different contexts, helping students separate the details of application from the concept's essence. Another is to use slight variations of the same question-perhaps different questions about the same situation-to explore the limitations of a concept or to relate different concepts. In general, use familiar situations for new concepts to develop understanding; use new situations for familiar concepts to check for understanding (as on an exam). This differs from common practice. Keep in mind the issue of "cognitive load": it can take significant mental resources for students to process and interpret a new problem situation or description, and once students have done so, it is efficient to reuse that situation for multiple questions.

Occasionally, including extra information in question statements or omitting necessary information is also beneficial. It helps students learn to decide for themselves what information they need to answer a question, a skill that is perhaps as valuable in real life as determining the answer itself.

Finally, when building a lesson, when and how a question is presented impacts the depth, quality, and nature of the resulting group work and student thought. Students will naturally assume that the question is relevant to whatever has just transpired, and this can lead to "pigeonhole" learning in which concepts are not structured in a broadly useful hierarchy, but are learned chronologically and only accessible within a narrow context. In general, if a question is posed before presentation or coverage of subject material, students will draw on preexisting knowledge, apply intuition, and extrapolate from prior course material. If it is presented after, they will draw on whatever was just covered regardless of its relevance. Which is preferable depends on our pedagogic goals for the question.

Meta-communicate.

The most powerful tool for changing students' attitudes about learning and enlisting them as active collaborators in their own education is metacommunication-high-level communication about the nature and purpose of the "normal" communication within the course. Meta-communication can and should address the learning objectives of the course and its components, the virtues of instructional techniques and styles employed, and the reasons why particular

assignments are given. Experience shows that students are far more cooperative when they understand why they are being asked to do something.

Meta-communication can also address individual learning habits and the dynamics of small-group and whole-class discussion. By accepting the role of a learning coach and advisor, we can help students find strategies that increase their benefit from the course and from education in general-that is, help them learn how to learn. This is particularly important with students who display frustration or hostility toward CCS use and associated pedagogy.