THE TWO PARADIGMS OF EDUCATION AND THE PEER REVIEW OF TEACHING

Dean A. McManus School of Oceanography and Center for Instructional Development and Research, University of Washington, Box 357940, Seattle, WA 98195-7940, mcmanus@ocean.washington.edu

ABSTRACT

Before a faculty member undergoes a peer review of teaching, both the reviewers and the faculty member should understand the two paradigms of education—the Teaching-Centered Paradigm and the Learning-Centered Paradigm, because the paradigm chosen, even tacitly, by a faculty member determines how he or she educates students. Although the distinction between the paradigms has centered almost entirely on teaching methods and classroom environment, the differences between them are more fundamental. The paradigm determines the instructor's educational assumptions, educational goals, and assessment of results. Further, it determines the instructor's sense of educational responsibilities, the relationship with students, and motivational and mentoring responsibilities. Therefore, the peer review of an instructor teaching with one paradigm by reviewers who teach with the other risks being unfair and misleading. Complicating the issue are the "invisibility" of the Teaching-Centered Paradigm to most instructors who use it and the common use of Learning-Centered teaching methods or aims by instructors who still follow the Teaching-Centered Paradigm. Owing to the increase in numbers of Learning-Centered instructors, peer review now requires greater sensitivity by reviewers than before. Aligning the appropriate tools for peer review with the teaching implications of paradigm choice is the object of this paper.

Keywords: Education – general; education – science; education – geoscience; education – testing and evaluation; education – peer review of teaching.

INTRODUCTION

Peer review – "Peer review of one's research results is standard practice in all fields of science, but only recently has this become a mechanism for advancing one's teaching knowledge and skills" (National Research Council, 1997). From our faculty experience we know that peer review of another faculty member's research results is not a simple task, even though all faculty members have been trained in research procedures and have practiced research in a scholarly manner. It should be no surprise, therefore, that most faculty, not having been trained to teach nor having practiced teaching in a scholarly manner, find peer review of teaching even more complex and difficult. The good news is that this difficulty can be alleviated by employing recommendations from such excellent general handbooks on peer review as those by Millis (1992), Arreola (1995), Innovative Higher Education (1996), and Chism (1999). For example Arreola (1995) and Chism (1999) discuss the need for reviewers to have access to multiple sources of information, use multiple methods, and review multiple times, whether as a formative review to help the instructor improve his or her teaching or as a summative review for administrative decisions. They note that reviewers should meet with the instructor before the review; examine written teaching materials, the teaching portfolio, and course portfolio; visit the classroom more than one time for observation (if trained to observe); and meet with the instructor after the classroom observation for clarification. Ideally, the faculty review system should be integrated into a faculty development program that can assist the instructor to teach better (Arreola, 1995). The bad news, however, is that even with these handbooks, a source of confusion and difficulty can persist in a review if the guidelines do not mention the existence of two very different paradigms of education and the significance of a faculty member's choice of paradigm to his or her decisions about teaching. (By "paradigm" is meant a frame of reference that determines how we perceive, interpret, and make sense out of how we educate students [Johnson et al., 1991].) Aligning the tools of peer review with the implications of that choice is the object of this paper.

The two paradigms – The two paradigms go by various names but will here be called the Teaching-Centered Paradigm and the Learning-Centered Paradigm. Teaching and learning occur in both paradigms. (A third paradigm, the Discipline-Centered Paradigm [National Research Council, 1997], is a special case in which an outside authority dictates the course-driving content to be covered. It will not be considered here.) The Teaching-Centered Paradigm has long been the traditional paradigm of higher education. Discussions about it have centered on the classroom technique of a lecturing instructor transferring information to passive, note-taking students. Unremarked in these discussions has been the curious circumstance that we have not recognized it as a paradigm, because it is so "deeply ingrained in each of us" (Meyers and Jones, 1993) that it is "invisible" (Barr and Tagg, 1995). It is the hard-to-see "context within which [we] live" (Smith and Waller, 1997a), like the air we breathe. To us it seems "a force of nature" (Barr and Tagg, 1995). By contrast, the Learning-Centered Paradigm is clearly identified as a paradigm, which renders it somehow "artificial" to many who follow the "invisible" Teaching-Centered Paradigm. Discussions about it have

centered on the classroom technique of students' learning actively under an instructor's facilitation.

Contrasts have often been made between the teaching methods of the two paradigms, but the differences between them are more fundamental than that. I believe they begin with the nature of the instructor's reflection on teaching, in particular, how critically that reflection examines his or her assumptions about teaching. As Brookfield (1995) notes, "…the most distinctive feature of the reflective process is its focus on hunting assumptions." The assumptions that the two paradigms make about education are quite different (Table 1). (The ensuing summary of differences is drawn from the references cited in Table 1, except as noted.)

The principal assumption of Teaching-Centered instructors is that subject matter content is primary—and not only primary but sufficient. Being experts in the discipline, they can feel that they own the knowledge and, as instructor, are central to the course in order to transfer the information (see also Pratt's, 1992, "engineering conception" of teaching and Kember and Gow's, 1994, "transmission of knowledge" conception). Students are assumed to enter the course with minds like empty vessels or sponges to be filled with knowledge. They are expected to differ little from the instructor and to learn the material as the instructor did years before, without having to experience or apply the facts or concepts. These assumptions tend to receive little critical reflection by instructors, because they are taken to be "common sense." After all, this is the system in which the instructors learned—and learned well enough to become professors.

…different assumptions about education lead to fundamentally different educational goals, and to different ways to achieve those goals and assess results.

For the Learning-Centered instructors, the students are not assumed to enter the course with empty minds but rather with a perceptual framework already intact that will be involved in the dynamic process of restructuring information and prior knowledge into new knowledge. This process of forming knowledge—that is, of learning—is deemed as important a part of education as the content learned. Owing to the importance given by these instructors to the learning process carried on by the students, they do not consider themselves to be of central importance in the course. Of greater importance is a partnership between instructor and students. Furthermore, the partnership is held to require the instructor to use a variety of teaching methods, owing in part to the need to match the teaching method to the expected learning outcome and in part to the additional assumption that all students are not like the instructor. Many of them are very different indeed, and different students are known to learn in different ways (Meyers and Jones, 1993), and few of these students will become professors as their instructor did. Regardless of their differences, students are expected to test ideas or use them in order to learn them. To use these assumptions to educate students requires the instructors to reflect critically on their teaching.

These different assumptions about education lead to fundamentally different educational goals, and to different ways to achieve those goals and assess results. If the tools to be used for peer review are those appropriate to the undetected traditional paradigm that is accepted by the reviewer and if these tools are applied to the review of a faculty member who has accepted the Learning- Centered Paradigm, the review will, unintentionally, be unfair. Hence, there is a need for new approaches to peer review of teaching (Kumaravadivelu, 1999; Cunningham, 2001.)

An annotation to the discussion should be made at this point. It may seem that the two paradigms are not so much a contrasting pair as the end points of a gradation or the different levels of a hierarchy. Samuelowicz and Bain (1992) refuted the hierarchical notion by showing that the "higher level" Learning-Centered Paradigm does not include all the elements of the "lower level" Teaching- Centered Paradigm. I believe that the paradigms are a contrasting pair, rather than the end points of a gradation, and that they are separated by the form in which the defining principle of an instructor's teaching philosophy is stated. One professes either "I teach geoscience to students and expect (want) them to learn it" or "I help students to learn, specifically to learn geoscience, by the way I teach them." The differences in these statements are not semantic; the differences are self-defining, as we shall see. The former is the defining principle for the Teaching-Centered instructor; the latter that for the Learning-Centered instructor.

The appearance of a gradation results, in my opinion, from the unreflective cross-paradigm borrowing of teaching methods by instructors who have not accepted the defining principle and the assumptions underpinning the paradigmatic application of those methods. This unreflective borrowing contributes to the widely reported disjunction between the stated aims of instructors and their educational practice (Murray and MacDonald, 1997). Thus, even though an instructor to be peer reviewed uses the Learning-Centered Paradigm, he or she may have accepted it tacitly through attraction to the teaching methods and may no more be able to articulate the defining principle and assumptions underpinning it than the instructor using the "invisible" Teaching-Centered Paradigm is able to articulate the defining principle and assumptions underpinning that paradigm. Distributing Table 1 to the faculty for their information may help each type of instructor better articulate these fundamental assumptions. If the instructor to be reviewed has reflected on his or assumptions about education, for instance in a statement of teaching philosophy in the teaching portfolio, the assumptions can be expressed to the reviewers at the initial meeting. The reviewers will then have clear expectations for the instructor's teaching. Let us turn now to the contrast in the characteristics of these paradigms and ex-

plore the implication of those differences on the peer review of teaching.

PARADIGM GOALS AND ASSESSMENT OF RESULTS

Goals – Teaching-Centered goals (Table 1) are for the instructor to transfer information and for students to accumulate knowledge. Learning-Centered goals are for the instructor to create a learning environment in which students can learn to restructure the new information and their prior knowledge into new knowledge about the content and to practice using it. Under both paradigms, the goals for a course state some content that is to be "learned." For the Teaching-Centered Paradigm, that is all, regardless of elaboration, because the instructor does not reflect critically on how students learn. Nor is the instructor expected to reflect. It is considered the students' responsibility to learn, by which is meant, to absorb the information presented. But under the Learning-Centered Paradigm the goal also includes *how* that content is to be learned, because the instructor has at least some idea of how students learn and is responsible for helping them learn. Having students acquire the skills of learning and of applying that learning is as important a goal for this paradigm as learning the content. In the peer review, both the instructor's selection of teaching strategies to achieve the goals and the effectiveness of the use of those strategies are evaluated. The course syllabus expresses course goals, and, for the Learning-Centered instructor, who is striving for student learning, it should be examined as an essential statement of the context in which the classroom observation is to be made (Cunningham, 2001).

Assessment of learning – Student learning is assessed under both paradigms. Under the Teaching-Centered

Table 1. Abbreviated contrast of the two paradigms of education. Compiled and adapted from Garvin (1991), Johnson et al. (1991), Meyers and Jones (1993), Barr and Tagg (1995), and Smith and Waller (1997a)

Characteristics	Teaching-Centered Paradigm	Learning-Centered Paradigm
Assumptions about education	Content is primary and instructor owns the knowledge Instructor is central Learning is cumulative Students enter class with empty minds Facts and concepts can be learned without experiencing or applying them Success is an individual accomplishment Classroom is private	Process of learning is as important as content learned Instructor and students are partners Learning is a dynamic process of restructuring Students enter class with a perceptual framework intact Facts and concepts must be tested and used to be learned Success results from teamwork Classroom is public—for review, assistance, and research
Educational goals	Instructor transfers information to students Students accumulate knowledge	Instructor creates a learning environment Students develop skills in constructing and using knowledge with instructor's guidance
Assessment of results	Instructor assessed at end of term on organization of lectures, coverage of appropriate content, understanding of the content, preparedness for class, respect for students' questions and comments Students are tested infrequently on knowledge of content Students are classified by average grades and sorted for careers, because ability is assumed fixed and scarce. Students are weeded out	Instructors are assessed on students' learning Students' learning is assessed frequently by instructor with classroom assessment techniques Students are assessed on what they can do with the knowledge Instructor uses assessment data to develop students' competencies and talents. Students are assumed capable of success
Teaching methods and classroom environment	Lecturing—speeches and declarative statements Emphasis on content only Environment competitive and individualistic	Various active learning methods, including lecturing Equal emphasis on content, learning process, and classroom environment Environment collaborative, cooperative, supportive of learning risk-taking

Instructor's responsibilities	Present the content, including selecting it Be current in knowledge of content Organize linear, logical lectures Deliver clear presentations Test for recall of content Control classroom Be an actor	Be current in knowledge of content Possess pedagogical content knowledge What students have learned, both the content and process of learning Set learning outcomes and goals of course Set explicit standards for learning and classroom environment Establish a supportive classroom environment Prepare for multiple paths of inquiry in discussion Regularly assess student learning Integrate course with others so that learning with respect to contextual cues of one course can be transferred to cues of another course Share control of content, direction, and pace of course with students Facilitate and guide Be a coach
Students' responsibilities	Record and absorb knowledge Recall content on tests	Care deeply about own education Learn to monitor and discuss own learning Collaborate with instructor and other students to discover and construct a framework of knowledge that can be applied to new situations
Instructor-students relationship	Impersonal Little interaction between instructor and students or among students	Personal, with students known as individuals in order for instructor to use their interests, backgrounds, and needs to select content and establish a learning environment Partnership between instructor and students Underrepresented minorities and other non-traditional students engaged
Motivating and mentoring students	Students are expected to be self-motivating Mentoring consists of enhancing the learning of content	Help students learn how to set goals, establish plan to achieve goals, and record progress Align students' intact motivation with course goals Mentoring consists of helping students become lifelong learners and turning majors from students into apprentices
Students' goals	Complete the requirements for the degree	Develop skills for lifelong learning
Preparation for teaching	Master the content—any expert can teach Develop clear presentations of lectures Teaching is a routine activity	Master the content Develop interpersonal skills of questioning, listening, responding, and sensitivity to group processes Learn how to assess students' needs and levels of understanding Develop pedagogical content knowledge Teaching is complex and requires training

Table 1, continued.

Paradigm, learning is assessed by testing the students' knowledge of the content, and in many courses students are tested only a few times during the course. Written reports are graded for content, with slovenly or obscure writing often, in my experience, dismissed with: "I know what he's trying to say." Instructors can use the results to improve the teaching effectiveness of their presentations and to classify the students by average grades and sort them for careers, because under this paradigm student ability is assumed fixed and scarce (Smith and Waller, 1997a). Instructors can feel obligated "to weed out" students of "lesser" ability. Peer review of the Teaching-Centered instructor's assessment of student learning should include examination of course materials, particularly tests

Course Material	Reviewfor Teaching-Centered Instructor	Review for Learning-Centered Instructor
Tests	Matching of content to course goals	Matching of content and skills to course goals
	Appropriate level of challenge	Tests knowledge of concepts as well as algorithms for solving problems
	Appropriate grading criteria	Grading rewards learning rather than placement in class
Classroom Exercises	Supplements course content	Is part of course content
	Encourages meaningful learning experiences	Is part of a learning experience Has amount of guidelines appropriate for learning outcomes Uses learning groups to teach abilities to solve problems Uses inquiry project for deep understanding
	Is appropriate level of challenge	Asks for student feedback on how well they are learning
	Outlines assessment method	Instructor uses feedback to adjust lesson and improve learning immediately Students learn self-assessment, which is related by instructor to goals of course

Table 2. A review of Learning-Centered instructors will require more specificity for some aspects of course materials because these specifics differ from those appropriate for Teaching-Centered instructors. Compiled from Chism (1999) for Teaching-Centered instructor and National Research Council (1997, 2000) and Hansen and Stephens (2000) for Learning-Centered instructor.

and classroom exercises, which can provide reviewers with insight about the instructor's level of learning goals in a course, what the instructor thinks is important, and the instructor's pedagogical style (Chism, 1999). The handouts, rather than the completed tests and exercises, can be sufficient for this review, for evaluation of the instructor's presentation is paramount in this paradigm. Tests usually seek to determine whether the information transferred to the students is still "inside" them (Shulman, 1999). That is, "learning" means that the students absorbed the content transferred to them, in accord with the defining principle: "I teach geoscience…." Chism (1999) provides examples of forms that can be used to review tests and exercises.

In the Learning-Centered Paradigm, student learning is assessed regularly, not infrequently, with classroom assessment techniques, such as those described by Angelo and Cross (1993), so that the teaching can be changed immediately to enhance student learning. Writing assignments are particularly important, because the instructor knows that "…slovenly writing reflects slovenly thinking, and obscure writing usually obscure thinking" (Beveridge, 1957). Tests are also given. The assessment includes not only the content knowledge but how effectively and efficiently students can use that knowledge, particularly in new situations. As a result of the assessment, instructors can find ways to develop students' talents, because under this paradigm students are assumed to be capable of success (Barr and Tagg, 1995). In reviewing the Learning-Centered instructor, the classroom assessment techniques are evaluated for their effective use by the instructor in responding to student feedback. The copies of tests and exercises for the review must have been graded, because student demonstration of learning and its assessment are central to a review of the instructor's teaching (Cambridge, 1996), in accord with the defining principle: "I help students to learn…." Some of the aspects listed on Chism's (1999) peer review forms, such as "appropriateness of length" and "provides clear directions" for tests and exercises, can be evaluated under each paradigm with the normal uncertainty of rendering judgments. Other aspects, however, require more specificity if they are to honor what the Learning-Centered instructor is trying to accomplish, because "learning" in this paradigm means something other than "absorbing content" (Table 2).

All of us should be able to evaluate the aspects listed in Table 2 for the Teaching-Centered Paradigm, even by using our own individual standards. (Of course, standards accepted by the department faculty should be used for a review.) When those same aspects are applied in the Learning-Centered Paradigm, however, the reviewer should consider them differently, owing to the emphasis on learning, as these examples illustrate. That is, skills, being as important as content, must likewise be matched to the course goals. To challenge learning, the knowledge of concepts is tested, as well as skill in using algorithms for solving problems, because students can memorize algorithms (National Research Council, 1997). To grade learn-

ing, the grading system must be based on a learning standard (scoring rubric), not a student's achievement relative to (in competition with) other students in the class (the curve or breaks-in-distribution) (National Research Council, 1997; Walvoord and Anderson, 1998). An exercise is part of a sequence, for assessment of learning is assessment of the student's development over time, and the process of development is more important than the individual product turned in for a grade, though accuracy of that product is expected (Hansen and Stephens, 2000). The most important concepts and ideas are assigned to inquiry exercises in order to ensure deep understanding (National Research Council, 2000). The Learning-Centered instructor coaches students in learning to self-assess the level of their learning and in providing him or her with regular feedback of that level so that the lesson plan can be modified, if need be, to keep the level of learning in line with the expected learning outcomes for the lesson (National Research Council, 1997, 2000).

PARADIGM TEACHING METHODS AND CLASSROOM ENVIRONMENT

Here is where discussions of the two paradigms have centered, for it is in the classroom that the results of research on teaching and learning are applied most often. The results have been summarized by Johnson and Johnson (1989), Johnson et al. (1991), and Bransford et al. (1999), among many others. Reports by the National Research Council (1997, 2000) contain synopses of the findings. The research finds that the Teaching-Centered methods are less effective than long thought in helping students learn scientific concepts. With the lack of reflection on teaching required by this "invisible" paradigm, it is not surprising that instructors using these teaching methods fall into the unreflective and deceptive habit of mind "…of justifying what we do by reference to unchecked 'common sense' and of thinking that the unconfirmed evidence of our own eyes is always accurate and valid" (Brookfield, 1995). The research also finds that students learn best when they are engaged in active learning, make observations and encounter concepts before learning terms and facts, build new knowledge and understanding by restructuring what they already know and believe, feel part of a community of learners in a classroom environment that supports their learning, take control of their own learning, and develop the ability to learn with understanding so that they can apply knowledge to new situations. These findings strongly favor the Learning-Centered Paradigm as the way to help students learn. They are also practically the same results obtained by research on adults learning in the workplace, which is the ultimate destination for our students. For instance, people in the workplace learn better when they are part of a learning community to practice what they are learning (Brown and Duguid, 2000).

Discussions contrasting the two types of teaching methods have usually dealt with the drawbacks of lecturing and the benefits of active learning. The Teaching-Centered instructor, however, though relying mainly on the lecture, may also use group work and discussions. The Learning-Centered instructor, though relying mainly on the active learning methods of discussion, group work, and inquiry or discovery activities, may also use lectures. It is essential, therefore, that the faculty reviewers know which paradigm the instructor is following. (It is also essential that the instructor know this, too, for an instructor may feel he or she is using active learning because the students are active and involved in the classroom and the classroom environment seems to be one of trust and openness. This feeling is self-delusion if the characteristics of the Learning-Centered Paradigm are absent [Garvin, 1991]. This situation is the commonly reported disjunction between aims and practice previously mentioned [Murray and Macdonald, 1997].) We shall examine each of these teaching methods with respect to peer review.

Lecturing – The Teaching-Centered instructor lectures to present information, as stated in the defining principle: "I teach geoscience…." The instructor selects material he or she thinks the students should know (Samuelowicz and Bain, 1992). Therefore during the classroom observation, the reviewers should pay attention to the instructor's variety and pacing of instruction, content knowledge, presentation skills, clarity, and the instructor-student rapport (Chism, 1999). The principal question the reviewers must answer about a Learning-Centered instructor's lecturing is the purpose it is serving for student learning, because the defining principle is "I help students to learn…." There are several good reasons to lecture in the active learning classroom: to clarify issues arising from student discussions, to disseminate information organized or modeled in a particular way, to present material that is either not available elsewhere or would take students much longer to locate on their own, to highlight similarities and differences between concepts, to arouse students' interest in the subject by communicating the instructor's enthusiasm, or to teach students who are primarily auditory learners (Johnson et al., 1991; Meyers and Jones, 1993).

Once the reviewers' question about "purpose" is answered, then a few of the review criteria for lecturing used to evaluate the Teaching-Centered lecturer can be applied to the Learning-Centered lecturer, for example, content knowledge and clarity. But the operational distinction between the two lecturers requires some new criteria for the Learning-Centered lecturer, who speaks briefly, usually for only ten or fifteen minutes at a time, for far less total time than the students in the class, rather than for far more than them. The lecture typically serves as a "bridge" between student activities, rather than a declarative transfer of information, and it may commonly be followed by an assessment of student understanding. Even the content is selected to engage and enhance student learning (Samuelowicz and Bain, 1992). Attention to all these aspects of lecturing is crucial to the proper review of a Learning-Centered instructor. But if the instructor has not reflected critically on his or her teaching, problems in the review can occur.

A study of 39 lecturers illustrates the problem that results when instructors reflect ineffectively on their teach-

Characteristics of Teaching-Centered Groups	Characteristics of Learning-Centered Groups
Individual accountability only	Both group and individual accountability. Members hold themselves and others accountable for high quality work.
Little or no attention to group formation	Deliberately formed groups
Assignments are discussed with little commitment to one another's learning.	Members promote one another's success, doing real work together.
Teamwork skills are ignored. Leader is appointed to direct members' participation.	Teamwork skills are emphasized. Members are taught and expected to use collaborative skills.
No group processing of the quality of the group's work.	Group processes quality of work and how effectively members are working together.

Table 3. Some contrasting characteristics of Teaching-Centered Groups and Learning-Centered Groups (after Smith and Waller, 1997b).

ing. Murray and Macdonald (1997) report that a few of these lecturers were, what we are calling, Teaching-Centered lecturers and a few were Learning-Centered lecturers, but the majority stated the aim of their teaching to be facilitating and otherwise helping students to learn, whereas they stated the purpose of their lecturing to be disseminating information. Murray and Macdonald concluded that the lecturers in the majority had not reflected critically enough to complete the reflection process and make a change in their practice. Furthermore, it seems to me, the lecturers were Teaching-Centered lecturers who had adopted the aims of the Learning-Centered Paradigm without reflecting on the implications of this selection for their use of the teaching methods. This disjunction is, for me, an example of the unreflective cross-paradigm borrowing that gives the impression of a gradation between the paradigms. Indeed, Hansen and Stephens (2000) report that most instructors who use active learning methods use them as "a toolbox supplement to lecturing" rather than as part of the Learning-Centered Paradigm. Peer review provides an opportunity to bring this self-contradiction to the instructor's attention.

Groups – Students are asked to work in groups by both Teaching-Centered and Learning-Centered instructors. The two types of groups reflect the assumptions and goals of the two paradigms and are therefore quite different classroom learning environments (Table 3). Indeed, the Teaching-Centered group can be a bad experience for students because the collaborative structure of the group is set in the competitive environment of the paradigm. In a classroom observation, evaluation should be placed on the performance of the individual student, not the group, for the students in the group have not been trained to work in groups. By contrast, it is the Learning-Centered instructor's responsibility to train and structure the groups for a successful learning activity in an environment supportive of students taking risks in learning. In a classroom observation of Learning-Centered groups, the reviewers need to evaluate the effectiveness of the instructor in attaining the content objective and the social-skills objective of the activity. They should observe the nature of the positive interdependence of the students in a group (division of labor, materials shared); individual accountability (self-check, students check one another); the instructor's social skill; instructor's feedback (to individual student, to group, to class as whole); group processing of the students' working arrangement as a group (social skills, academic skills), and so forth (see Johnson et al., 1991).

Discussion – Discussion is rarely used by the Teaching-Centered instructor. In fact, a survey of mathematics and science instructors in colleges and universities recorded less than 3% of class time being spent by the instructor in questioning students, and further, 87% of the questions asked were at the lowest cognitive level (Barnes, 1994). Questions at higher cognitive levels often are only probing for the correct answer about content. In reviewing this instructor, the usual forms are appropriate, such as noting whether the instructor "has good questioning skills, models good listening habits, and responds to questions clearly" (Chism, 1999). In reviewing a Learning-Centered instructor, however, the reviewers evaluate the instructor's effectiveness in achieving the content and pedagogical objectives of a discussion and the instructor's preparation for handling the uncertain direction a discussion can take. They evaluate the instructor's ability to use various kinds of questions at various cognitive levels to engage, challenge, and encourage the students to take part in a rigorous analysis, and they evaluate the instructor's ability to listen sensitively to the flow of the discussion and to respond both to student comments and to the group dynamics so that the learning outcome for the discussion is achieved and the ultimate goal of developing the groups' ability at self-discovery is attained (Garvin, 1991).

Laboratories and Field Trips – The first question for reviewing any laboratory or field instructor is: What is the goal of a laboratory exercise or field trip? The usual answer by the Teaching-Centered instructor is that the goal is to probe deeper the students' understanding of a concept introduced in lecture or to teach laboratory or field

techniques. Just as discussions led by the Teaching-Centered instructor tend to follow the lecture (Meyers and Jones, 1993), so too do laboratories or field trips tend to follow the lecture. This sequence is a natural expression of this instructor's belief that students need some background information before they can undertake a learning activity on their own. Considering himself or herself central to the course, the Teaching-Centered instructor feels more comfortable introducing the information and providing a well-structured lab exercise or field trip; that is, the handouts or guidelines will closely guide what the students do. Although these experiences are a step up for students from the highly structured "cookbook" lab manuals that bored them in introductory courses, the risk is that the exercises will merely confirm what they heard in lecture or what they read in the assignments. Such exercises can be just as boring as those in a "cookbook" manual. During the lab or field trip, the instructor, or TA, should move among the students with questions, answers, and suggestions, and generally guide the students' learning (National Research Council, 1997), but there is a great temptation in this paradigm to "tell" the students information rather than "coach" them to the answers. Students usually work in pairs but without having been trained in the interpersonal skills of cooperation. Items on an evaluation form for lab and field trip peer review could include "experiments/exercises are well chosen and well organized, procedures/techniques are clearly explained/demonstrated, the instructor is thoroughly familiar with the experiments/exercises, assistance is always available during experiments/exercises, experiments/exercises are important supplements to course, experiments/exercises develop important skills, instructor provides aid with interpretation of data, instructor works well with students and other parties in the setting" (Chism, 1999).

The Learning-Centered laboratory or field trip is very different. It occurs prior to the "lecture," as recommended by Schwab (1962). It begins with questions, posed by the instructor, the lab manual or field guide, or by the students, depending on the learning outcomes set by the instructor (National Research Council, 2000). The objectives are for the students to grapple with the situation before them, using their previous knowledge—which the instructor has probed and reflected on before developing the situation—and their reasoning ability to decide what should be observed, make observations, develop conceptual models to explain the phenomena, test the models, and arrive at the need for terms to assign to the concepts in order to connect to the scientific literature (for references see National Research Council, 1997, 2000). In other words, the situation is constructed for them to learn as "novices," not as "experts" like us—a major distinction (Bransford et al., 1999). The "lecture" period is then the site for elaboration on the concept by means of active learning techniques. Using this sequence, the instructor can even hold the laboratory and "lecture" period in the same room, if the class size is small, and alternate from one format to the other during a class session, for the students work in groups in both laboratory and "lecture" period and have been trained by the instructor in the skills required for successful collaboration. The instructor creates an environment in which the raising of questions and discussion of possible answers is the manner by which the students learn. Having students discuss and share their data in the laboratory (National Research Council, 2000), or in the field, helps them improve the accuracy and precision of their techniques and strengthen their reasoning. By listening to student questions and discussions, the instructor detects mistakes, confusion, and misconceptions, which can then be addressed in a constructive manner.

A final difference between the two types of laboratories to be mentioned here is the amount of structure or guidance provided the students (Table 4). In the Teaching-Centered laboratories, the instructor provides considerable guidance, as previously mentioned, in accordance with the paradigm that makes the instructor central to the course. In the Learning-Centered laboratory, the instructor may provide guidance through a sequence of questions, especially at the beginning of the course, or leave the exercise unguided and give the students ownership of the exercise, which increases their interest in its completion. The relationship is a partnership. In laboratories and on field trips we can readily recognize the parallels between inquiry-based active learning and the inquiry that is scientific research. In undergraduate research projects and senior theses, these two applications of inquiry merge. Items on an evaluation form for a Learning- Centered laboratory or field instructor could include some items mentioned for evaluating Teaching-Centered instructors, such as experiments/exercises are well chosen and well organized, the instructor is thoroughly familiar with the experiments/exercises, and assistance is always available during experiments/exercises. In addition, however, attention should be given to such learning emphasis as: exercises/field trips are question driven rather that fact driven, exercises/field trips are used to engage students to explore new ideas before explanations are available, exercises/field trips are integral to course content, students have opportunity to pose relevant questions for inquiry, students have opportunity to develop writing and speaking skills for communicating explanations through practice drafts, students have opportunity to analyze alternative explanations.

Instructor's responsibilities and instructor-students relationship – The successful use of any teaching method is a function, in part, of the instructor's meeting his or her responsibilities and effecting an appropriate instructor-students relationship. These responsibilities and relationships differ with the paradigm (Table 1). (The students' responsibilities and goals are likewise different but will not be discussed here.) The responsibilities and the complexity of the relationships are greater for the Learning-Centered instructor because of the greater interaction with students, with attendant greater need for reflection on teaching. For instance, consider the instructor's responsibility for knowledge. The Teaching-Centered Paradigm demands an instructor possess knowledge only of the geoscience content; therefore any

Essential Feature	Teaching-Centered Lab	→←	Learning-Centered Lab
Students engaged in exercises.	Students engaged by questions in lab manuals or from lecture.	Students select among questions, pose new questions.	Students pose questions.
Students learn what data are needed and how to obtain them through observation.	Students given data and asked to analyze them.	Students directed to observe certain data.	Students determine what constitute data, and they make observations.
Students learn to formulate explanations.	Students given possible ways to use data to formulate explanation.	Students guided in process of formulating explanation from data.	Students formulate explanation after summarizing data.
Students connect explanations to scientific knowledge.	Students given possible connections.	Students directed toward areas and sources of scientific knowledge.	Students examine other resources and form links to explanations.
Students communicate and justify explanations.	Students provided broad guidelines for communication.	Students coached in development of communication.	Students form reasonable and logical arguments to communicate explanations.

Table 4. Contrasting Teaching-Centered Laboratories and Learning-Centered Laboratories (after National Research Council, 2000, Table 2-6).

expert is qualified to teach. Teaching is a routine function, like eating. Hence, instructors in this paradigm accept the responsibility for knowledge of content but see no need for themselves or their TAs to be taught how to teach, whereas in the Learning-Centered Paradigm everyone who teaches a class has the responsibility to learn how to teach students so that they learn geoscience. That is, the Learning-Centered Paradigm demands that the instructor possess Pedagogical Content Knowledge (Shulman, 1986), in addition to geoscience content knowledge. Pedagogical Content Knowledge is the synthesis of instructors' geoscience content knowledge with their knowledge about teaching and learning such that they create an environment in which learning is best enhanced by their knowing know how best to represent ideas and concepts, to make analogies, to present examples, and to present challenging material for deeper learning (see National Research Council, 2000). Pedagogical content knowledge can be applied successfully in the classroom only with critical reflection on teaching.

In reading the instructor's syllabus, course assignments, tests, exercises, lab exercises, field trip guides, and teaching portfolio, and in observing the instructor in the classroom, the reviewers can evaluate the extent to which the instructor is meeting his or her responsibilities and the nature of the relationship with students. One could prepare a first approximation of an evaluation form for this review by using the statements on instructor's responsibilities and instructor-students relationship in Table 1. Place the appropriate verb in the statements that lack a verb and make "instructor" the subject of the statements that have a verb, for example, "instructor presents the content, including selecting it." For all that, it can still be difficult for reviewers to identify the classroom application of some of the Learning-Centered responsibilities and relationships—and some other Learning-Centered characteristics. The following references for Learning-Centered activities are offered as examples. They are taken from "Some Great Ideas for Geoscience Teachers" printed in the November 2000 issue of this journal: 1) engaging student interest by relating exercise to prior experience, interest, or knowledge—Benison; Dowse; Stull; Lighthart; 2) engaging students with questions—Mattox; 3) engaging students with surprising demonstrations (surprises raise questions)—Colson and Colson; O'Connell; 4) having students make observations before they hear about the concepts—Reynolds and Semken; Peacock and Reynolds; 5) having students connect their explanations to scientific knowledge—Fenster; 6) having students participate in demonstration of a difficult concept—O'Connell; 7) letting students select inquiry of interest—Pestrong; 8) accommodating different learning styles—McGrew and McGrew. Many papers published in this journal over the last several years have described Learning-Centered teaching methods.

NONCLASSROOM TEACHING

As we have seen, Learning-Centered instructors reflect more on their teaching than do Teaching-Centered instructors. The results of this reflection carry outside the classroom so that these instructors perform differently outside the classroom as well as inside it. Inasmuch as a Teaching-Centered instructor places emphasis on transferring information to the students, who are competing with one another, and fosters an impersonal relationship with them, as befits the one-way communication, then it is reasonable for this instructor to expect the students to be self-motivated and need no external encouragement. (The instructor was, of course, self-motivated as a student.)

Mentoring Element	Teaching-Centered Mentor	Learning-Centered Mentor	Advantage of Learning-Centered Mentoring
Mentor's Role	Authority	Facilitator	Facilitator maintains supportive climate.
Mentee's Role	Passive receiver	Active partner	Adults learn best when invoved in own learning.
Learning Process	Mentor directed	Mentee directed	Adult learners need to be self-directed.
Mentoring Relationship	One mentor	Multiple mentors	Experiences of other mentors enriches learning process.
Focus	Product oriented: Knowledge transfer and acquisition.	Process oriented: Critical reflection and application	Adults learn best when internally motivated to learn.

Table 5. Contrasting Teaching-Centered Mentor and Learning-Centered Mentor (after Zachary, 2000).

Any mentoring will probably consist of enhancing learning of content, for learning content is assumed to be the primary goal of education. Therefore, reviewers can evaluate the instructor's involvement in nonclassroon teaching from information on his or her amount of time spent, participation in seminars or projects organized for or by students, commitment to undergraduate and graduate student advising and mentoring, academic progress of students advised, and so forth (see Chism, 1999). By contrast, nonclassroom teaching is very important to the Learning-Centered instructor (Cunningham, 2001). In particular, the instructor strives to motivate students by helping them learn how to set learning goals, establish a plan to achieve those goals, and record progress. Both inside the classroom ands outside it, the challenge is to align the intact motivation that students bring into the classroom with the goals of the course. Mentoring means turning students into lifelong learners and, for the students majoring in the discipline, it means beginning to turn them into apprentices on the way to becoming colleagues. (See Table 5 for contrasts in mentoring under the two paradigms) Reviewers should be able to evaluate the instructor's nonclassroom teaching from comments in the instructor's teaching portfolio.

CONCLUSION

As often said, we teach the way we were taught. Most faculty members were taught by instructors who used the Teaching-Centered Paradigm and therefore they likewise used it when they began to teach. It requires little reflection on teaching, other than on the nuts and bolts, because it passes unrecognized as a paradigm and is considered to be the common-sense way of doing things. Teaching-Centered instructors accept the paradigm assumption that teaching is a routine activity that requires no training. Several guidebooks for the peer review of these instructors' teaching have been cited. The major challenge to fair and proper peer review arises from the need to review the growing number of instructors who, as part of the national reform of science education, are Learning-Centered instructors. These instructors hold to different assumptions about education, which leads them to different beliefs and values about education, educational goals, assessment, and utilization of teaching methods. In the Learning- Centered paradigm educational emphasis is on learning, not teaching, though both are essential. This emphasis renders teaching complex and demands the instructor be trained. Learning to teach this way takes time, just as learning to do research takes time. "It requires a shift in the role, preparation, knowledge, and skills of instructors" (Garvin, 1991). An instructor who has not consciously and with effort made the shift is still following the Teaching-Centered Paradigm, regardless of teaching method used. An unwitting mixture of Learning- Centered aims and Teaching-Centered methods creates a common disjunction between teaching aims and practices. Early preparation for peer review of their teaching should solve this and similar problems for instructors by helping them understand their role in teaching with respect to the two paradigms of education. The peer review itself provides valuable feedback on what instructors are doing well and what changes they should make.

The peer reviewers must ascertain that the instructor under review possesses accurate and current knowledge of geoscience content, regardless of the paradigm the instructor has accepted. Beyond that, however, the role of the reviewers varies with the paradigm. The role of the peer reviewer of a Teaching-Centered instructor is to obtain information on the instructor's teaching of the content. The role of the peer reviewer of a Learning-Centered instructor is to obtain information on the students' learning of content and skills, including the skill of how to learn. Therefore the first reviewer is seeking to learn what

and how the instructor teaches. The second reviewer is seeking to learn what and how the students learn. The contrast is illustrated by the information in Tables 2, 3, 4, and 5. Whether for tests and classroom exercises, group work, laboratories, or mentoring, the instructor's one-way communication to the students is the metric of Teaching-Centered teaching, whereas the students' learning products (especially their written products), increasing self-direction, and feedback to the instructor are the metric of Learning-Centered teaching. The contrast also holds for other teaching methods in the classroom and for other nonclassroom teaching activities. Recommendations have been offered in this paper for peer review of specific teaching activities. These recommendations, like those in the references cited, are generic. A department faculty should construct specific guidelines for peer review of its members' teaching.

ACKNOWLEDGMENTS

My thanks go to my colleagues James Borgford-Parnell and Donald Wulff at the Center for Instructional Development and Research and to the referees of the original manuscript for their very helpful reviews.

REFERENCES

Angelo, T.A., and Cross, K.P., 1993, Classroom assessment techniques: A handbook for college teachers (2nd edition): San Francisco, Jossey-Bass, 427 p.

Arreola, R.A., 1995, Developing a comprehensive faculty evaluation system: Bolton, MA, Anker Publishing, 191 p.

Barnes, C.P., 1994, Questioning in college classrooms, *in* K.A. Feldman and M.B. Paulsen, editors, Teaching and learning in the college classroom, Needham Heights, MA, Ginn Press, p. 393-409.

Barr, R.B., and Tagg, J., 1995, From teaching to learning—A new paradigm for undergraduate education: Change, v. 27, no. 6, p. 13-25.

Benison, K.C., 2000, Using analogous materials in large introductory geology classes: Journal of Geoscience Education, v. 48, p. 570.

Beveridge, W.I.B., 1957, The art of scientific investigation: New York, Random House Vintage Books, 239 p.

Bransford, J.D., Brown, A.L., and Cocking, R., editors, 1999, How people learn: brain, mind, experience, and school: Washington, D.C., National Academy Press, 319 p.

Brookfield, S.D., 1995, Becoming a critically reflective teacher: San Francisco, Jossey-Bass, 296p.

Brown, J.S. and Duguid, P., 2000, The social life of information: Boston, Harvard Business School Press, 320 p.

Cambridge, B.L., 1996, The paradigm shifts: examining quality of teaching through assessment of student learning: Innovative Higher Education, v. 20, no. 4, p. 287-297.

Chism, N. van N., 1999, Peer review of teaching: a sourcebook: Bolton, MA, Anker Publishing, 141 p.

Colson, M. and Colson, R., 2000, The spirit of the volcano: Journal of Geoscience Education, v. 48, p. 574.

Cunningham, M., 2001, Observation beyond the lecture: new learning models require new evaluation methods: The Teaching Professor, v. 15, no. 5, p. 6.

Dowse, M.E., 2000, Everyday minerals: Journal of Geoscience Education, v. 48, p. 571.

Fenster, M.S., 2000, A jigsaw exercise in classification of coasts: Journal of Geoscience Education, v. 48, p. 579.

Garvin, D.A., 1991, Barriers and gateways to learning, *in* C.R. Christensen, D.A. Garvin, and A. Sweet, editors, Education for judgment: Cambridge, MA, Harvard Business School Press, p. 3-13.

Hansen, E.J. and Stephens, J.A., 2000, The ethics of learner-centered education: dynamics that impede the process: Change, v. 33, no. 5, p. 41-47.

Innovative Higher Education, 1996, Special issue on peer review of teaching: v. 20, no. 4, p. 219-307.

Johnson, D.W. and Johnson, R.T., 1989, Cooperation and competition: theory and research: Edina, MN, Interaction Book Co., np.

Johnson, D.W., Johnson, R.T., and Smith, K.A., 1991, Active learning: Cooperation in the college classroom: Edina, MN, Interaction Book Co., np.

Kember, D. and Gow, L., 1994, Orientations to teaching and their effect on the quality of student learning: Journal of Higher Education, v. 65, p. 59-74.

Kumaravadivelu, B., 1995, A multidimensional model for peer evaluation of teaching effectiveness: Journal on Excellence in College Teaching, v. 6, no. 3, p. 95-113.

Lighthart, A., 2000, Hollywood geology: Journal of Geoscience Education, v. 48, p. 601.

Mattox, S.R., 2000, Teaching the basics about volcanoes to K-16 students: Journal of Geoscience Education, v. 48, p. 576-577.

McGrew, A.J. and McGrew, H.S., 2000, The photoessay as a teaching tool in introductory Earth science: Journal of Geoscience Education, v. 48, p. 602.

Meyers, C., and Jones, T.B., 1993, Promoting active learning: Strategies for the college classroom: San Francisco, Jossey-Bass, 192 p.

Millis, B.J., 1992, Conducting effective peer classroom observations, *in* D.H. Wulff and J.D. Nyquist, editors, Resources for faculty, instructional, and organizational development: To Improve the Academy, v. 11, p. 189-206.

Murray, K. and Macdonald, R., 1997, The disjunction between lecturers' conceptions of teaching and their claimed educational practice: Higher Education, v. 33, p. 331-349.

National Research Council, 1997, Science teaching reconsidered: Washington, D.C., National Academy Press, 88 p.

National Research Council, 2000, Inquiry and the National Science Education Standards: a guide for teaching and learning: Washington, D.C., National Academy Press, 202 p.

O'Connell, S.B., 2000a, An ocean-density demonstration: Journal of Geoscience Education, v. 48, p. 581.
O'Connell, S.B., 2000b, Visualizing the Coriolis effect: Journal of Geoscience Education, v. 48, p. 580.
Peacock, S.M. and Reynolds, S.J., 2000, Explore the data first: Journal of Geoscience Education, v. 48, p. 592.
Pestrong, R., 2000, Your personal park: Journal of Geoscience Education, v. 48, p. 604.
Pratt, D.A., 1992, Conception of teaching: Adult Education Quarterly, v. 42, p. 203-220.
Reynolds, S.J. and Semken, S.C., 2000, Rocks before terms and tables—from the concrete to the abstract: Journal of Geoscience Education, v. 48, p. 572.
Samuelowicz, K. and Bain, J.D., 1992, Conceptions of teaching held by academic teachers: Higher Education, v. 24, p. 93-111.
Schwab, J., 1962, The teaching of science as enquiry, *in* The teaching of science: Cambridge, MA, Harvard University Press, p. 1-103.
Shulman, L.S., 1986, Those who understand: knowledge growth in teaching: Educational Researcher, v. 15, no. 2, p. 4-14.
Shulman, L.S., 1999, Taking learning seriously: Change, v. 31, no. 4, p. 11-17.
Smith, K.A., and Waller, A.A., 1997a, Afterword: New paradigms for college teaching, *in* W.E. Campbell and K.A. Smith, editors, New paradigms for college teaching: Edina, MN, Interaction Book, p. 269-281.
Smith, K.A. and Waller, A.A., 1997b, Cooperative learning for new college teachers, *in* W.E. Campbell and K.A. Smith, editors, New paradigms for college teaching: Edina, MN, Interaction Books, p. 185-209.
Stull, R.J., 2000, Geological hazard assessment of the home: Journal of Geoscience Education, v. 48, p. 591-592.
Walvoord, B.E. and Anderson, V.J., 1998, Effective grading: a tool for learning and assessment: San Francisco, Jossey-Bass, 272 p.
Zachary, L.J., 2000, The mentor's guide: facilitating effective learning relationships: San Francisco, Jossey-Bass, 195 p.

"Although we have a critical teacher shortage, the nation's 1300 schools of education prepare more than enough new teachers each year. Our public schools leak talent like a sieve: More than 30 percent of all teachers, and up to 50 percent of teachers in large urban districts, leave their jobs within five years."

The Chronicle of Higher Education