

*This chapter provides capsule summaries of simple, representative Classroom Assessment Techniques used in a variety of disciplines to assess four dimensions of learning—the “what,” the “how,” the “when and where,” and the “why.”*

## Ten Easy Pieces: Assessing Higher Learning in Four Dimensions

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Classroom Assessment is a simple method faculty can use to collect feedback, early and often, on how well students are learning what they are being taught. The purpose of Classroom Assessment is to provide faculty and students with information and insights needed to improve teaching effectiveness and learning quality. College instructors use feedback gleaned through Classroom Assessment to inform adjustments in their teaching. Faculty also share feedback with students, using it to help them improve their learning strategies and study habits in order to become more independent, successful learners.

Classroom Assessment is one method of inquiry within the framework of Classroom Research, a broader approach to improving teaching and learning. Just as the essay test is only one of many possible methods of testing, Classroom Assessment is one of many possible methods of carrying out Classroom Research. Developed by K. Patricia Cross and Thomas A. Angelo, both Classroom Research and Classroom Assessment are attempts to bring the advantages of assessment and educational research into the classroom and under the control of individual college teachers (Cross and Angelo, 1988).

To date, Classroom Assessment is the most highly developed and widely practiced form of Classroom Research. This chapter presents ten examples of simple Classroom Assessments carried out by faculty in ten different disciplines. These are examples of quick and easy approaches for gathering data on student learning. As such, they are meant to illustrate the concept of Classroom Assessment and inspire other teachers to design or adapt their own techniques for getting feedback on the full range of learning in their disciplines.

Before faculty can meaningfully assess student learning, they need to identify what kinds of learning they want to focus on. In my own teaching, I have found it useful to categorize the kinds of learning my courses are designed to promote into four distinct, though interrelated, dimensions.

## Assessing Four Dimensions of Learning

Following common usage in psychology, the first three dimensions are referred to as declarative learning, procedural learning, and conditional learning. The fourth dimension is one I refer to as reflective learning. My purpose in using these four dimensions to organize the ten examples is to demonstrate simple ways in which Classroom Assessment can be used to gain insights and information on *all* levels of student learning—not just the learning of simple facts and principles.

**Dimension One: Declarative Learning (Learning What).** Declarative learning is easily the most common dimension of learning promoted in classrooms, from kindergarten through graduate programs. Simply put, declarative learning in higher education is learning the facts and principles of a given field—learning the “what” of the discipline. When we teach students the elements of the periodic table, the Linnaean system of classification, the conjugations of irregular verbs in Italian, the crucial battles of the U.S. Civil War, or the principles of accounting, we are teaching for declarative learning.

We commonly assess how well students have learned relevant facts and principles by asking them to *declare* in speech or writing what they know, hence the term *declarative*. A quick look through college catalogues will show that most college curricula are primarily aimed at producing gains in this dimension of learning.

**Dimension Two: Procedural Learning (Learning How).** While knowledge of facts and principles is necessary to higher learning, it is hardly sufficient. Students must also develop skills. Learning how to do things, the processes and procedures involved, is procedural learning. There are some skills that all college students are expected to master, and many courses are designed to promote this general level of procedural learning. For example, most college faculty are interested in helping students improve their skills in thinking, speaking, and writing clearly.

At the same time, however, each discipline has its own particular skills to impart. To become competent musicians, for instance, students must develop sight-singing skills. To be competent botanists, they must learn to categorize taxonomically. Prospective economists must learn to present and understand information in graphic form. Those studying civil engineering must learn to correctly calculate stresses and loads for various structures and materials. And apprentice automotive technicians must learn to use sophisticated equipment to diagnose the performance of mechanical and electronic systems.

Thus, each discipline is defined not only by a particular body of (declarative) knowledge that its aspiring members are expected to learn, but also by a collection of discipline-specific skills they must master. The mix of general and specific skills taught in colleges and universities makes up the procedural dimension of learning.

**Dimension Three: Conditional Learning (Learning When and Where).** Although the third dimension is less often explicitly taught than the first two, it is nonetheless a critical element in a meaningful higher education. Conditional learning is learning when and where to apply the knowledge and skills one has mastered. Its name refers to the learner's ability to evaluate the *conditions* under which the application of declarative and procedural knowledge is likely to be most successful. In plain language, conditional learning is learning good judgment in a particular field. It is knowing when and where to use what you know to greatest advantage.

Three quick examples may help to illustrate the conditional dimension. It is one thing for a French horn player to learn what vibrato is (declarative learning), and another to learn how to produce vibrato (procedural learning). To learn how to decide when and where it is appropriate to use vibrato is conditional learning. In learning to write, students need to develop an understanding of levels of formality and different genres and to become skilled in producing them appropriately. But students who have not developed the judgment needed to decide whether to take a formal or informal tone, or whether to write an expository essay or a narrative, are not yet writers. They lack sufficient conditional learning. A graduate student in statistics may master the various tests for statistical significance and how to perform them, but if that same student cannot decide which test to apply to a given "real-world" statistical problem, the knowledge and skills are of little use.

To the extent that we teach conditional learning, it is often done through the use of examples and modeling. The case-study method and clinical instruction, two teaching methods widely used in professional education, often focus directly on developing applications and judgment—as does one-on-one coaching.

**Dimension Four: Reflective Learning (Learning Why).** As important as the first three dimensions of higher learning are, even their mastery is not enough to qualify a student as a liberally educated person. To constitute more than job training, higher education must also help students develop the habits of mind and heart required for the full exercise of citizenship and the responsible pursuit of individual happiness. To become independent, lifelong learners, students need to learn ways to reflect on their interests, motivations, attitudes, and values. In short, students need to learn to be self-reflective, to understand why they believe, think, and act as they do—and to value self-reflection.

In many colleges, this dimension of learning is dealt with in the general

education curriculum or in career counseling and other personal development courses. But in each academic field, there are particular questions of values, beliefs, and attitudes that students must confront to understand and participate fully in the “culture” of that discipline.

## Examples of Classroom Assessment in Ten Disciplines

The ten very brief examples that follow are meant to suggest simple means for assessing student learning across a variety of disciplines in each of the four dimensions. While each example focuses on assessing a single key dimension, this approach is merely a useful simplification. In reality, of course, effective learning is always multidimensional, and the efforts involved in learning content, skills, applications, and self-awareness are interrelated and mutually reinforcing. As a fortuitous consequence, assessing and promoting learning in one dimension can help improve learning overall.

I wish to acknowledge my many colleagues whose experiences are reflected in the following examples. Though details have been changed and situations greatly simplified, I am certain they will recognize their contributions.

### Assessing Declarative Learning

We will turn first to some examples of how faculty have assessed declarative learning in political science, chemistry, and statistics, respectively.

**In Political Science.** Before the first meeting of his required freshman-level survey course on U.S. government and politics, a political science instructor decided to assess what his students already knew. He wanted to do this for two reasons. First, he felt it would help him apportion his instructional time more effectively. By finding out what they did and did not already know, he could give more time and attention to teaching the latter. Second, it would help him identify good discussion “openers,” topics students were familiar with that could be used as bridges to new information.

He created a Background Knowledge Probe (Cross and Angelo, 1988, pp. 30–32), a two-page questionnaire asking students to rate their level of knowledge about fifteen important concepts, documents, and individuals they would soon be studying. Three of the fifteen questions he used are reproduced here:

#### 1. Federalism

- (1) Have never heard of this concept.
- (2) Have heard of it, but don't really know what it means.
- (3) Have some idea what this means, but not too clear.
- (4) Have a clear idea what this means and can explain it.

#### 4. The Articles of Confederation

- (1) Have never heard of this document.
- (2) Have heard of it, but don't really know what it is.
- (3) Have some idea what this is, but not too clear.
- (4) Have a clear idea of what this is and can explain it.

#### 7. James Madison

- (1) Have never heard of this person.
- (2) Have heard of him, but don't really know who he was.
- (3) Have some idea who this was, but not too clear.
- (4) Have a clear idea and can explain who this was.

After explaining its purpose and asking students *not* to put their names on the questionnaire, the instructor gave the class ten minutes to respond. Before the next class meeting, he tallied the number of responses to each choice. He found, for example, that very few students felt they knew what Federalism meant, while many thought they could explain the concept of separation of powers. Similarly, most students indicated they could explain what the Constitution was, but very few were familiar with the Articles of Confederation. Having this information on students' prior knowledge allowed the instructor to use the more familiar item in each pair to introduce and explain the less familiar one.

At the end of the first few weeks of the course, but before the first mid-term, he gave out the questionnaire a second time, as a post-assessment. Comparing the class's responses to the first and second administrations allowed both the students and their instructor to identify progress made and areas to be reviewed before the midterm.

**In Chemistry.** On the first day of class, a chemistry professor asked students in his introductory course to give chemistry-related examples of three key terms—*data*, *law*, and *theory*—that they would encounter frequently in subsequent lectures and readings. In other words, he wanted to assess whether his students could provide plausible, discipline-specific examples of a data statement, a scientific law, and a theoretical statement. This is an example of a Misconception/Preconception Check (Angelo and Cross, *in press*), another way to get feedback on students' prior knowledge.

The chemistry instructor explained that he was not concerned about the correctness of the examples, only their appropriateness. He assured the students that it was not a test and reminded them *not* to put their names on the papers. He gave the class ten minutes to write down the examples and then collected them.

In reading through their responses later that evening, the instructor found that over 70 percent of the class could produce an acceptable data statement, but less than 20 percent could provide a statement of theory or a law. Faced with this evidence, he realized he could no longer assume, as he had for more than twenty years, that students arrived with well-formed,

useful concepts of basic, key terms. In the subsequent class session, he followed up by using students' responses, correct and incorrect, to explicitly teach the concepts of *law* and *theory* as applied to chemistry.

**In Statistics.** To find out what facts and principles students were focusing on during her lectures, a statistics professor used an adaptation of the One-Minute Paper (Cross and Angelo, 1988, pp. 148-150). At the end of each class period, she asked her thirty-five introductory-level students simply to list the three most important points covered in the lecture. The first time she did this, she received a total of fifteen different responses as candidates for the lecture's three most important points. This perplexed the instructor, who was certain she had been quite clear in pointing out the most critical points. At the next session, she reviewed their responses with them and explained why she considered some points more important than others.

During the next few class sessions, the statistics instructor made special efforts to indicate which were the most important facts and principles. For three weeks, she continued to use the assessment technique at the end of each lecture. She also continued to "feed back" this information to the class, reviewing her intended main points each time and encouraging the students to explain why they thought others were as or more important. In following up the assessments this way, she used the feedback to teach students how to discriminate more effectively between the central information and the details in her lectures.

Over the three weeks during which she used the modified One-Minute Paper technique, the average number of different responses given as the three most important points in the lecture gradually decreased from fifteen to six or seven. The statistics instructor viewed this narrowing range of answers as evidence that more students were more clearly perceiving the most important facts and principles of the lectures as she did. In other words, her "novice" students were learning to evaluate and understand the lecture content more as an "expert" would.

## Assessing Procedural Learning

To assess procedural learning, faculty in English literature, clinical nursing, and mathematics have drawn on a variety of techniques.

**In English Literature.** An English instructor teaching a lower-division U.S. literature course for majors was dissatisfied with her students' superficial readings of assigned texts. She decided to assess the students' skill at reading for meaning in the hope of finding ways to improve that skill. She modified a technique known as the One-Word Journal, used in Writing Across the Curriculum programs to improve summarizing skills.

Several times during the semester, when she assigned short homework readings such as poems or short stories, the English instructor asked students to come up with the single word they felt would best summarize that

particular reading. After choosing a word, they were to write one page or less explaining why the individual words they chose were such apt summaries. In other words, they were asked to choose a single summary word and then justify their choices. For their One-Word Journal entries, students received full credit, half-credit, or no credit—depending on the completeness and quality of their responses. The amount of credit given for the assessment exercise equaled that given for a typical homework assignment.

The instructor read through One-Word Journal entries quickly to get a sense of the students' depth of reading and the quality of explanation. As she read, she made notes, and she later commented in class on weaknesses and strengths in students' explanations and justifications of the chosen words. Early on, they asked to hear which words their classmates had chosen and why, and so she allotted class time to discuss their journal entries. Interest and participation were high in these discussions, with students working hard to convince one another of the aptness of their summary words.

By the third round of One-Word Journals, she found that the overall level of explanation and justification had improved noticeably and that the weaker students in class seemed to be benefiting even more than the others. In response to her feedback and the various examples provided by their classmates, students began imitating and trying out new approaches to justifying their word choices. The quality of class discussions convinced her that students were reading more carefully and deeply when they were assigned One-Word Journals.

This relatively simple assessment technique gave the instructor a window into her students' reading of literature. With that information, she was able to zero in on their difficulties and suggest strategies. One unintended benefit of the One-Word Journal came when students began to argue the need to develop standards for evaluating the quality of the summary words and their justifications. Their expressed desire to learn to evaluate summaries gave the teacher a wonderful opening to teach them about the development of criteria for quality in literary criticism. Thus, the technique not only provided the instructor with information on how and how well students were reading, but also raised their awareness to the explicit level.

When the English teacher later asked students to evaluate the usefulness of this assessment technique, nearly all responded with enthusiasm. Several noted that it gave them a powerful "handle" on the material. They explained that they had not previously realized that there were techniques for reading literature that could help them get beneath the surface. Several of the students had assumed that reading deeply was not a skill, but rather a talent that some students had, that they did not, and that could not be developed. The One-Word Journal exercise challenged those assumptions.

**In Clinical Nursing.** Although she regularly assigned homework designed to help students learn important clinical skills, this nursing in-

structor found that they too often came to class unable to perform the skills they had studied. Suspecting that most of the students had weak reading and study skills, she decided to assess them. To find out how well and carefully they read, she used the Directed Paraphrasing technique (Cross and Angelo, 1988, pp. 34-37).

As homework, she assigned a short reading on how to draw medicine from a vial using a syringe. She directed students to read the short text, then to prepare half-page paraphrases, in their own words, of the procedure they had read about. The paraphrases were to be written so clearly that a student not in their class would be able to read them and carry out the procedure perfectly.

The next day, students turned in their paraphrases at the beginning of class. They were then asked to demonstrate the technique with real syringes and vials. The nursing instructor noted that only one student stumbled through the procedure, rather than half the class, as had happened often before. When she asked the students why the assessment exercise had so dramatically improved their performance, most of them said it had made them think more carefully about what they were doing and how they were doing it. To write the paraphrase, they had to read more carefully and actively. This, in turn, led to more effective learning and retention of the skill.

In this example, although the instructor did subsequently read and comment in class on the Directed Paraphrases, the real assessment of their procedural learning came in their performance of the task. Having students paraphrase the steps of the procedure in writing was a powerful way to prepare them for that performance assessment. Because of the success of this assessment, the nursing instructor went on to assign paraphrasing exercises to reinforce the learning of each new clinical skill taught.

**In Mathematics.** To better understand how well his students' problem-solving skills were developing, a veteran calculus teacher used an adaptation of the Documented Problem-Set Solution technique (Cross and Angelo, 1988, pp. 38-40). He did this in a way that allowed him to get more feedback on their learning of these critical skills without increasing his overall workload.

Specifically, the instructor substituted the assessment technique for part of an existing homework assignment. Instead of assigning and grading five homework problems for each class session, as had been his procedure for many years, he cut the number of daily homework problems to four. As a part of each day's homework, in place of the fifth problem, he gave students the following assessment exercise directions: "Choose any one of the four problems in this set that you have already solved. Explain and document, step by step, in complete and grammatical sentences, exactly how you solved that problem. Be prepared to lead the class through your documented problem solution next session."



At first, several of the students balked at doing an ungraded, noncredit assessment exercise that seemed to have more to do with writing skills than with calculus. The instructor quickly decided to offer students credit for doing the assessment exercise equal to what they would have received for the fifth homework problem. For a detailed, thoughtfully documented, well-written response, students got full credit. For a slapdash, pro forma response, on the other hand, they received no credit.

He still refrained from grading the assessments, however, limiting himself to writing a comment, suggestion, or question in the margin. The students' documented problem solutions gave him many insights into how and where students got stuck or took "wrong turns" in their problem-solving approaches. Being able to see students' thinking processes reflected in their writing gave him many opportunities to diagnose and treat problems more effectively and to praise good strategies more clearly.

In class, the instructor called on individual students to talk through their solutions to specific homework problems. Each time a student picked up the chalk and demonstrated a solution, he or she was forced to become an active participant. Instead of demonstrating solutions as students took notes—which he had come to see as doing the work for them—the instructor was able to act as a learning "coach," providing his students with valuable practice in problem solving and helping them when they became stuck or got off the track.

After about a month of documenting problem solutions, nearly all the students in his calculus class became relatively skilled at explaining the steps they had taken. They also greatly improved their ability to identify where they ran into difficulties in problems they failed to solve. By focusing on and assessing their problem-solving skills, the calculus instructor found he had helped students learn these skills more effectively.

## Assessing Conditional Learning

Assessing conditional learning in such fields as business management and social work involves testing students' ability to apply practical strategies in real-world situations.

**In Business Management.** Once students in an advanced seminar on conflict resolution had become familiar with the five different negotiating strategies they had read about and discussed, their professor decided to assess their ability to appropriately apply those various approaches to real-life conflicts—that is, to choose the relevant strategy. In other words, she wanted to see how well students could move from examples of situations to relevant principles (Angelo and Cross, in press). To assess how well the students could identify conditions in which a given strategy would be most likely to succeed, she wrote five brief sketches of typical conflicts ripe for negotiation. In her mind, each half-page sketch was

clearly best resolved by a different one of the five negotiating strategies covered in the seminar.

She gave these problem sketches to the students and asked them to identify the specific negotiating strategy most likely to lead to a successful resolution of each conflict. In addition, she asked them to explain, in a paragraph or two for each sketch, why the strategy they chose was the best one to use in that situation. Students were to write responses and be prepared to discuss them in the seminar meeting the following week.

During the in-class discussion of their responses, the instructor soon realized that what had seemed to her to be obvious matchups between conflict sketches and negotiating strategies were not nearly so clear-cut to the students. From listening to and later reading their responses, she found that many of them were choosing negotiating strategies with little analysis of or regard for the interests of the parties to the conflicts. Nor did the students pay much attention to the context in which the conflicts were embedded. More often, they selected strategies for one or more of the following three reasons: (1) They assumed the particular strategy had a greater likelihood of success under any circumstances, (2) they felt it was somehow inherently more ethical or more sophisticated, or (3) they felt more confident in applying some strategies than others.

The results of the assessment showed the instructor quite clearly that although her students had learned the content of the five negotiating strategies well, they felt their mastery of the skills involved was uneven. This uneven procedural learning caused them to rely too much on familiar strategies. In retrospect, the students' feedback did not surprise the instructor, since the seminar had devoted much time to discussing but little time to practicing the five strategies. She also realized that most of the students had not yet become skilled at analyzing and diagnosing the dynamics of conflicts. She could see that they were not basing their choices of negotiation techniques on a clear analysis of actors, interests, and environments.

These two realizations led the instructor to rethink and redirect the seminar. After talking with the students about the sketches and explaining her diagnosis of their learning needs, there was general agreement on the need to improve skills in using the various negotiating strategies at the same time that they improved their ability to judge when and where to use them. As a consequence, the instructor decided to replace one of the later topics in the syllabus with more intensive work on building skills in negotiation. In her judgment, it was more important for seminar members to develop a deep understanding of a few topics than a more superficial understanding of many.

**In Social Work.** In his graduate course on social work practice with children, teenagers, and families, this professor stressed the importance of learning a wide variety of helping strategies and learning when to apply them. By mid-semester, through active engagement in simulations and case

studies, his students had been exposed to a number of typical problems and a range of potentially useful interventions. At that point, the instructor decided to assess their ability to apply those intervention strategies. In other words, in this example the instructor wanted to assess the students' ability to move from principles back to practice.

To assess their conditional learning, he simply gave the class a list of the helping strategies they had covered and asked them to provide a context in which each intervention was most likely to be appropriate and successful. He assigned three different interventions, more or less randomly, to each student. That meant that each helping strategy would be dealt with by several students, but none would be dealt with by everyone. For each of the three strategies assigned, each student was to write a mini-case—less than one page long—outlining the setting, clients, and most important dynamics involved, and to briefly explain the appropriateness of the intervention. He told the students to draw on their personal and professional experiences as well as on their imagination in creating these Student-Generated Mini-Cases (Angelo and Cross, *in press*), but to be sure to protect the anonymity of sources.

In reading through their mini-cases, the professor noted that most of the students came up with plausible applications. But he also noted that most seemed to link specific helping strategies to particular circumstances, such as homelessness, or to particular kinds of clients, such as single mothers. They rarely made reference to the overall dynamics within the family systems, the clients' cultural backgrounds, or the larger social systems that might affect the outcomes of their interventions. In other words, from the professor's point of view, the students' applications were essentially reasonable, but unacceptably narrow.

Armed with this information, he created a plan to help students think through the broader applicability of various helping strategies. After giving the class feedback on the strengths and weaknesses of their mini-cases, he gave a follow-up assignment. He directed the students to trade papers, so that each would have another's mini-cases. He then asked them to come up with a second mini-case application for each intervention that was as different as reasonably possible from their classmate's example. They were to vary the type of client, setting, and dynamics to the limits of the intervention's useful range. In this way, he helped them see the broader applicability of the helping strategies they were learning.

## Assessing Reflective Learning

The Student Goals Ranking technique and the Informal Attitude Survey Questionnaire are techniques that have proved useful in assessing reflective learning in physical education and physics, respectively.

**In Physical Education.** Even after several years of teaching a large-enrollment, elective aerobics class, this dance instructor had never come to

terms with the high dropout rate and absenteeism that characterized the course. In discussing the problem with her departmental colleagues, she had been surprised to find that her attendance and retention figures were well within the normal range. Colleagues tried to reassure her by arguing that attendance and retention were always problems in elective activity courses for nonmajors and that she should not take it personally.

Over the years, she had changed the class in various ways, hoping to discover a solution to the problem. She had tried making the class more structured and rigorous. She constantly updated the music and the routines to make the course more relevant. Despite her attempts, however, attendance and retention failed to improve.

Finally, she had the insight that the students' goals and expectations might be the key to the issue. She decided to assess the students' goals, using an adaptation of the Student Goals Ranking technique (Cross and Angelo, 1988, pp. 90-93). Early in the semester, she wrote down what she thought the students' most important goals were in taking the course. Then, taking a few minutes out of the class period, she handed out blank index cards and asked the students to write down their most important goals for the aerobics course.

After class, she took the students' responses back to her office and read through the cards, quickly tallying types of answers. When she had finished tallying, she compared what she expected the students' goals to be with what their goals actually were. The instructor *thought* that her aerobics students' most important goals would be the following: (1) to increase cardiovascular fitness, (2) to lose weight, and (3) to improve muscle tone. By contrast, the most frequently mentioned goals *actually were* these: (1) to improve self-confidence or self-esteem, (2) to reduce stress, and (3) to feel healthier and more energetic.

Once the dance teacher saw the mismatch in goals, she realized that her attempts to make the class more challenging and rigorous were very likely coming into direct conflict with students' goals of improving self-confidence and reducing stress. She also realized that students who felt defeated and stressed by her class were unlikely to feel healthier and more energetic. Nor were they likely to develop more positive attitudes toward exercise and fitness, one of her most important instructional goals.

She reported the results of the assessment to the group during the next class meeting and invited suggestions. Based on the assessment and the discussion, she decided to incorporate the students' goals and suggestions into the course in several ways. First, she began teaching two levels of routine for each aerobic workout. That is, she taught the class a relatively easy routine and a relatively challenging one to the same music. The students could self-select, allowing those who felt less able to start with the simple routine, while the more able could choose the more difficult workout. Second, she provided readings and held an in-class discussion on the

relationship among body image, self-image, and self-esteem. She also taught students a few simple stress reduction techniques they could practice on their own. And finally, she explained and gave examples of ways in which regular exercise could increase one's energy and improve overall health.

By assessing students' goals, she also helped them to become more aware of their expectations and to take more responsibility for their learning. Once she and the students knew they were working toward the same goals, the atmosphere in the classroom changed. For the last two years, she has continued to assess student goals in the aerobics course and has made further adjustments. Since her first experiments with Classroom Assessment, attendance and retention in the aerobics class have improved and have remained much higher than in the past. (An earlier summary of this project can be found in Angelo, 1990, pp. 80-81.)

**In Physics.** This instructor's large introductory physics course was one of only three courses that undergraduates could take to fulfill their general education requirement in the physical sciences at his college. As a result, he had many students who might otherwise not have taken physics. He was especially eager to interest more women in majoring in physics but suspected that students' preconceptions and attitudes toward physics worked against his goal.

To discover how his students viewed physics and physicists and to help them become more self-aware, he used a simple Classroom Assessment. He made up a short Informal Attitude Survey Questionnaire (Angelo and Cross, in press). Among the dozen prompts included in the questionnaire were the four reproduced below. He set aside ten minutes of class time for the survey and provided each student with a copy. Students were directed to circle only one of the five possible responses to each prompt. They were also told *not* to put their names on the questionnaires. He did ask students to indicate their gender, however.

1. Very few physicists ever marry or have children.
  - A. Obviously true
  - B. Probably true
  - C. Don't know
  - D. Probably not true
  - E. Obviously false
4. There have been no outstanding women physicists.
  - A. Obviously true
  - B. Probably true
  - C. Don't know
  - D. Probably not true
  - E. Obviously false
8. All outstanding physicists have been Europeans or European-Americans.
  - A. Obviously true

- B. Probably true
  - C. Don't know
  - D. Probably not true
  - E. Obviously false
11. You need a near-genius IQ to get a doctorate in physics.
- A. Obviously true
  - B. Probably true
  - C. Don't know
  - D. Probably not true
  - E. Obviously false

As he had suspected, many of the students held stereotypical beliefs and attitudes toward physicists that were often demonstrably false or, at the very most, only partially true. He was surprised to find that most of the women in his class seemed to share the gender biases of their male classmates. Most of the women as well as the men, for example, believed it was probably or obviously true that there were no outstanding women physicists. A majority of students of both genders also believed men were somehow naturally better adapted to doing physics than women.

Once the instructor had tallied and recorded the results of the survey, he shared them with his class and discussed the twelve questionnaire prompts one by one. He presented the available facts in relation to each prompt and answered questions. After the class had finished reviewing the questionnaire, he handed out an annotated version containing short answers and some references.

Throughout the semester, he often referred to the survey and presented students with further information related to the questions on it. He continued to gently challenge misconceptions about race and gender and scientific achievement. Near the end of the semester, the physics teacher gave the survey again. The second time through, he found that most had changed most of their "mistaken" attitudes, and that the women students had changed more, on average, than the men.

## Conclusion

Perhaps the most important lesson to draw from the ten preceding examples is the importance of adapting or creating assessment techniques to meet the specific needs of a particular class. The instructors mentioned in this chapter were successful in using Classroom Assessment largely because they observed a cardinal axiom of the approach: Adapt, don't adopt. It is my hope that readers will make use of these examples in the same spirit, by adapting them creatively to the requirements of their disciplines and the needs of their students.

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