A Cooperative Approach to Teaching Mineral Identification

Terri Lynn Constantopolous
Department of Physical Sciences, Station 33
Eastern New Mexico University
Portales, New Mexico 88130

ABSTRACT
A new approach to teaching mineral and rock identification, based on cooperative learning, was implemented at Eastern New Mexico University to boost achievement and motivation in freshman-level geology labs. Cooperative learning, a concept based on group work in which the students are responsible for others' learning as well as their own, has proven successful in improving student achievement and motivation. Jigsaw Teaching, a cooperative learning approach, was modified and applied to mineral and rock identification. For this discussion, mineral identification is used as an example; however, the procedure can be used for rock identification as well. Students work in groups of four and are responsible for learning to identify 20 minerals. Each student within the group becomes an "expert" on five of the 20 minerals, then the student "experts" take turns teaching the other members of the group how to identify their five minerals. By the time the group finishes, each student has learned to identify all 20 minerals. All of the students have a stake in the assignment and are actively involved in the learning. Furthermore, teaching other students reinforces what each student has learned about mineral identification. As a result, grades have improved and the lab has become a positive learning environment, thereby fostering participation, motivation, and enthusiasm.

Keywords: Education - geoscience; education - laboratory; education - undergraduate; geology - teaching and curriculum.

Introduction
Teaching mineral and rock identification in introductory geology labs that include both geology majors and nonmajors has proven to be a challenge. It is not easy to motivate and hold the interest of all students since there is such a wide range of academic backgrounds, levels, and interests. Part of the problem lies in the traditional methods used to teach these exercises. For example, mineral identification is usually taught over two lab periods, and each student is given a set of approximately twenty minerals, a brief overview of physical properties, a set of tools for mineral identification, and a lab manual that has mineral-property charts. At this point the students, presumably, are fully armed and ready to identify minerals, but the problem is that many students are not motivated, and to them the thought of wading through a pile of minerals is considered sheer torture. Some students persevere and make it through on their own. Others claim to work better in groups, especially with their friends. However, for many of those it turns out to be only one or two students who do all the work, while the other students in the group jot down the mineral names and provide entertainment. Regardless of whether the students work individually or in small groups, most of them lack enthusiasm and motivation, and this creates a negative learning environment. This lack of enthusiasm for mineral and rock identification prompted me to restructure the mineral and rock identification lab exercises.

Cooperative Learning: Jigsaw
Cooperative learning has gained much attention due to its widespread success in improving student achievement. There are several methods of cooperative learning, all focusing on the idea that students work together to learn and are responsible for others' learning as well as their own (Slavin, 1990 p. 3). Two central features of cooperative learning are: 1) establishing group goals and working together to achieve those goals; and 2) defining individual accountability so that group success depends on the individual learning of all group members.

Jigsaw teaching is an approach to cooperative learning that was first developed by Elliot Aronson and his colleagues in 1978. A simpler and more practical version of Jigsaw, called Jigsaw II, was later introduced by Slavin (1986). In both versions the students work in groups of four to six and are assigned material to read. In the original version of Jigsaw each student in a group becomes an "expert" on specific topics by reading sections that are different from those read by the other group members. Jigsaw II requires that all students read the same material, but each student becomes an "expert" on a specific topic within the same reading. Both versions of Jigsaw call for students from different groups to meet and discuss their common topic and thus become the "expert group" on that topic. The "experts" then return to their original group and teach their topic to the other members. When the exercise is complete, each student will have taught his or her topic to the other members of the group, and all group members are responsible for all topics covered. Finally, students take quizzes that cover all topics, and quiz scores become team scores.

Since I was intrigued by the success of cooperative learning, I decided to try it by modifying the Jigsaw approach for use on mineral and rock identification. Mineral identification will be used as an example for outlining the procedure in this discussion; however, the procedure can also be used for rock identification.

In this version of Jigsaw, the students work in groups of four. Each group is required to identify a total of 20 minerals. Each student within the group is assigned five minerals and hence will become an "expert" on those five minerals. The student "experts" then take turns teaching the other group members how to identify those five minerals. Ultimately each student is responsible for learning to identify all 20 minerals.

Once the students learn how to identify minerals, the procedure is the same whether they individually identify only five minerals or all 20. For most students the prospect of identifying only five minerals seems much more reasonable than identifying 20. As a result, not only are the students more motivated, but they do not feel rushed. This enables them to spend time carefully observing the physical properties of the five minerals, thereby leading to more success with mineral identification.

Each student has a stake in the assignment and is therefore more actively involved in learning. The active involvement benefits the students in at least two ways: 1) teaching the other students in the group how to identify the five minerals reinforces what was learned about mineral identification; and 2) being familiar with mineral identification enhances interaction among group members when they are being taught by fellow students.

Group Selection

The students are placed in groups of four. They will remain in the same groups for all of the mineral and rock identification exercises. This way, each student can get to know and trust fellow group members. The groups can be balanced according to the students' rank (freshman, sophomore, and so forth), ages, background, or level of achievement. Another way to place the students into groups is to use the luck of the draw, where each student draws a group assignment out of a box. This works well because it is entirely random, and, while the groups may not be balanced as well as they are by preselection, the students do not question why they are placed in a particular group. Furthermore, drawing for group placement eliminates any biases on the instructor's part and is a good way to separate friends in a completely neutral manner. Separating friends enables students to learn to work with different people (as they would in a job situation) and enhances overall class interaction.

Each group is assigned a number, and each member within a group is assigned a letter (A, B, C, or D). The letter establishes which five minerals each student is required to identify, and hence the letter establishes the "expert groups." For example, one student from each group will be assigned the letter A. Each student with the letter A will identify the minerals numbered from one to five. If there are five groups, then there will be five students comprising expert group A.

Mineral Identification

In the past it seemed that spending two lab periods on mineral identification with an overview of physical properties at the beginning of the first lab period left students overwhelmed. Elaborate explanations with extensive demonstrations of what physical properties are and how they are used to identify minerals were not very productive since the students did not have enough time to assimilate the information. They usually began to understand toward the end of the first lab period, only to lose it over the week between the first and second lab periods.

Rather than spending two lab periods on mineral identification with physical properties thrown in, it made more sense to break these topics into two separate periods. The first lab is spent entirely on physical properties. Students learn what the physical properties are and how to test for them through hands-on exercises. Several stations are arranged with sets of unknown minerals selected to highlight the different physical properties. The students do scratch tests to determine relative hardness, count cleavage directions and measure cleavage angles, distinguish between cleavage surfaces and crystal faces, determine mineral color, streak color, and luster, and qualitatively rank minerals based on specific gravity. The students leave the first lab knowing how to determine basic physical properties, and, when they return for the next lab, they are ready to use those physical properties for mineral identification.

The minerals are numbered from 1 to 20, and, although each set has the same 20 minerals, the samples vary from set to set. Each group is given one set of minerals to identify. Students in group "A" identify samples 1 through 5, group "B" identifies samples 6 through 10, group "C" 11 through 15, and group "D" 16 through 20. Each student begins by working independently to identify his/hers five minerals.

Once the students have identified the five minerals, they meet in their "expert groups." Each student brings his/hers five specimens to the meeting so the "expert group" can compare and discuss the results of their identification, work out any discrepancies, and see the variations among samples of the same mineral. When the students agree on the identification of all five minerals, they create a master list for the instructor to check. Once the students in the "expert groups" have correctly identified all five minerals, they remain in the "expert groups" to make additional observations that they can point out when teaching others how to identify their minerals. The "experts" then return to their original groups where each teaches the other group members how to identify his/hers five minerals until all 20 minerals have been covered. By the end of the exercise each student will have learned to identify all twenty minerals and will have become an expert on five of those minerals. When the students have finished teaching all 20 minerals, a good way to reinforce what they have just learned is to have each group place all of the minerals together in one pile and come up with their own ways to distinguish among minerals that look alike.
A Cooperative Approach to Teaching Mineral Identification

Instructor's Role

Before the students are turned loose to identify their five minerals, each student is given a piece of the same unlabeled sample (for example, fluorite). Since they are all already familiar with the physical properties, the instructor systematically leads the students through the physical properties to illustrate how to identify a mineral.

Once the students begin working on the exercise, the instructor acts as a mediator and intervenes only when necessary. The instructor observes the students while they work and is available to answer questions. When the students are in their "expert groups" and have compared their results and have created a master list of the five minerals, the instructor checks the master list, answers questions, and points out key observations that will enhance the students' expertise.

When the students return to their original groups to teach the other members how to identify the five minerals, the instructor makes sure that the students do not simply describe the physical properties of their minerals, but that they show the physical properties to the other group members. Upon completion of the work, the instructor can close with clarifications or remarks that are pertinent to the exercise and praise for a job well done.

Troubleshooting

The number of students in a class and the amount of time for the exercise are two important considerations. Ideally, the number of students in the class will enable each group to have four members, but unfortunately this is not always the case. For incomplete groups, rather than having two or three students do the work of four, each student identifies his five minerals and meets in the appropriate "expert group." When the time comes for the students to teach each other how to identify the minerals, the students in the incomplete group can join a complete group so that the "expert" from the complete group can teach them how to identify the remaining minerals.

The lab periods at Eastern New Mexico University are limited to slightly less than two hours, so a definite time interval needs to be set for each phase of the exercise. A sample schedule for a two-hour lab would be to allow 10 minutes to explain how to identify minerals, 30 minutes for initial identification of the five minerals, 20 minutes for the "expert groups" to come up with a correct list of mineral names and ask questions, 30 minutes for the students to teach their minerals, and 20 to 30 minutes for the students to distinguish among similar minerals and for the instructor to conclude the lab.

Regardless of how much time is allowed for initial mineral identification (before meeting in the "expert groups"), there will always be those who finish early and those who do not finish within the allotted time. Since there is usually only one instructor available to help 20 to 25 students, enlist the students who finish early to help other students. At this point all students are familiar with the physical properties, so they can help each other identify any of the 20 minerals. Not only does this prevent the students who finish early from becoming bored, they benefit from more practice while the other students benefit from the help.

There are often a few students who are not finished when the allotted time for the initial mineral identification is used up. These students can still meet in the "expert groups" where they can obtain help from other students who did finish identifying the same five minerals. This enables the instructor to use time more efficiently.

Results

I have used this procedure for five semesters now and the results have been astounding. The lab has become a positive learning environment, which has fostered participation, motivation, and enthusiasm. As a direct result grades have greatly improved.

In addition, the students interact more with each other. When students have trouble identifying a mineral or rock, they usually either ask someone else in the same group for help, even though that person is not identifying the same mineral or rock, or they ask someone in another group who is identifying the same mineral or rock. The students truly work together. This cooperation has created an open and enjoyable classroom environment where the students interact with each other as an entire class.

References Cited


Acknowledgments

I thank Becky Lowe and James Constantopoulos for our discussions on innovative teaching methods. I also thank the members of the Geology faculty at Eastern New Mexico University for allowing me the freedom to try my nontraditional ideas in the classroom and W. Patrick Seward for reviewing this article. Finally, I thank the students for their participation, which is what has made this idea a success.

About the Author

Terri Constantopoulos received a BS degree in geology from California State University, Northridge, a BS degree in secondary education with a major in physical sciences from the University of Idaho, and is currently working on an MS degree in chemistry at Eastern New Mexico University. She is instructor of geology in the Department of Physical Sciences at Eastern New Mexico University, where she coordinates and teaches all introductory geology laboratory courses, including physical, environmental, and historical geology.