INNOVATIVE
TECHNIQUES FOR
LARGE-GROUP
INSTRUCTION

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The fourteen articles in *Innovative Techniques for Large-Group Instruction* were selected from the *Journal of College Science Teaching* (1997–2002) by a committee of higher education science faculty. The committee was headed by Timothy M. Cooney, professor of Earth science and science education at the University of Northern Iowa and chairperson and director of the National Science Teachers Association’s (NSTA) Committee on College Science Teaching. Also on the selection committee were Daniel Brovey, director and professor of science and technology education, Queens College; Rita Hoots, professor at Woodland Community College; and Gerald Summers, associate professor of biological sciences at the University of Missouri.

At NSTA, Claudia Link, managing editor of the *Journal of College Science Teaching*, made the initial contacts for the book, Judy Cusick acted as the project editor, Linda Olliver designed the cover, and Catherine Lorrain-Hale coordinated book layout, production, and printing.
Introduction

Large college science classes, taught via the lecture method, still predominate across college campuses in the United States. Administrators often favor these large, and mostly introductory, science classes because they appear to be financially efficient and generate large numbers of student credit hours. A department with a limited number of faculty can handle many more students by having classes held in large lecture halls or auditoriums. Innovative Techniques for Large-Group Instruction presents effective ways to stimulate active learning in classes with more than fifty students. Reviewers for this collection selected articles from the Journal of College Science Teaching that tell us what research says about effective large-group instruction and that show us how college science faculty have successfully modified their lecture courses to stimulate active learning.

An assessment of popular teaching styles and their effectiveness are presented by Leonard in his article, “How Do College Students Best Learn Science?” Leonard first presents research evidence that the dominant lecture method just does not seem to work as an effective tool for teaching. Then he discusses the effectiveness of constructivist learning, followed by evidence that college students have various learning styles that college science faculty should take into consideration when preparing to teach. Leonard’s article concludes with recommendations that provide sound and proven ideas for enhancing learning in college science.

In “Are We Cultivating ‘Couch Potatoes’ in Our College Science Lectures?” Lord tells about an invitation to sit in on a colleague’s large biology class at another university. He describes what he observed and how he was unable to admit to his colleague that the students didn’t pay much attention during the lecture and that they probably didn’t learn a great deal. The drive back to his own university provided time for Lord to reflect on the lecture method and the reluctance of science professors to give up that method.

The remaining articles in this compendium describe how college science professors instituted active learning in their large classes. Many of these strategies align well with Leonard’s recommendations. Some techniques incorporate the use of current information technology. We learn also, in many cases, how and why these professors gave up the “lecture only” method. For example, Caprio and Micikas describe how to make the transition from traditional teaching practices to those that are student centered in their article “Getting There from Here.” They discuss two forms of barriers to this transition and present arguments against these barriers. The article concludes with suggestions on how to use the many resources available to faculty members who want to move their classes away from the standard lecture format to a more active learning environment.

Klionsky presents a quiz-based, group-learning approach that he adapted for very large sections of introductory biology. In “Constructing Knowledge in the Lecture Hall,” he describes a format for teaching that encourages student preparation prior to class and uses problem solving instead of excessive lecturing. Klionsky follows his description with discussions about the concerns and benefits of this approach.

As presented in “Active Learning in the Lecture Hall,” Anderson tells how she modified course requirements and engaged students in a variety of active learning activities. In her nonlaboratory Problems of the Environment course for nonscience majors, she used essays, special team presentations, a garden project, drawings, and concept mapping to challenge students to apply their knowledge in meaningful ways. Although she describes these techniques as successful, Anderson cautions that designing a course to elicit active learning takes time to design and is challenging for faculty and students alike.

Some university professors, like French and Russell, enlist lecture facilitators to support students and teachers in large lecture classes. They discuss this technique in “The Lecture Facilitator: Sorcerer’s Apprentice.” The facilitators assist with group work, operate the classroom technology, and perform demonstrations. Survey results indicate that students benefited from the use of lecture facilitators. The authors conclude that the use of facilitators made the transition from traditional teaching styles to an inquiry-based style much easier for students and faculty.

Convinced that active learning is more effective than the traditional lecture, Pestel uses “discovery questions” to help develop independent learning in her classes. A description of this technique appears in “Facilitating the Reading/Discussion Connection in the Interactive Classroom.” Pestel presents examples of the types of discovery questions she uses. Each question is structured around a specific and
limited reading assignment. These questions are distributed at the beginning of class and students are given 10–20 minutes to work in groups to determine the answers.

Writing is a valuable learning tool, but it is difficult to include in many large classes. In their article, “A Peer-Reviewed Research Assignment for Large Classes,” Henderson and Buising report on a successful technique they have used to incorporate writing in their classes. They use active learning in collaborative groups to produce research papers on instructor-supplied topics in a biochemistry class. Peer groups evaluate first drafts, and final drafts are posted on a class website for additional evaluation and feedback. Students receive evaluation criteria in advance so they know how to write their papers and how to provide helpful feedback to their peers.

Stencel provides a slightly different method to help make a transition from the didactic lecture approach. His article, “An Interactive Lecture Notebook—Twelve Ways to Improve Students’ Grades,” presents a strategy on how to draw students’ attention to what they need to know in a lecture. Students comment that the interactive notebook helped them get more involved in class and others felt the notebooks gave them time to learn and listen instead of just trying to write notes in class.

A number of professors incorporate the use of modern information technology into their courses to make the classes more interactive. E-mail communication is one of the leading ways to enhance communication between students and instructors. Hedges and Mania-Farnell describe how redirecting students’ work through e-mail helped students identify misconceptions and helped the instructor identify areas that needed to be covered further in a human biology class. In “Using E-mail to Improve Communication in the Introductory Science Classroom,” the authors describe how students were asked to read a variety of current articles and news briefs from journals and science magazines, and then discuss the articles by e-mail. Besides increased student-instructor interaction, the authors discuss several other beneficial outcomes.

In “Using Internet Class Notes and PowerPoint in the Physical Geology Lecture,” Mantei explains how these technologies lead to higher exam scores for students. He compares student performance in physical geology classes using traditional lecture methods and those where lecture notes and practice examinations were placed on a class website. Preliminary evaluation data show strong student acceptance for these techniques.

Marbach-Ad and Sokolove tell how students in a large mixed majors/nonmajors introductory biology class used e-mail and written notes for questions on class content or organization. Their article, “Creating Direct Channels of Communication: Fostering Interaction with E-mail and In-class Notes,” indicates that women and science majors were most likely to communicate in this manner. For students who are reluctant to ask questions during class and those having questions outside of class, this method is efficient and effective.

Action research provides a unique way to improve teaching practices. Adams and Slater present their findings in an article titled “Using Action Research to Bring the Large Class Down to Size.” They present four action research studies conducted in support of improving introductory astronomy, a course with more than 200 nonscience majors in a single lecture. The article provides readers with evidence that the large-group learning environment can be improved by making decisions based on data.

Another professor used an assessment tool to help refine teaching techniques. In “Gauging Student’s Learning in the Classroom: An Assessment Tool to Help Refine Instructors’ Teaching Techniques,” Heady reports that the use of the Student Assessment of Learning Gains (SALG) in an introductory biology course is a more helpful instrument than traditional course evaluations in obtaining data that can be used to improve course instruction.

In conclusion, professors whose articles are presented in this collection have used the most current research on teaching and learning, information technology, and research to improve large-group instruction at their colleges and universities. The strategies they present range from small-scale innovations to a complete revamping of teaching techniques. The desire to improve college science teaching and learning is the goal of each author. Their strategies provide excellent examples for others who wish to move away from the traditional lecture-only method.

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Innovative Techniques for Large-Group Instruction brings you sciLINKS, a new project that blends the two main delivery systems for curriculum—books and telecommunications—into a dynamic new educational tool for children, their parents, and their teachers. sciLINKS links specific science content with instructionally rich Internet resources. sciLINKS represents an enormous opportunity to create new pathways for learners, new opportunities for professional growth among teachers, and new modes of engagement for parents.

In this sciLINKed text, you will find an icon near several of the concepts being discussed. Under it, you will find the sciLINKS URL (www.scilinks.org) and a code. Go to the sciLINKS website, sign in, type the code from your text, and you will receive a list of URLs that are selected by science educators. Sites are chosen for accurate and age-appropriate content and good pedagogy. The underlying database changes constantly, eliminating dead or revised sites or simply replacing them with better selections. The sciLINKS search team regularly reviews the materials to which this text points, so you can always count on good content being available.

The selection process involves four review stages:

1. First, a cadre of undergraduate science education majors searches the World Wide Web for interesting science resources. The undergraduates submit about 500 sites a week for consideration.

2. Next, packets of these web pages are organized and sent to teacher-webwatchers with expertise in given fields and grade levels. The teacher-webwatchers can also submit web pages that they have found on their own. The teachers pick the jewels from this selection and correlate them to the National Science Education Standards. These pages are submitted to the sciLINKS database.

3. Scientists review these correlated sites for accuracy.

4. NSTA staff approve the web pages and edit the information provided for accuracy and consistent style.

sciLINKS is a free service for textbook and supplemental resource users, but obviously someone must pay for it. Participating publishers pay a fee to NSTA for each book that contains sciLINKS. The program is also supported by a grant from the National Aeronautics and Space Administration (NASA).
How Do College Students Best Learn Science?

An Assessment of Popular Teaching Styles and Their Effectiveness

William H. Leonard

This paper is based on William Leonard’s “How Do College Students Learn Science?” Chapter 1 in Effective Teaching and Course Management for University and College Science Teachers, edited by E. Siebert, M. Caprio, and C. Lyda. Dubuque, IA: Kendall/Hunt Publishing Co.

The vast majority of college students are not successfully learning science. Lord summed it up, “The present way we teach undergraduate science at colleges and universities almost everywhere simply does not stimulate active learning” (1994). The dominant lecture method just does not seem to be doing the job (Leonard 1992).

Our students entering and leaving high school are not scoring well on tests that measure understanding of science (and mathematics) relative to other developed countries, and this appears to continue through college (National Center for Education Statistics 1997). Moreover, college science courses are notorious for poor teaching (Lord 1994; Seymour 1995). In fact, Angelo (1990) has shown that students remember only 20 percent of what they hear in a traditional lecture.

Researchers and educators have suggested that one major reason for the lack of success of the lecture method is that students do not expend much energy thinking about what is being discussed in a traditional lecture presentation. On the other hand, a truly interactive lecture, interactive group learning, or experiential learning setting such as a laboratory or field work provides plenty of opportunities for students to process, interpret, and internalize the concepts they experience.

The literature contains many testimonials and experimental research studies that support the idea that meaningful learning is tied to experience (Bodner 1986; Leonard 1989 a and b; Angelo 1990; Lorsch and Tobin 1992; Bybee 1993; Caprio 1994; Lawson 1990, 1992, 1993; Lord 1994; Roth 1994 Seymour 1995). Cannon (1999) has suggested that a lack of appropriate learning strategies (especially student-centered methods) is the largest variable contributing to attrition in science majors.

CONSTRUCTIVIST LEARNING

A learning approach called constructivism is receiving much attention in the literature. Frequently cited as the source of this term, von Glaserfeld (1987) states, “Constructivism is a theory which asserts that knowledge is not primarily received, but actively built and that the function of cognition is adaptive and serves the organization of the experiential world.” Rooted in Piagetian thought, information processing, and concept mapping, constructivism assumes that learners build upon prior experiences. The learner has a neural network that organizes and relates previously learned knowledge. New understandings are constructed by the learner as a result of new experiences.

“Constructivists hold that learning is an interpretive process, as new information is given meaning in terms of the student’s prior knowledge. Each learner actively constructs and reconstructs his or her understanding rather than receiving it from a more authoritative source such as a teacher or textbook” (Roth 1994).

Constructivist learning can be compared or contrasted to an objectivist approach in which knowledge is viewed as something that can be imparted. Objectivists like to use the lecture approach because they believe that
they can open up the student’s head, pour in knowledge, close the student’s head and then have the student take a test. Caprio (1994) believes that, “The objectivist teacher rewards students when their understanding is more or less the same as that of the instructor.” This is a very dangerous learning approach when viewed in terms of how scientists themselves discover new knowledge. The objectivist approach is also popular among university administrators interested in the lowest possible cost of getting a student through a course.


Lord has suggested that having students work in collaborative groups is central to a constructivist learning environment because it provides opportunities for students to clarify their understandings.

Constructivism warrants serious consideration in college science teaching. It is becoming clearer to many college science faculty that constructivism facilitates meaningful understanding of science. The strong support in the literature for constructivism is probably why both the National Science Education Standards and the Benchmarks for Science Literacy endorse constructivist approaches to learning.

STUDENTS LEARN IN DIFFERENT WAYS

There is also much evidence that students learn in different ways. The term learning styles has been used extensively in the literature to describe the possible means by which an individual student may best learn. Some research supports that individuals prefer to learn through one or more of the different senses (Jung 1970). Concrete learners rely more on touch, taste, and smell and more intuitive and abstract learners prefer hearing and sight.

Meyers and Briggs (1958) believe that learning style preferences are related to personality type. For example, sensory learners (S) depend on experiences taken in through their senses. Intuitive learners (I) benefit from discussions of abstractions. Feeling learners (F) tend to relate what they learn to their own personal and/or societal values. Thinking learners (T) benefit most from a logical progression of organized and related concepts.

There is also evidence to suggest that the vast majority of learners do not sort entirely into any one of the above categories but instead into four combinations of two of these categories (Silver, Hansen, and Strong 1981; Krause 1996). Thus, ST (sensory-thinking) learners need a highly organized and quiet environment, work best alone, memorize well, benefit from repetitious drill and practice and do well on recall exams.

Krause (1996) believes that STs are the classic student for which American schools have been structured. The SF (sensory-feeling) is a verbal learner, is highly interpersonal, and benefits from stories and examples. Cooperative learning works well for SFs. ST and SF
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learners are a large proportion of entering college freshmen. They are highly constructivist because they build abstractions through progressive concrete experiences.

IT (intuitive-thinking) learners search for logic and patterns of understanding. Since it is beneficial for them to see the whole picture of where specific knowledge fits, advance organizers such as concept maps are helpful. Being global and deductive learners, they do not memorize well but can handle abstract theories. IF (intuitive-feeling) learners tend to learn from metaphors, do well in social contexts such as cooperative learning, yet are very creative. Krause (1996) believes that IF learners are the most endangered in traditional American schools.

There is much debate in the literature on learning styles primarily because of the different ways in which learning styles are categorized. Some evidence indicates that learning is most effective if a student is provided information about his or her unique learning style preference and is then given instruction that takes into account that particular style (Krause 1996). It has been suggested that most instructors teach using their own preferred learning style and overlook the fact that most of the students in their class learn better in other ways. Given that there do seem to be style preferences in the way individuals learn, instructors may be well advised to first recognize this and then try to diversify the teaching methods they use in order to accommodate the learning needs of a diverse student population.

RECOMMENDATIONS

▲ Use significantly more active learning. Active learning is already a large part of contemporary high school science curricula, discussed in such texts as ChemCom: Chemistry in the Community (1998), Biology: A Community Context (1988), and Active Physics (1998). Active learning is also emerging in mathematics, language arts, and social studies curricula because it makes learning interesting to teachers and students alike. It also provides learning based upon experiences to which students can make relevant connections to their worlds.

The college science community was found to be more interesting to students than the old-fashioned lecture because there is an element of mystery as well as more active student participation in the learning process. The interaction between instructor and student provides students time to adequately process concepts.

Lawson (1992) has suggested some specific ways to “push” previously tran-
he lectured less and gave students more responsibility outside of class for their own learning. Cannon (1999) suggests assessing the student perception of the extent to which a classroom environment is consistent with constructivist epistemology. He has developed an instrument that can help teachers to reflect on and, perhaps, reshape their teaching practices.

▲ Use lab before lecture to teach the same science concepts. This allows instruction to proceed from concrete to abstract and will make learning much more successful for nonmajor students.

▲ Provide your students with a conceptual framework and advance organizers. Advance organizers allow ideas to fit into students’ existing networks and will encourage students to relate what is being learned to what is already known.

▲ Accommodate the many ways in which different students learn by using many different approaches. In two articles published in 1989, I made suggestions for accommodating different student learning styles using visuals and objects and for making abstractions more concrete to students in large-enrollment classes.

▲ Use science content and instructional methods consistent with the National Science Education Standards and Benchmarks for Science Literacy. Bybee and McInerney (1995) recommend that colleges and universities implement national standards and benchmarks both in their courses for nonmajors and in their teacher preparation programs. In addition, they recommend that colleges and universities use appropriate, research-based pedagogy for these audiences. These recommendations include science department programs that train teaching assistants.

References