CATs

Classroom Assessment Techniques

WHAT IS CLASSROOM ASSESSMENT?
from Classroom Assessment Techniques: A Handbook for College Teachers
by Thomas A. Angelo and K. Patricia Cross

Through close observation of students in the process of learning, the collection of frequent feedback on students' learning, and the design of modest classroom experiments, classroom teachers can learn much about how students learn and, more specifically, how students respond to particular teaching approaches. Classroom assessment helps individual college teachers obtain useful feedback on what, how much, and how well their students are learning. Faculty can then use this information to refocus their teaching to help students make their learning more efficient and more effective.

PURPOSE OF CLASSROOM ASSESSMENT

Despite the diversity of the over-three thousand colleges and universities across America, all share one fundamental goal: to produce the highest possible quality of student learning. In other words, the central aim of all colleges is to help students learn more effectively and efficiently than they could on their own.

Learning can and often does take place without the benefit of teaching--and sometimes even in spite of it--but there is no such thing as effective teaching in the absence of learning. Teaching without learning is just talking. College instructors who have assumed that their students were learning what they were trying to teach them are regularly faced with disappointing evidence to the contrary when they grade tests and term papers. Too often, students have not learned as much or as well as was expected. There are gaps, sometimes considerable ones, between what was taught and what has been learned. By the time faculty notice these gaps in knowledge or understanding, it is frequently too late to remedy the problems.

To avoid such unhappy surprises, faculty and students need better ways to monitor learning throughout the semester. Specifically, teachers need a continuous flow of accurate information on student learning. For example, if a teacher's goal is to help students learn points A through Z during the course, then that teacher needs first to know whether all students are really starting at point A and, as the course proceeds, whether they have reached intermediate points B, G, L, R, W, and so on. To ensure high-quality learning, it is not enough to test students when the syllabus has arrived at points M and Z. Classroom assessment is particularly useful for checking how well students are learning at those initial and intermediate points, and for providing information for improvement when learning is less than satisfactory.

Through practice in classroom assessment, faculty become better able to understand and promote learning, and increase their ability to help the students themselves become more effective, self-assessing, self-directed learners. Simply put, the central purpose of classroom assessment is to empower both teachers and their students to improve the quality of learning in the classroom.

CHARACTERISTICS OF CLASSROOM ASSESSMENT

Classroom assessment is an approach designed to help teachers find out what students are learning in the classroom and how well they are learning it. This approach is learner-centered, teacher-directed, mutually beneficial, formative, context-specific, ongoing, and firmly rooted in good practice.

Learner-Centered

Classroom assessment focuses the primary attention of teachers and students on observing and improving learning, rather than on observing and improving teaching. To improve learning, it may often be more effective to help students change their student habits or develop their metacognitive skills (skills in thinking about their own thinking and learning) than to change the instructor's teaching behavior. In the end, if they are to become independent, lifelong learners, students must learn to take full responsibility for their learning. To achieve that end, both teachers and students will need to make adjustments to improve learning. Classroom assessment can provide information to guide them in making those adjustments.

Teacher-Directed

A defining characteristic of any profession is that it depends on the wise and effective use of judgment and knowledge. No one can provide teachers with rules that will tell them what to do from moment to moment in the complex and fluid reality of a college classroom. What faculty do depends on their skill, experience, professional knowledge, and insight. Classroom assessment respects the autonomy, academic freedom, and professional judgment of college faculty. As a result, in this approach, the individual teacher decides what to assess, how to assess, and how to respond to the information gained through the assessment.

Mutually Beneficial

Because it is focused on learning, classroom assessment requires the active participation of students. By cooperating in assessment, students reinforce their grasp of the course content and strengthen their own skills at self-assessment. Their motivation is increased when they realize that faculty are interested and invested in their success as learners. When students focus more clearly, participate more actively, and feel more confident that they can succeed, they are likely to do better in their course work.

Faculty also sharpen their teaching focus by continually asking themselves three questions: "What are the essential skills and knowledge I am trying to teach?" "How can I find out whether students are learning them?" "How can I help students learn better?" As teachers work closely with students to answer these questions, they improve their teaching skills and gain new insights.

Formative

Classroom assessment is a formative rather than a summative approach to assessment. Its purpose is to improve the quality of student learning, not to provide evidence for evaluating or grading students; consequently, many of the concerns that constrain testing do not apply. Good summative assessments--tests and other graded evaluations--must be demonstrably reliable, valid, and free of bias. They must take into account student anxiety, cheating, and issues of fairness. Classroom assessments, on the other hand, are almost never graded and are almost

always anonymous. Their aim is to provide faculty with information on what, how much, and how well students are learning, in order to help them better prepare to succeed--both on the subsequent graded evaluation and in the world beyond the classroom.

Context-Specific

To be most useful, classroom assessments have to respond to the particular needs and characteristics of the teachers, students, and disciplines to which they are applied. Any good mechanic or carpenter will tell you, "You need the right tool to do the job right"; similarly, you need the right classroom assessment technique to answer the question right. Therefore, classroom assessment is context-specific: what works well in one class will not necessarily work in another.

Ongoing

Classroom assessment is an ongoing process, perhaps best thought of as the creation and maintenance of a classroom "feedback loop." By employing a number of simple classroom assessment techniques that are quick and easy to use, teachers get feedback from students on their learning. Faculty then complete the loop by providing students with feedback on the results of the assessment and suggestions for improving learning. To check on the usefulness of their suggestions, faculty use classroom assessment again, continuing the "feedback loop." As this approach becomes integrated into everyday classroom activities, the communications loop connecting faculty to students--and teaching to learning--becomes more efficient and more effective.

Rooted in Good Teaching Practice

Most college teachers already collect some feedback on their students' learning and use that feedback to inform their teaching. Classroom assessment is an attempt to build on existing good practice by making it more systematic, more flexible, and more effective. Teachers ask questions, react to students' questions, monitor body language and facial expressions, read homework and tests, and so on. Classroom assessment provides a way to integrate assessment systematically and seamlessly into the traditional classroom teaching and learning process.

By taking a few minutes to administer a simple assessment before teaching a particular class session, the teacher can get a clearer idea of where the students are and, thus, where to begin instruction. A quick assessment during the class can reveal how well the students are following the lesson in progress. Classroom assessment immediately after the class session helps to reinforce the material taught and also uncovers gaps in understanding before they become serious impediments to further learning.

Finally, teaching students techniques for self-assessment that they can use in class or while they are studying helps them integrate classroom learning with learning outside school. Directed practice in self-assessment also gives students the opportunity to develop metacognitive skills; that is, to become skilled in thinking carefully about their own thinking and learning.

NEED FOR CLASSROOM ASSESSMENT

As they are teaching, faculty monitor and react to student questions, comments, body language, and facial expressions in an almost automatic fashion. This "automatic" information gathering and impression formation is, in large part, a subconscious and implicit process. Teachers depend heavily on their impressions of student learning and make important judgments based on them, but they rarely make those informal assessments explicit or check them against the students' own impressions or ability to perform. In the course of teaching, college faculty assume a great deal about their students' learning, but most of their assumptions remain untested.

Even when college teachers routinely gather potentially useful information on student learning through questions, quizzes, homework, and exams, it is often collected too late--at least from the students' perspective--to affect their learning. In practice, it is very difficult to "de-program" students who are used to thinking of anything they have been tested and graded on as being "over and done with." Consequently, the most effective times to assess and provide feedback are before the chapter tests or the midterm and final examinations. Classroom assessment aims at providing that early feedback.

STEP 1: PLANNING

Start by selecting one, and only one, of your classes in which to try out the classroom assessment. We recommend focusing your first assessments on a course that you know well and are comfortable with. Your "focus class" should also be one that you are confident is going well, one in which most students are succeeding and relatively satisfied. Although this may seem an odd suggestion, it is best not to use classroom assessment to gather data on a problematic or difficult situation until you become experienced in the approach. In other words, it is best to minimize risks while you develop confidence and skill.

Once you have chosen the "focus class," decide on the class meeting during which you will use the classroom assessment technique. Make sure to reserve a few minutes of that class session for the assessment. At this point, you need to select a CAT. The five techniques listed below, described in detail in Chapter Seven of Angelo and Cross's book Classroom Assessment Techniques, are all flexible and easily adaptable to many situations, and simple and quick to apply. They also generate data that are easy to analyze. For those reasons, they make excellent introductory CATs and have been widely used by faculty from many disciplines.

Minute Paper (CAT 6)
Muddiest Point (CAT 7)
One-Sentence Summary (CAT 13)
Word Journal (CAT 14)
Documented Problem-Solutions (CAT 21)

They can be quickly summarized here. The *Minute Paper* asks students to respond to two questions: (1) What was the most important thing you learned today? (2) What questions remain uppermost in your mind as we conclude this class session? The *Muddiest Point* is an adaptation of the Minute Paper and is used to find out what students are unclear about. At the

end of a lecture or class session, students are asked to write brief answers to the following question: What was the muddiest point in my lecture today? The *One-Sentence Summary* assesses students' skill at summarizing a large amount of information with a highly structured, compact format. Given a topic, students respond to the following prompt: Who did what to / for whom, when, where, how, and why? In a course on U.S. government or American history, for example, this CAT could be used to assess students' understanding of the Constitutional Convention. The *Word Journal* assesses students' memory and ability to synthesize and summarize information. Typically, after a short reading assignment, students are asked to choose a word they believe best summarizes the text; then, students defend their word choice in a paragraph or two. Finally, *Documented Problem-Solutions* is a CAT that assesses students' understanding of a problem-solving technique or skill. It is particularly useful in math classes.

Detailed descriptions of five of Angelo and Cross's CATs are included in this packet of handouts.

STEP 2: IMPLEMENTING

Once you have chosen a focus course and selected a simple CAT to use in it, let students know beforehand (at the beginning of the class period or at the prior class meeting) what you are going to do. Whenever you announce your plans, be sure to tell the students why you are asking them for information. Assure them that you will be assessing their learning in order to help them improve, and not to grade them. In most cases, it is best to ask for anonymous responses.

When it comes time to use the classroom assessment technique, make sure that the students clearly understand the procedure. You may need to write directions for the CAT on the chalkboard or project them using an overhead projector and transparency. Let students know how much time they will have to complete the assessment. The first time you use a particular CAT, it is helpful to allow a little extra time for responses.

STEP 3: ANALYZING STUDENT RESPONSES

After the students have finished, collect their responses and read through them quickly as soon as you can. If you have time to read and analyze the responses fully immediately after class, so much the better. However, if you must put the CAT responses aside for a while, this fast "read-through" will help you recall exactly what students were responding to when you later read their answers more carefully.

As a rough technique for estimating time required, you can expect to spend one to two minutes per response analyzing the feedback. For example, if you were to use the Muddiest Point technique in a class of thirty students, you would need to budget at least thirty minutes--one minute per response--of your out-of-class time to analyze the feedback; for the Minute Paper, which poses two questions, you would estimate sixty minutes; for the One-Sentence Summary, which requires more complex feedback from students, you would probably need slightly more than an hour. The good news is that, with practice, teachers get faster at "processing" the data from classroom assessments.

Even a cursory reading of the five CATs can provide useful information. In analyzing feedback from the Muddiest Point technique, for example, you can simply note how many and which "muddy points" are mentioned and how many times the same "muddy points" come up. The same method can be used to analyze feedback from the Minute Paper or any other CAT that elicits student opinions or questions. Other techniques, such as Directed Paraphrasing, the One-Sentence Summary, or Applications Cards, prompt responses that can be judged more or less correct, or more or less complete. Student response to this type of CAT can be quickly sorted into three piles: correct / complete (or "on-target") responses, somewhat correct / complete (or "close") responses, and incorrect / incomplete ("off-target") responses. Then the number of responses in each pile can be counted, and the approximate percentage of the total class each represents can be calculated. Teachers also can look for particularly revealing or thoughtful responses among the on- and off-target groups.

STEP 4: RESPONDING

To capitalize on time spent assessing, and to motivate students to become actively involved, you will need to "close the feedback loop" by letting them know what you learned from the CAT exercise and what difference that information will make. Take a few moments to think through what, how, and when you will tell your students about their responses. Responding can take the form of simply telling the class, "Forty percent of you thought that X was the 'muddiest' point, and about one-third each mentioned Y or Z. Let's go over all three points in that order." In other cases, a handout may allow for a more effective and complete response. However you respond, let the class know what adjustments, if any, you are making in your teaching as a result of the information they have provided. Just as important, inform students of adjustments they could make in their behavior, in response to the CAT feedback, in order to improve learning. In other words, let students know that their participation in the classroom assessment can make a difference in your teaching and their learning.

Work Cited

Angelo, Thomas A. and K. Patricia Cross. Classroom Assessment Techniques: A Handbook for College Teachers. 2nd ed. San Francisco: Jossey-Bass, 1993

MINUTE PAPER
Angelo and Cross – CAT #6

DESCRIPTION

Students write a brief response to one of the following questions: What was the most important thing you learned in this class? ***Or*** What important question remains unanswered?

PURPOSE

This technique provides manageable amounts of timely feedback, allowing instructors to check quickly how well students are learning.

POSSIBLE LEARNING GOALS

- Students improve ability to synthesize information and ideas.
- Students develop ability to think holistically.

STEP-BY-STEP PROCEDURE

1) Decide whether you want to focus on what students learned from homework or previous exercise (so do this at the beginning of class) or on understanding of the current class/lecture (so do this at the end of class).
2) Allow about five minutes for the exercise.
3) Using the two basic questions in the description above, construct a prompt for your class.
4) Before class, write the prompt on the board or overhead.
5) When you're ready for the writing, hand out index cards or half-sheets of paper.
6) Provide instructions, informing students of how much time they have and what kind of answers you want and how you will use these.

SUGGESTIONS FOR USE

This versatile technique works especially well in classroom settings that are predominately lecture- or discussion-based; however, teachers may easily adapt the technique to assess what students have learned from a reading or lab assignment, film, field trip or performance.

PROS

Allows immediate mid-course feedback.
Responses can be read and analyzed quickly.
Shows respect for student feedback.

CONS

If over- or poorly-used, can be perceived as busy work.
Not all learning experiences can be captured in this format.

MINUTE PAPER
Sample Form

Directions: *In a single (*or several) *well-constructed sentence, provide the information to the following questions:*

What was the most important thing you learned from today's lesson?

_____

_____

_____

_____

_____

What important question remains unanswered?

_____

_____

_____

_____

_____

MUDDIEST POINT
Angelo and Cross – CAT #7

DESCRIPTION

Simple to administer, this technique consists of asking students to jot down a quick response to one question: "What was the muddiest point in _____?" The focus of the Muddiest Point assessment might be a lecture, a discussion, a homework assignment, a play, or a film.

PURPOSE

The Muddiest Point technique provides information on what students find least clear or most confusing about a particular lesson or topic. Learners must quickly identify what they do not understand and articulate those muddy points. Consequently, even though the technique is extremely simple to administer, responding to it requires some higher-order thinking.

RELATED TEACHING GOALS

- Develop ability to concentrate and pay attention
- Improve listening skills
- Develop appropriate study skills, strategies, and habits
- Learn terms, facts, concepts and theories associated with this subject

SUGGESTIONS FOR USE

While this technique can be used in virtually any setting, it is particularly well suited to large, lower-division classes. The Muddiest Point question should be posed at the end of a lecture, at the close of a discussion or presentation, or immediately after a reading assignment. This CAT can be used frequently in classes where new information is presented each session where, providing a steady stream of possible "muddy points." On the other hand, the Muddiest Point is best used sparingly in courses where the emphasis is on integrating, synthesizing, and evaluating information.

STEP-BY-STEP PROCEDURE

1) Determine what you want feedback on: the entire class session or one self-contained segment? A lecture, a discussion, a presentation?
2) If you are using the technique in class, reserve a few minutes at the end of the class session. Leave enough time to ask the question, to allow students to respond, and to collect their responses by the usual ending time.
3) Let students know beforehand how much time they will have to respond and what use you will make of their responses.
4) Pass out slips of paper or index cards for students to write on.
5) Collect the responses as or before students leave, perhaps stationing yourself at the door and collecting "muddy points" as students file out.
6) Respond to the student's feedback during the next class meeting or as soon as possible afterward.

PROS

- Quick, simple, and easy to administer, requiring little preparation (can be used successfully on the spur of the moment)
- Provides a "lifeline" for students who are lost and hesitant to ask questions in class
- Provides a "snapshot" diagnosis of what students are finding difficult
- Allows teacher to focus subsequent lessons and assignments more effectively
- Enables teachers to see the material through their students' eyes.
- When used frequently, may lead to increased self-assessment by students

CONS

- Places emphasis on what students don't understand
- Some students have difficulty articulating what they don't understand

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MUDDIEST POINT
Sample Form

Directions: *As specifically as possible, complete the following statement:*

After the ___(name of course activity)___, I am still confused about

_____

_____

_____

_____

ONE-SENTENCE SUMMARY
Angelo and Cross – CAT #13

Description

This simple technique challenges students to answer the questions "Who does what to whom, when, where, how, and why?" (represented by the letters WDWWWWHW) about a given topic, and then to synthesize those answers into a single informative, grammatical, and long summary sentence.

Purpose

The One-Sentence Summary enables teachers to find out how concisely, completely, and creatively students can summarize a large amount of information on a given topic. It allows faculty to scan and compare responses quickly and easily. The One-Sentence Summary also gives students practice in using a technique for "chunking" information-condensing it into smaller, interrelated bits that are more easily processed and recalled.

Related Teaching Goals

- Develop ability to synthesize and integrate information and ideas
- Improve memory, listening, and reading skills
- Reinforce ability to write grammatically

Suggestions For Use

This assessment technique can provide feedback on students' summaries of just about any information that can be represented in declarative form, from historical events, to the plots of stories and novels, to political processes, to chemical reactions and mechanical processes.

Step-By-Step Procedure

1) Select an important topic or work that your students have recently studied in your course and that you expect them to learn to summarize.
2) Working as quickly as you can, answer the questions "Who Did/Does What to Whom, When, Where, How, and Why?" in relation to that topic. Note how long this first step takes you.
3) Next, turn your answers into a grammatical sentence that follows WDWWWWHW pattern. Note how long this second step takes.
4) Allow your students up to twice as much time as it took you to carry out the task and give them clear directions on the One-Sentence Summary technique before you announce the topic to be summarized.

Turning The Data You Collect Into Useful Information

Perhaps the easiest way to organize the data from these summaries is to draw slash marks between the focus elements of the sentence, separating the responses to the various questions ("Who?" "Did/Does What?" and so on) with penciled-in vertical lines. To make the analysis faster and easier, ask the students to insert the separating lines after they have completed their sentences. As you separate the components of the summary

sentence, evaluate the quality of each by writing a zero, a check mark, or a plus above that element. Zero indicates an "inadequate" or "incorrect" element; the check means "adequate"; and the plus sign indicates "more than adequate." You can then make a simple matrix to represent the whole class's responses, with the questions as column headings and the three marks--zero, check, plus--as row headings. When you have totaled the responses, insert the totals in the responses. For example, the totals can tell you whether your students are better at answering "who" and "what" questions than "how" or "why" questions.

Pros

- Provides quick, easy way to assess students' ability to summarize succinctly and coherently.
- Help students grasp complex processes and explain them in nontechnical language.
- Uses a format (the sentence) that is familiar, memorable and useful to students

Cons

- Not appropriate for focus questions would have multiple answers.
- Potential for oversimplification of difficult or complex material.

ONE-SENTENCE SUMMARY
Sample Form

Directions: *Answer the following questions on the topic which was just covered:*

Who:
Did/Does What:
To Whom:
When:
Where:
How:
Why:

Now, summarize the information into one grammatically correct, complete sentence.

_____

_____

_____

_____

WORD JOURNAL
Angelo and Cross – CAT #14

DESCRIPTION

The Word Journal prompts a two-part response. First, the student summarizes a short text in a single word. Second, the student writes a paragraph or two explaining why he or she chose that particular word to summarize the text. The completed response to the Word Journal is an abstract or a synopsis of the focus text.

PURPOSE

The Word Journal can help faculty assess and improve several related skills. First, it focuses on students' ability to read carefully and deeply. Second, it assesses skill and creativity at summarizing what has been read. And third, it assesses the students' skill at explaining and defending, in just a few more words, their choice of single summary word.

RELATED TEACHING GOALS

- Develop ability to synthesize and integrate information and ideas
- Develop ability to think holistically: to see the whole as well as the parts
- Improve memory, listening, reading, and study skills

SUGGESTIONS FOR USE

The Word Journal works wherever students are expected to read carefully and thoughtfully--to understand concepts, not simply to memorize information. This CAT is best used to assess the reading of short text, such as essays, poems, short stories, short articles, and cases.

STEP-BY-STEP PROCEDURE

1) Choose one of the short texts that your students will be assigned to read.
2) Decide what aspect of that text--main theme, central conflict or problem, core metaphor--you want students to focus on.
3) To determine whether the exercise is feasible and productive, try following your own directions, taking a few minutes to come up with your own list of reasonable "summary words" for the assigned text.
4) Tell the students that the choice of a specific word is less important than the quality of the explanation for that choice. Give them some ideas about what their explanations should contain, and inform them that the words they choose must be connected to their interpretations of the text.
5) When analyzing the responses, keep track of words used by more than one student or related terms that crop up. Pay close attention to the justifications that students give for their word choices. When possible, categorize Word Journal responses not only by the summary words but also by the types of explanations offered.

PROS

- Requires students to read deeply and to construct meaning from what they have read
- Encourages students to make personal connections with the texts they are reading and to take responsibility for their ideas.
- Helps students develop skills in summarizing, remembering, and communicating information-skills that they can use in academic and professional life.

CONS

- Somewhat time-consuming to prepare, administer, and analyze
- For students to benefit from the exercise, requires additional class time to discuss and compare responses, making anonymity difficult

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WORD JOURNAL
Sample Form

Directions: *On one side of the index card you received, write one word that you believe effectively summarizes the content of the material (reading assignment, lecture, film, etc.)*

Single word

On the other side of the card, in one or two paragraphs, defend and explain your choice.

explanation/ justification in 1-2 paragraphs

DOCUMENTED PROBLEM SOLUTIONS
Angelo and Cross – CAT #21

DESCRIPTION

The Documented Problem Solutions technique prompts students to keep track of the steps they take in solving a problem--to "show and tell" how they worked it out. By analyzing these detailed protocols--in which each solution step is briefly explained in writing--teachers can gain valuable information on their students' problem-solving skills.

PURPOSE

Documented Problem Solutions have two main aims: (1) to assess how students solve problems and (2) to assess how well students understand and can describe their problem-solving methods. Therefore, the primary emphasis of the technique is on documenting the specific steps that students take in attempting to solve representative problems--rather than on whether the answers are correct or not. As they respond to the assessment, students benefit by gaining more awareness of and control over their problem-solving routines. Understanding and using effective problem-solving procedures is, after all, a critical component of mastery in most disciplines.

RELATED TEACHING GOALS

- Develop ability to apply learned principles and generalizations to new problems and situations
- Develop problem-solving skills
- Improve mathematical skills
- Learn techniques and methods used to gain new knowledge in this subject
- Learn to evaluate methods and materials in this subject
- Develop a commitment to accurate work

SUGGESTIONS FOR USE

The Documented Problem Solutions technique is especially useful for assessing problem solving in highly quantitative courses, such as accounting, algebra, calculus, computer programming, engineering, microeconomics, physics, and statistics. It can also be used in other fields that teach structured approaches to problem solving, fields such as logic, tort law, organic chemistry, transformational grammar, and music theory.

STEP-BY-STEP PROCEDURE

1) Select one, two, or three representative problems from among the problems studied during the previous few weeks. If you decide to assign three problems, for example, try to select at least one that all the students can solve, another that most of the class can solve, and a third that will challenge most of your students.
2) Solve the problems yourself, and write down all the steps you take in solving them. Note how long it takes you and how many steps each problem solution required.
3) If you find any of the problems too time-consuming or too complicated, replace or revise them.

4) Once you have good problems that you can solve and document in less than thirty minutes, write them up. Assume that it will take students at least twice as long as it took you to document the solutions. Make your directions very explicit.
5) Hand out and explain the assessment problem(s), making clear to the students that it is not a test or a quiz. It is more important for students to explain how they try to solve the problems than to get the right answers. Having well-documented steps is even more important if they fail to get a correct answer, since they can then diagnose where and how they went wrong. When assigning as homework, let students know the maximum amount of time they should spend on it.

Turning the Data You Collect Into Useful Information

If you are teaching more than a handful of students, select a few responses to analyze. After skimming quickly through all of them, pick three responses in which the answers are correct and the solutions well documented. Pick another set of three that contain well-documented solutions but incorrect answers. Compare the solutions within and across sets. Make notes on solution paths that led to successful outcomes and those that led to mistakes. Try to locate general zones, or the exact spots, in the solution processes that determined correct or incorrect results. For example, were the results incorrect because the students skipped steps? After completing your analysis, write down three or four main insights and /or suggestions to share with students. If time allows, prepare an overhead transparency or a handout detailing one or two particularly elegant solutions.

PROS

- Helps teachers and students look "behind" specific answers to glimpse the students' thinking processes and problem-solving strategies, focusing on the process rather than the final product
- Allows the teacher and the students to become aware of a range of possible successful--and unsuccessful--approaches to problem solving.
- Promotes the development of discipline--specific metacognitive skills--in this case, awareness of and control over problem-solving processes.

CONS

- At first, many students may find it quite difficult to explain how they solve problems
- Faculty may not always be able to figure out and explain why a given set of steps worked or failed to work.
- When students take different solution paths or are working at a wide variety of levels, it may not be useful or even possible to give general feedback on their responses.

Caveats

- Be prepared to help students learn how to write good step-by-step solutions – most have little experience reflecting on and articulating their problem-solving processes.
- Can be difficult and time-consuming for students. To get thoughtful and thorough responses, consider offering credit for completing the assessment.
- Don't feel bound to analyze more data than you can comfortably handle, but make sure that students at all levels get some useful feedback.

DOCUMENTED PROBLEM SOLUTIONS
Sample Form

Directions: *On the left side of the worksheet, solve the problem using the techniques you have learned. On the right side of the worksheet, explain the reasoning (examples: mathematical, logic, scientific or other thought processes) that you used to reach your solution in a step-by-step approach.*

1. Problem

Documentation

Step 1:

Step 2:

Student's Solution

Step 3:

To the instructor: *If you prefer lines, use the lines below to adapt your problem.*