Cooperative-Learning Activities in Large Entry-Level Geology Courses

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ABSTRACT
Small-group cooperative-learning activities involving writing and/or oral presentations promote active learning in large lecture-based physical and historical geology courses. Groups include informal pairings of students for short discussions, writing peer-review groups of three to four students, and groups that work together throughout the semester on a variety of other projects. Writing assignments consist of ungraded in-class writing and graded short papers on a variety of geological topics. Oral presentations include debates, panel presentations, and skits. As students exchange ideas and work with one another in these activities, they are learning geology as well as improving their communication and collaboration skills. The learning communities that develop reduce the isolation many students feel in a large lecture class. To implement cooperative-learning, instructors should design activities that incorporate key elements of cooperative learning and are directly related to course objectives.

Keywords: Education — geoscience; education — (by) writing and speaking; education, undergraduate; geology — teaching and curriculum.

Introduction
The most common teaching method used in entry-level courses, particularly those with high enrollments, is undoubtedly lecturing. Although lecturing is an efficient and time-honored way to present information, students listening to lectures often act as relatively passive learners who are not directly engaged with the subject matter. Teaching methods such as cooperative learning that require students to communicate and cooperate, and thus become more actively involved in content, may result in enhanced learning. Using cooperative methods to supplement lectures provides a variety of experiences for students with different backgrounds and preferred learning styles. Although some might argue that these methods can be used effectively only in small courses in which students interact directly and regularly with the instructor, we feel they are adaptable to the large classes common in many universities.

We have incorporated writing assignments and small-group cooperative activities into physical and historical geology, two lecture-based courses with enrollments of 100 and 50 students, respectively. In this paper, we discuss the rationale for using such approaches, describe activities used in informal and formal cooperative groups (with a greater emphasis on the former), and offer suggestions for implementing effective cooperative-group activities.

Writing, Small-Group Cooperative Activities, and Learning
Geoscience educators have long been aware of the value of student writing (see the May 1991 issue of the Journal of Geological Education and the cited references). The relationship between writing and learning provides the basis for the “writing-across-the-curriculum” movement, in which writing assignments are given in courses in all disciplines to teach both content and writing. Writing is viewed as both a product and a process. The process of putting words down on paper helps to clarify and develop ideas (Emig, 1977; Fulwiler, 1987). Instructors approaching writing as a process assume that students may learn as they write, rather than only before they write, and thus they give writing assignments to encourage learning.

Small-group cooperative experiences involve a variety of students working together to complete an assignment. Within the groups, students might collect data, explain concepts to one another, discuss ideas and results, summarize information collected by individual group members, and make interpretations. Group work provides excellent opportunities for students to practice skills such as analysis, synthesis, decision-making, oral and written communication, and group dynamics (Johnson and others, 1994).

Although the geoscience education literature includes many articles on small-group activities, relatively few focus specifically on cooperative learning (see Bykerk-Kauffman (1993) for an exception). The articles in this issue demonstrate the increased interest in using cooperative and collaborative learning. Johnson and others (1991) have stated that cooperative-learning groups “must have clear positive interdependence, members must promote each other’s learning and success face to face, hold each other personally and individually accountable to do a fair share of the work, use appropriately the interpersonal and small-group skills needed for cooperative efforts to be successful, and process as a group how effectively members are working together” (p. iv).

The potential benefits of using cooperative learning include increased academic achievement for all ability groups, improved social and communication skills, greater accommodation of diversity and different learning styles, and increased motivation and interest in subject matter (Johnson and others, 1994; Sharan and Sharan, 1990; and Slavin, 1990). These
Cooperative-Learning Activities in Large Entry-Level Geology Courses

conclusions, based primarily on work with precollege populations, have also been supported by research at the post-secondary level (Cooper and Mueck, 1990). Bykerk-Kaufman (this issue) presents the case for using cooperative learning based on current understanding of the learning process.

Writing activities, which can focus student attention, generate ideas, and provide individual accountability, can help make cooperative learning more effective (Wiswall and Srogi, this issue). Given the value of writing assignments and small-group cooperative activities in promoting active learning, integrating both into large lecture-based courses is an effective teaching strategy. When students exchange ideas and work with one another, they are learning geology as well as improving their communication and collaboration skills.  

Johnson and others (1991) described three types of cooperative-learning groups. Informal cooperative-learning groups are temporary groups that form for a short discussion or one class period. These groups, formed by either the students or the instructor, are commonly used during lectures to help students focus their attention and actively process what is being learned. Formal cooperative-learning groups are groups of students who work together to accomplish shared goals for a time ranging from one class period to several weeks. The instructor assigns students to groups, and may assign roles within each group. Finally, base groups consist of three or four students who stay together throughout the term to support, encourage, and assist one another as they progress academically. This personalizes the learning experience. The next two sections describe the use in entry-level geology courses of informal cooperative-learning groups and formal groups that have some of the characteristics of base groups.

INFORMAL COOPERATIVE-LEARNING GROUPS

A variety of informal cooperative activities can easily be incorporated into lecture-based courses. These activities are completed relatively quickly by groups that may be together for only that one activity. They can direct students’ attention to the material to be learned, provide time for reflection and cognitive processing, get students to apply what they have learned to a new situation, and build relationships among students (Johnson and others, 1991; Millis, 1994). Informal cooperative-learning structures are “content-free ways of organizing social interaction in the classroom” (Kagan, 1989/90) that, when combined with content appropriate to the discipline, become meaningful classroom activities or learning experiences (Millis, 1994). These structures include Think-Pair-Share (Lyman, 1987), Think-Pair-Square, and Roundrobin (Kagan, 1989/90). Different structures satisfy different learning objectives; one may be useful for brainstorming, another for promoting equal participation by group members, and another for processing material covered in a lecture. An overview of different structures and their academic and social functions is given by Kagan (1989/90). Other activities that can be adapted for informal cooperative activities include freewriting and classroom assessment techniques.

In Think-Pair-Share, the instructor poses a question or problem, then asks all students to think about the question or problem. We find this works best when students write out their (ungraded) response. After a minute or two, the instructor has students discuss their answers with a neighbor to share views or to reach consensus if one correct answer is warranted. Finally, the instructor randomly calls on a few students to answer, ensuring some accountability, getting different perspectives, and bringing the short discussion to closure. This procedure gives each student time to compose an answer and then to express his or her ideas. It typically produces high-quality responses from a greater variety of students than the more traditional question and answer format. Another benefit is that instead of getting a response from only one student, half the class will be talking at a given time, most on the topic under discussion. Think-Pair-Share can be used to have students develop applications or examples of principles presented in lecture or identify arguments for or against an interpretation. In geology courses, we have used it to review potential test questions. The technique provides an immediate check for understanding and an opportunity for clarification by the instructor if needed.

Quieting and refocusing a large class after lively pair discussions can be challenging. One effective strategy is to raise your hand; once students see the raised hand, they raise a hand and finish the sentence, then stop talking (Harrin, 1994). The room generally quiets in less than 30 seconds.

Think-Pair-Square is similar to Think-Pair-Share, but rather than a student sharing the pair’s answer with the entire class, each pair shares its response with another pair. The instructor may call upon members of the foursomes to respond to open-ended questions or give the answer to closed questions to allow groups to self-check.

Roundrobin is another alternative to encourage student responses to questions, problems, or issues posed by the instructor. Students form groups of approximately four. After the question or issue is presented, group members take turns responding until everyone has had a turn. If there are many possible responses, students continue taking turns until the ideas or time has been exhausted. A representative of the group may be called upon to share some of the group’s answers.

Freewriting responses and classroom assessment techniques are used either as stand-alone activities or, when combined with paired or small-group discussions, as cooperative-learning activities. Freewriting exercises are two- or five-minute responses written at the beginning of class in reaction to a prompt. For example, the instructor might prompt students to write what they know regarding a specific topic (for example, groundwater), about which they might have misconceptions, before formally introducing the topic.
Cooperative-Learning Activities in Large Entry-Level Geology Courses

Figure 1. Informal cooperative learning and the lecture. (Used by permission from Smith, 1994.)

Or students might be asked to explain a geologic feature or outcrop. These prompts focus student attention and give more timid students a written text on which to rely when a discussion begins.

Classroom assessment techniques (CATs) are ways to assess student learning and elicit student responses (Angelo and Cross, 1993). One example is the one-minute paper, in which students might write about the most important point of a lecture or ask a question left unanswered by the lecture. This can be done just before the end of the class period, turned in, read by the instructor, and then addressed at the beginning of the next class period. Reading the ungraded papers takes relatively little time, but provides valuable feedback on student understanding.

These short informal cooperative and writing activities have been used effectively, but occasionally, in geology lectures for several semesters. Another approach would be to use them to break up a lecture into segments of 10-15 minutes, about the length of time an adult can concentrate on a lecture (Johnson and others, 1991). Smith (1994) provided an excellent visual representation of this approach (Figure 1). For example, Think-Pair-Share could be used in the intervals between lecture segments to reinforce a point, get students to extend the material covered, or check for comprehension. A freewriting exercise could be used at the beginning of class and a classroom assessment technique could be used in the summary time at the end.

FORMAL COOPERATIVE-LEARNING GROUPS

In both physical and historical geology courses at the College of William and Mary, students write short papers that are peer-reviewed; details of assignments and group structures have been described in Macdonald (1991). The peer-review groups are examples of the formal cooperative groups described by Johnson and others (1991). More recently, writing groups (modified formal groups) have been established. Each writing group consists of 10-14 students who work in teams of three to five on a variety of assignments ranging from individual short papers to group oral presentations. Groups meet for the entire class period eight to ten times during the semester. The membership of the writing groups remains the same throughout the semester in order to build team cohesion. Each writing group has an undergraduate teaching assistant who serves as a group monitor and resource person. When the courses are taught using teaching assistants (TAs), students complete four of these assignments a semester; without TAs, they complete one or two assignments a semester.

Assignments include cooperative activities in which students gather information (from their own observations or from geology articles in the scientific and/or popular literature) and then write an individual paper and/or prepare a group presentation. One type of assignment involves each student writing a short, peer-reviewed paper on topics such as rock/outcrop descriptions and interpretations, summaries of articles relating to geologic controversies, career profiles, and geology and its relationship to societal issues. A second type of assignment uses the jigsaw structure described by Tewksbury (this issue) in which each student becomes an expert on a particular aspect of a topic, and then teaches it to other members of a small group. Another type of assignment requires different students in a group to read different articles or chapters in a book and summarize their reading to the rest of the group. Each student then writes a short paper based in part on chapters he/she did not summarize.

To conserve time spent evaluating individual papers, we also designed assignments in which the final project of the group endeavor is an oral presentation, with individual accountability in the form of questions on an examination. For one type of assignment, each member of a group reads a different journal article representing the same position on a geologic controversy. Other groups cover other positions. Each group then prepares for a class debate, selecting one person to serve as the group’s spokesperson. A second type of assignment requires all members of each team (within a writing group) to read the same chapter (for example, a chapter in Control of Nature by John McPhee). Each team then prepares and delivers to the writing group a presentation on the relevant geologic information and the different perspectives in their chapter. The presentations are informative, lively, and creative, taking the form of skits, talk shows, interviews, and panel discussions. In both types of assignments, each student is responsible for mastering the material in all of the chapters.

Advanced undergraduate geology majors serve as teaching assistants (TAs) to monitor work in groups and respond to drafts of writing assignments and previews of oral presentations. The TAs participate in a 20- to 30-hour training session to prepare them for their responsibilities. The TAs respond to the first drafts of papers, which significantly reduces the time.
Cooperative-Learning Activities in Large Entry-Level Geology Courses

spent by the instructor in reading and evaluating the final drafts. This makes it feasible to give several of these assignments in large classes.

Students have responded positively to these cooperative assignments. For example, students in historical geology evaluated the four cooperative writing/presentation assignments as very worthwhile (an average rating of 4.3 on a 5 point scale) and more than 90% of the students who responded indicated that such assignments should be used in future courses.

Suggestions for Implementing Cooperative Learning

In cooperative learning, the instructor gives initial instruction in course content and/or skills, then designs assignments that help students apply and practice that content or skill. The instructor must determine specific tasks/goals to be accomplished by the groups, types of cooperative learning that best support these goals, criteria for success, and expected group behaviors (for example, everyone participating, staying on task, listening effectively). The instructor also sets group size and composition, roles for group members, and evaluation methods for individual and/or group outcomes. While the groups are working, the instructor monitors group activities and assists groups in accomplishing their designated tasks. It is critical to explain to students the rationale for using cooperative learning to minimize resistance to working in groups that may be present due to previous experiences with poorly structured group work.

To realize the advantages of cooperative-learning, instructions about the assignment should be clear, the activities should be directly related to course objectives, and explicit attention should be given to incorporating the key elements of cooperative learning in the activities, including strategies to foster effective group work.

We suggest using base-building activities to increase the comfort level of students with peers early in the semester at the beginning of group activities. These personalize learning and promote positive interdependence (a sense of "we're all in this together"). Base-building activities allow students to learn and recognize each others' commonalities as well as unique attributes. Examples of base-building activities include Paired Introductions in which each student interviews a partner, then introduces him/her to the rest of the group. Students then switch roles with their partners so everyone is introduced. Autograph Hunt involves students finding others in their group who share common interests, attributes, likes, dislikes, and so on. A list of items is given and students connect with as many other students as possible to secure signatures for each category on the list. A third base-building activity is Geology Treasure Hunt, in which teams of students locate features of geologic interest on campus. This activity promotes a sense of community among members of cooperative groups at the same time that it focuses on a geologic topic. Lyman and Foyle (1990) give examples of other base-building activities.

For formal cooperative activities, we suggest that the instructor form the groups. In Physical Geology, students were arranged into writing groups alphabetically, primarily due to time constraints. In Historical Geology, students were arranged into heterogeneous groups on the basis of year in school (first or second vs. third or fourth), gender, number of geology courses previously taken, and self-reported ability to write and to work in groups. Our sense, based only on anecdotal information, is that the heterogeneous groups worked more effectively than the alphabetical groups. This may reflect the benefits of purposefully assigning heterogeneous groups or merely the difference in class size (50 versus 100) or writing group size (10 versus 14). For informal cooperative activities, students were allowed to select their partners from among the students in adjacent seats.

In many cooperative activities, students assume specific roles in their groups, such as recorder, reporter, facilitator, encourager, or time-keeper. Folded note cards placed in front of each student can be used to designate role responsibilities. Rotating roles for successive assignments ensures that all students participate and learn the different group skills associated with each role.

Another important element for effective group functioning is regular group processing, or having students discuss how well they are working together as a team to accomplish their goals. Having members talk about behaviors or tasks that the group does well and identifying one or two specific behaviors to improve upon in future sessions help to ensure that groups become increasingly more effective. Processing, which can be done in the last few minutes of the activity, should occur at the end of every group session initially, and at least periodically once groups are well established.

One concern that many students and instructors have about cooperative-learning activities is determination of grades. Some practitioners assign the same grade for a group project to all students, others include a weighting factor associated with each member's contribution (determined by the instructor or the group members), whereas others do not grade group activities explicitly (this is especially true of informal activities), but do evaluate the learning on (later) examinations. This is a complicated issue, and we admit that we have not found a universal solution. However, it is critical that the cooperative activities be directly linked to course objectives, which include mastery of course content, and that students understand and believe that the group work will help them master that content.

Class time spent on cooperative-learning activities will reduce the amount of material covered via lecture. However, this reduction may be compensated for by increased depth of coverage. Cooperative-learning experiences often decrease the amount of material to be memorized, but increase analysis, synthesis, and understanding of content.

Instructors who are new to group work may wish to begin by using informal and less time-consuming
Cooperative-Learning Activities in Large Entry-Level Geology Courses

cooperative activities. As familiarity with cooperative learning increases, more formal cooperative assignments can be developed and implemented. Instructors of large classes are advised to introduce cooperative exercises gradually, and build upon successes in their classrooms.

Conclusion

Innovative writing assignments and associated small-group activities that complement lectures in large entry-level courses benefit students by giving them ways to enhance learning and develop communication and cooperative skills. When students write about geology, they learn about the content and process of geology as well as develop their ability to communicate in writing. When they work together to complete an assignment, they bring different perspectives to the discussion and develop their ability to communicate orally and to work collaboratively. Individuals also have opportunities to learn from their peers. The learning communities that develop promote shared responsibility for learning as well as reduce the isolation many students feel in large lecture classes.

Acknowledgments

We thank our students, especially those who suggested ways to improve the group activities. We also thank our colleagues, George Bass, Ron Giese, and Colleen Kennedy, who shared ideas about ways to incorporate writing assignments and cooperative-learning activities into lecture-based courses. The writing group project was supported by National Science Foundation Grant USE 9156138. Reviews by Ann Bykerk-Kaufman and Molly Miller greatly improved the manuscript.

References


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