Research & Occasional Paper Series: CSHE.15.05

CSHE | Center for Studies in Higher Education

UNIVERSITY OF CALIFORNIA, BERKELEY
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ON COLLEGE TEACHING*

December 2005

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ABSTRACT

A survey of 2800 teachers from 33 two- and four-year colleges shows markedly different perceptions of teaching goals and roles. The most significant differences occurred across fields of study. For example, whereas 55 percent of the science teachers said they were primarily concerned about teaching students the facts and principles of their subject matter, only 17 percent of the English teachers saw mastery of subject matter as their primary goal. These and other findings are related to research on college teaching, and suggestions are offered for applying findings to classroom teaching.

I'd like to start today by making five assertions about what I think we know about college teaching. And then I'll expand a bit on the research that leads us to those conclusions, ending with some suggestions about what teachers can do in their own classrooms to make teaching more professional, more productive, and more intellectually satisfying.

My first assertion is that we know that good teaching does make a difference in student learning. There has been so much discussion and research on the always-dubious assertion that schools don't and can't make much difference in the face of poor family background, low socioeconomic status, and the like that it is now necessary to reassure teachers at all levels that they do make a difference. It is not a very startling research finding, but students who are well taught learn more than students who are poorly taught.

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* Presented at the Annual Convention of the American Society for Engineering Education, New Orleans, June 17, 1991. A version of this paper was later published in *Journal of Engineering Education* (January 1993): 1-12.

Second, we know that at the college level, teachers vary markedly in what they are trying to accomplish through their teaching. Teaching goals are heavily associated with academic disciplines, but they also vary with personal perceptions of the teaching role.

Third, we know that there are some characteristics and teaching methods that are consistently associated with effective teaching. Characteristics such as "enthusiasm" and "knowledge of subject matter" show up on almost everyone's list of the qualities of good teachers, but it is becoming increasingly clear that effective teachers have some basic understanding of the learning process. That means that they are able to make the connections between what students already know and what we want them to learn.

Fourth, we know that teaching can be evaluated and rewarded. Students, faculty colleagues, and administrators **do** know good teaching when they see it, and there is sufficient agreement that we can put to rest the notion that we can't reward good teaching because we can't agree on what good teaching is.

Finally, we know that there is ample room for improvement. Teaching is in a primitive state of development, and improvement can take place all along the line, starting with the training of teaching assistants in graduate school, and proceeding through recruitment, hiring, orientation, professional development, promotion, and tenure.

Now I am ready to defend those assertions, largely through a synthesis of recent research on teaching and learning, but I also believe that teachers' own experiences can be a good source of knowledge about teaching effectiveness **if** teachers systematically observe the impact of their own teaching on the learning of students in their classrooms. I'll come back to experience as a source of evidence later. But first, let's look at what the research of the past 20 years has to say about college teaching.

Teachers do make a difference. We all know that, of course, through our own experience as learners. Indeed, I suspect that many of us owe our choice of career to the influence of a teacher who made intellectual work satisfying and exciting for us. But research across a variety of institutions and classrooms now attributes a substantial portion of learning to the quality of teaching (McDonald and Elias, 1976; Fenstermacher, 1982).

One study used a rough global measure of "earned credit" as the criterion and concluded that the teacher was the single most important factor in the college environment in whether students across 180 classes in three community colleges completed a course successfully (Guskey, 1988). The researchers concluded that, "There was more variability among teachers who taught the same subject at the same college than there was across courses, departments, or colleges. Teachers were clearly the most important factor in explaining the difference in earned credit rate" (p. 11). Since the course completion rate was only 62 percent in the community colleges studied, student retention was a matter of some concern.

The finding that teachers make a difference in student retention is of special significance to engineering educators because, nationwide, the drop-off rate in the sciences is high; only 40 percent of declared science majors actually graduate in science and engineering at the end of their senior year (Tobias, 1990). It seems likely that putting freshmen science majors together with the best **teachers** might improve retention in the critically important introductory courses. But most programs designed to improve retention are administrative programs having to do with orientation, counseling, financial aid, and the

like. We don't often look to the quality of instruction as a critical factor in retention. I don't find it especially surprising that the major factor in whether students complete a course or stay in college is whether they feel their work is worthwhile and they are experiencing some success in learning.

While simple retention, as the criterion of whether teachers make a difference, is a very rough measure, there is ample research evidence now, from a number of finely tuned studies, to state with confidence that differences in student learning are related to differences in the quality of instruction (Powell, 1978, p. 28)

I'm not going to belabor that point because I suspect that if any of us harbored the thought that our work made no difference, we could not find our jobs very satisfying -- or very honest. What teachers consider their work, however, varies a great deal. My colleague, Tom Angelo, and I have just completed a study of college teaching goals, and it is clear from our data that teachers of science have markedly different perceptions of their role as teachers than teachers of English, for instance.

When we asked more than 2800 teachers from 33 two- and four- year colleges which of six teaching roles they considered **primary**, the most highly significant differences occurred across fields of study. For example, whereas 55 percent of the science teachers said they were primarily concerned about teaching students the facts and principles of their subject matter, only 17 percent of the English teachers saw mastery of subject matter as their primary role. English teachers were far more likely to choose, "helping students develop higher-order thinking skills." The six teaching roles are shown in Table 1.

Table 1. Primary Teaching Role, in percent, as perceived by Two- and Four-Year College Teachers, by discipline. N-2700.

Primary Teaching Role	ALL	HUMANITIES	ENGLISH	BASIC SKILLS	SOCIAL SCIENCE	BUSINESS	MEDICINE	SCIENCE	MATH	ARTS
Higher-Order Thinking Skills	28	32	47	13	44	26	17	28	35	20
Facts and Principles	28	31	17	8	35	28	18	55	44	24
Jobs/Careers	17	2	3	7	4	32	44	10	2	11
Student Development	17	24	19	20	14	12	12	3	7	37
Basic Learning Skills	7	6	15	51	2	1	1	3	9	3
Role Model	3	5	2	2	3	1	8	2	3	5

The percent of college teachers selecting each role as primary is shown in the first column. While the roles of teaching facts and principles and developing higher order thinking skills are the leading preferences for teachers across all disciplines, they each attract just 28 percent of the teachers. Thus, there is wide variety in the roles that teachers consider primary.

Table 1 also shows that teachers' perceptions of their role is closely related to the subjects they teach. Thus, teachers in the humanities, English, and the social sciences are most likely to perceive the teacher's role as "Helping students develop higher-order thinking skills," whereas those in math and science are most likely to try to "Teach students facts and principles of the subject matter." Not surprisingly, teachers of business and medicine (in this case, mostly nursing and allied health) see themselves as "Preparing students for jobs and careers." Those in the fine and performing arts see their primary role as "Fostering student development and personal growth," which seems appropriate, given the personal expression that lies at the heart of the arts. Teachers of basic skills are, of course, largely concerned about the "Development of basic learning skills."

Perhaps today's college teachers are just modest, but despite all of the talk about mentors and role models, few teachers see themselves as role models for their students. Women and minorities are no more likely to see themselves as role models than are white males.

In addition to asking the question shown in Table 1 about the **role** preferences of teachers, the Teaching Goals Inventory (TGI), asks college teachers to select one course that they are currently teaching and to rate the importance of each of 52 goals to the teaching of that course. What teachers wanted students to learn from them varied greatly with discipline taught, but only occasionally with gender, age, whether full- or part-time teachers, or whether they taught in a community college or a four-year liberal arts college.

Table 2. TGI Goals Most Frequently Rated "Essential" by Two- and Four-Year College Teachers of Math, Science, and Engineering. N=811.

ITEM	PERCENT
Develop problem-solving skills	66
Develop ability to apply principles and generalizations to new problems and situations	63
Learn terms and facts of this subject	60
Learn concepts and theories of this subject	59
Develop analytic skills	56

Table 2 shows the five teaching goals most likely to be considered "essential" by teachers of math, science, and engineering. For these top-rated goals, a majority of the teachers said that they felt the goal was "essential" to their teaching of the selected course. I suspect there are no particular surprises to you in these goals; they are strongly subject matter-oriented, and emphasize the development of analytic skills.

Table 3. TGI Goals Most Frequently Rated "Essential" by Two-and Four-Year College Teachers of English. N=327.

ITEM	PERCENT
Improve writing skills	84
Develop capacity to think for one's self	75
Develop analytic skills	66
Develop ability to think holistically: to see the whole as well as the parts	61
Develop ability to apply principles and generalizations to new problems and situations	55
Improve reading skills	55

For comparison, let us look at Table 3, which shows the teaching goals most often rated "essential" by teachers of English. There are two items in common for science and English faculties -- "development of the ability to apply principles and generalities to new problems and situations," and "development of analytic skills." But Table 3 also shows some rather different content-specific goals for English faculties. For example, despite all of the talk about writing across the curriculum, improving students' writing skills is seen by English teachers and, although it is not shown in this table, by almost everyone else, as the primary responsibility of the English department. Eighty-four percent of the English teachers in our sample considered the improvement of student writing skills an essential goal of their teaching. That commitment was shared by only 27 percent of the humanities teachers and 14 percent of the business teachers, fields in which one might expect writing skills to be critically important. Math teachers similarly accept almost sole responsibility for improving math skills; 84 percent consider the improvement of math skills "essential" to their teaching, compared with only 17 percent of science teachers.

Now let us look at the TGI goals that were rated extremely low by science faculties -- and, I might add, low by most of your colleagues in other disciplines (Table 4). Broadly speaking, these low-rated items are not subject matter-oriented; rather they might be termed values of a liberal education. Even the first item, "develop an appreciation of the liberal arts and sciences" is rated "essential" by fewer than one-tenth of science faculties, and you don't get much help from your colleagues in other disciplines. Even if data are limited to the faculty in our sample from four-year liberal arts colleges, the percent of science and math teachers considering it important to teach an **appreciation** of their subject matter is very low -- 8 percent for math teachers and 14 percent for science teachers. The next two items concerning ethical choices and social issues, might be thought important in these times when science is playing such a vital role in medicine, the environment, and indeed the future of Planet Earth. But our data suggest that few scientists purposefully try to address these issues in their science classes, and apparently they aren't addressed to any major extent by teachers in the humanities and social sciences either.

Table 4. TGI Items Rated Low by Two- and Four-Year College Teachers

ITEM	PERCENT "essential"	
	Science N=811	Total N=2705
Develop an appreciation of the liberal arts and sciences	9	17
Develop capacity to make informed ethical choices	7	19
Develop an informed concern about contemporary social issues	6	17
Develop commitment to one's own values	6	17
Develop commitment to exercise rights and responsibilities of citizenship	4	10
Develop informed appreciation of other cultures	2	15

Table 4 does not make a very strong case for liberal education. In our efforts to cram ever more content into the skulls of students, are we ignoring the uses of education in a democratic society? Are college faculties becoming too specialized? Most faculty members today, whatever their disciplines, deplore the fact that students don't seem to be able to express themselves in writing. Where are they supposed to learn to write a technical report, for example? Not in science classes, apparently; only 7 percent of the science teachers and only 2 percent of the math teachers consider the improvement of student writing an essential goal of their teaching.

These data seem to offer some support for the charge that the curriculum of higher education is highly fragmented, with each teacher working hard to teach his or her particular discipline, leaving it to the students to put it all together to approach our ideal of an "educated person."

What seems clear from our study of teaching goals is that most college teachers are teaching their disciplines, plus a core of academic values that Talcott Parsons has labeled "cognitive rationality" -- which might be characterized as cool, rational, analytic thinking, fairly well divorced from emotion and personal involvement.

Although it is clear that the subject matter taught has a powerful pull on teaching goals, teachers also seem to develop their own ideas about teaching roles. In his classic interview study of teachers in the humanities, Axelrod (1976) found four different prototypes or mental images that teachers hold about the nature of their work. He found that the largest group of teachers focus their attention on teaching content; for them, the primary function of their teaching is to provide information about their subject matter. The motto Axelrod devised for this teacher prototype is "I teach what I know." Class work and assignments center on the mastery of a defined body of subject matter. In our TGI goals study, most science and math teachers identify with this prototype.

Axelrod's second most common prototype was instructor-centered. Instead of giving primary attention to mastery of a defined body of subject matter, this teacher samples the content of the field in order to demonstrate how a scholar in the discipline deals with

the topics selected. In this mode, the teacher is modeling for students how an expert handles the materials of the subject, and to some extent, how an educated person deals with learning. The motto for this prototype is, "I teach what I am." Although Axelrod assigned a rather large number of teachers to this prototype on the basis of his interviews, we found very few teachers admitting on the Teaching Goals Inventory that they saw themselves serving primarily as role models for students.

The third and fourth prototypes are student-centered, one emphasizing cognitive development, the other the development of the whole person. These prototypes emphasize not so much what students know --subject matter content--as how they acquire knowledge. The student-as-mind prototype selects and organizes course content so that the material is suitable for leading students to perform complex intellectual operations. "I train minds" is the motto of this teacher, who would today espouse goals such as critical thinking, analysis, synthesis, and the like. In our sample, teachers of English and humanities tended to identify with this prototype

Finally, the fourth prototype is represented by the motto, "I work with students as people." The student-as-person prototype rejects mind as separate from person and contends that learning requires non-cognitive as well as cognitive involvement. This teacher would find herself in agreement with the teachers in our TGI sample who believe that motivation, self-esteem, and the like are integral parts of learning. In our goals study, for example, 63 percent of the teachers of basic skills said that improving the self-esteem and self-confidence of students were **essential** goals of their teaching.

Axelrod, in painting the portraits of these prototypes, shows that different beliefs about the nature of the teaching role lead to different teaching methods, ranging from heavy emphasis on the lecture for the teacher who teaches what he knows to emphasis on exploration and student-initiated discussion for the teacher who works with students as people.

With all of these differences in goals and approaches to teaching, isn't there some truth to the contention that good teaching has so many faces that we can't judge it accurately and therefore can't reward it?

It turns out that good teaching is not as difficult to judge as we sometimes pretend. The fact is that all of us know good teaching when we see it. But because students are in the best position to observe teachers day in and day out, they are the most frequent evaluators of teaching today.

More than 1300 research studies have been done on the reliability, veracity, validity, and usefulness of student ratings of instruction (Cashin, 1990). The conclusion that drives right through the middle of all of the questions that have been raised about student ratings is that they are generally pretty consistent, unbiased, and useful. (See Cross 1988 for a review of the research.) Students might be even better evaluators, of course, if they were trained to observe the impact of the teaching on their own learning.

Do students agree on what makes a good teacher? The simple answer is "yes," and moreover, students' perceptions agree pretty well with the judgments of faculty colleagues and administrators. In a review of nearly 60 studies of students' descriptions of effective teachers, Feldman (1976) found eight core characteristics that appeared at the top of the list in almost all of the studies. You could probably guess most of them -- concern for students, knowledge of subject matter, stimulation of interest, availability,

encouragement of discussion, ability to explain clearly, enthusiasm, and preparation. Most of these items appear on student rating scales today, and factor analysis of these scales show four common factors that might be considered generic across the disciplines. That is, if hundreds of the items from student rating forms are thrown together and intercorrelated, four clusters will emerge which pretty well cover the characteristics of effective teachers, as students see them. They have been labeled as follows: "Skill," which represents the ability to communicate in an interesting way; "Rapport," which involves empathy, interaction with and concern for students; "Structure," which concerns class organization and presentation of course materials; and "Load," which refers to workload and instructor demands (Kulik and McKeachie, 1975).

The ultimate criterion of effective teaching, of course, is effective learning. There is simply no other reason for teaching. But we are beginning to see that learning probably depends more on the **behavior** of students than on the **performance** of teachers. Thus, research on teaching is shifting from observing how well the teacher is performing to observing how well students are responding. Good teaching is not so much a performing art as an evocative process. The purpose is to involve students actively in their own learning and to elicit from them their best learning performance.

Whether you call it an "art" or a "science," teaching is in a primitive state of development today. It is related more to the characteristics and predilections of teachers than to the needs of the students. I think it is safe to say that graduate schools today are not turning out any better **teachers** than the graduate schools of 50 years ago. That is not to say that knowledge in the disciplines isn't far more sophisticated than it was 50 years ago; it is simply to observe that because graduate students receive no new information about teaching, they teach as they were taught. Generation after generation of teachers, exposed to limited teaching models and left to their own devices, develop teaching styles within the confines of their disciplines and their own inclinations and personalities. After the first couple of years in the classroom, according to the research, most teachers settle into a rather stable pattern (Levinson-Rose and Menges, 1981).

The recent educational reform movement, combined with recent research on learning will, I believe, challenge those traditional patterns. Teachers who know something about the learning process can't help being engaged by the intellectual challenge of seeing if they can improve the impact of their teaching on students' learning.

Let me select one broad conclusion from current research on learning to illustrate the intellectual challenge for teachers. David Ausubel, a pioneer in the study of meaningful learning, made the point more than 15 years ago, but it is receiving renewed attention today. He said, in essence, find out what a student knows and teach accordingly. That bit of wisdom is almost lost in the vocabulary of cognitive psychology, but we talk about "schemata" today as the mental structures that store and organize learned material. One can picture a schema as a multi-dimensional map of interrelated ideas, with all sorts of connections among stored material. Learning is not so much an additive process, with new learning simply piling up on top of existing knowledge, as it is an active, dynamic **process** in which the connections are constantly changing and the structure reformatted.

The excitement of learning comes when new connections are made, sometimes transforming the structure, pulling apart some connections and making new ones. The point is that new information results in meaningful learning when it connects with what already exists in the mind of the learner.

Research on the difference between the learning of novices and experts shows clearly that for the expert, new information is quickly grasped in useable form because connections to existing knowledge are numerous. The learning of a novice, in contrast, is labored and slow, not because the novice is less intelligent than the expert or even less motivated, but because connections between new information and existing schemata are sparse. There are no hooks on which to hang the new information. Thus, it falls in a heap on the floor, sorted and recalled only with great difficulty.

To illustrate at the very simplest level the association between new learning and old, we might note the proliferation of 1-800 numbers. Call 1-800-WINDOWS to get information about new windows for your home, or call 1-800-GO BEARS for tickets to Cal football games. Not only are letters easier to remember than numbers because of the associations we have already formed, but the advertiser is tying the particular word to the product sold. She is seeking to make maximum connections and therefore to increase the likelihood of recall and use.

All of this suggests one reason for today's emphasis on understanding cultural differences of increasingly diverse student populations. What do students already know, and how can new learning be framed to make meaningful connections? The more teachers can develop analogies and metaphors to relate to the backgrounds of students, the more likely new knowledge will become integrated into the schemata or knowledge structure that represents the student's understanding.

You may remember the scene in the movie *Stand and Deliver*, in which the high school math teacher, Jaime Escalante, is trying to teach the concept of negative numbers to a rather hostile group of students from the barrio of East Los Angeles. Escalante says, "Negative numbers ...very important. You dig a hole in the sand and put the sand next to the hole. The hole, minus two. The sand, plus two. You see that?" He says this to a group of students who have spent much of their young lives at the beach. "The hole is minus two. The pile of sand is plus two. What do you get if you add them back together?"

This brief scene shows how the teacher has brought together knowledge of his subject matter and an understanding of his students to make valid connections between what the students already know and what he wants them to understand. It is why metaphor and analogy are so effective in teaching. They connect new information to familiar concepts.

There is much more that can be said about teaching and learning, most of it complex. The major message, I think, is that there is no quick fix. We're going to have to provide college teachers with enough initial knowledge about the learning process that the daily information coming to them from the learners in their own classrooms can find connections to deepen and perhaps transform their understanding of teaching and learning.

Let me sum up my assertion that teaching can be improved by practicing it at a more sophisticated and professional level by making an analogy to farming. A successful farmer is judged by the quality and quantity of his crops-- not by whether he wears bib overalls or rises with the sun. A farmer's attention is concentrated on understanding the nature of the things he is trying to grow. He knows that some plants require four hours of sun a day; others do well in shade. Some plants are draught resistant; others require

irrigation. Some plants require one kind of fertilizer; others something else. The point is that the farmer's actions are determined by the needs and nature of his crop.

We haven't reached that point in teaching yet. Teachers' actions, especially at the college level, are determined more by the predilections, personalities, and perceptions of the teacher than by the needs of the students. We have not done the extensive research and experimentation that characterizes scientific agriculture. We don't really know why some students thrive and others don't. We don't often observe whether the seeds we plant take root. We can't detect wilt, and even when we see the beginning signs of boredom or disengagement, we don't take immediate steps to treat it because we assume it's the nature of the plant to wilt -- or more often perhaps because we don't know how to treat wilt or we don't have time. It is hard to imagine a farmer not being challenged by wilt or not having time to treat it. It is also hard to imagine him treating wilt in plants that don't have it simply because treating wilt is what is on his agenda for that day. If, of course, he doesn't recognize wilt or has no idea what causes it, he may have to ignore it and lose his crop.

Teaching today is more like home gardening than like scientific agriculture. Care, attention, and experience will certainly result in better crops than neglect, and some home gardeners get wonderful results. By and large, teachers, like home gardeners, learn from experience as they go, without much understanding of how students learn or how to increase the productivity of their teaching.

I believe that the real intellectual challenge of teaching lies in the opportunity for individual teachers to observe the impact of their teaching on students' learning. And yet, most of us don't use our classrooms as laboratories for the study of learning. Instead we talk about teacher "burn out" and about having to keep ourselves intellectually alive through doing research in our disciplines, while the most fascinating challenge of all sits before us every day withering or thriving, and we assume that students will get from our class whatever they will get; bright students will get more than dull ones, and that's the nature of students rather than teachers. I don't think that's going to suffice anymore. The more we know about learning, the more intellectually challenging teaching will become.

And that brings me to a brief discussion of the role of Classroom Research in the continuing development of effective teaching. Given the considerable differences in teaching goals by teachers in the various disciplines, the structural differences in subject matter, and the diversity of students, broad generalizations about teaching are rather unlikely to yield much improvement. Providing teachers with knowledge about current research on learning will almost certainly expand the number of hooks on which to hang new learning, but teachers are going to have to use their own experience in the classroom to deepen their understanding of the learning process.

Classroom Research encourages teachers across the disciplines to use their classrooms as laboratories for the study of learning and the impact of their teaching upon it. Like any research, it consists of systematic and sensitive observation, careful analysis of the data, and exploration of the implications. But unlike traditional educational research, Classroom Research does not seek to discover general laws of learning. Rather it seeks to answer the very specific question, What are **my** students learning in **my** classroom as a result of **my** efforts? Classroom Research may be publishable or not; but it is a continuing on-going effort by a teacher to evaluate the accomplishment of his or her teaching goals. Obviously, the more a teacher knows and

learns about the learning process, and the knowledge structure of his or her discipline, the more imaginative and creative the Classroom Research can be.

In an effort to get college teachers started on Classroom Research, my colleague, Tom Angelo, and I have prepared a handbook of 30 simple Classroom Assessment Techniques which are appropriate across the disciplines and which require no background in education or the psychology of learning (Cross and Angelo, 1988). The purpose of the techniques is to assess what students already know, what gets added during a class session or as a result of an assignment, and what kind of connections students make between new learning and old. In the best of all possible worlds, Classroom Research provides the challenge for continuous experimentation on how teaching can be changed to make a greater impact on learning.

Let me give some examples of Classroom Research to make the concept concrete. My personal favorite among the assessment techniques we describe in the *Handbook* is one of the easiest to administer, yet it provides very rich and useful data. It is called "Minute Papers," and was originally proposed by Charles Schwartz, a professor of physics at the University of California, Berkeley. A few minutes before the end of class, he asks students to write the answer to two questions: 1) What was the most important thing you learned today? and 2) What questions are uppermost in your mind as we conclude this class session?

I have used Minute Papers in my own graduate classes at Harvard and at Berkeley. Inevitably, I find that the first time I use Minute Papers in class, some students are hard-put to articulate anything of importance that they learned in the class session, and much to my dismay and disappointment, they seize desperately on the last thing said. Some students pick up something that I thought was fairly incidental, but that had particular meaning for them; it made some connections with what they already knew. Some, to my delight, choose as most significant, something that they learned, not about content, but about themselves as learners. A few students synthesize beautifully, picking up the major themes and articulating them clearly, and then raising some rather interesting questions.

I find that Minute Papers are good teaching techniques as well as useful feedback devices. Even among graduate students, Minute Papers done early in the semester tend to bring forth fairly low-level cognitive learning. Some students, for example, cite specific facts or content that they deem significant. As the semester progresses and I feed back to students the responses of classmates, students who formerly thought largely in terms of facts begin to model the higher stages of cognitive learning shown by some of their classmates. They begin to look for broader principles and concepts and to articulate those as among their most significant learnings.

In addition to providing information about what students are learning while there is still time to make mid-course corrections, the simple device of Minute Papers carries some strong pedagogical messages. It puts students on notice that they are expected to be able to synthesize and articulate their learning; and they are expected to be active learners, raising questions and thinking about implications.

I have also found that opening a class session with a review of what students, as a group, found most significant from the previous class session builds a nice bridge of continuity from one class to the next, and it also gives me an opportunity to prepare handouts or otherwise clarify issues that students found puzzling or provocative.

For the past several years, we have been working with some colleges in the San Francisco Bay Area on Classroom Research. Let me give a few examples of some of the actual projects carried out by these college teachers.

A pre-calculus teacher had long been troubled by the extreme diversity of math backgrounds in his course, so prior to the teaching of each new unit, he developed a brief questionnaire to determine students' familiarity with the procedures and terminology of the new material. With this classroom assessment technique that we call a "background probe," he could anticipate where students would run into difficulties and could modify his teaching accordingly. He reported that an unanticipated benefit was students' appreciation of his concern and interest in their background for the unit. The "background probe," like most classroom assessment techniques, is based in cognitive science. In this case, the teacher is trying to determine what the student already knows, i.e. to get a snapshot of the schemata.

Another example comes from a course in third-semester calculus where the purpose was to prepare students for advanced courses in engineering and physics. The question the teacher of this course chose to investigate was, Were students, in fact, able to apply math in the learning of science concepts? He collected simple applications from his colleagues in the science department and determined how well students could handle them, and then experimented to see how he could help them learn more effectively. A side benefit of his project was the conversation and collaboration of teachers across departments.

In conclusion, it seems to me that if we are to raise teaching to a more sophisticated level of development, classroom teachers are going to have to take more responsibility for generating knowledge about what and how well students are learning whatever it is that teachers are trying to teach. As we have seen, that varies from discipline to discipline. True, there are some generic characteristics of good teaching, and most of us are far from the fullest possible development of those. But by and large, outstanding teachers will be developed through knowledge, sensitive observation of students in the process of learning, and, perhaps most important of all, commitment to and respect for the profession of teaching.

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