

Specific Strategies for Using the "Jigsaw" Technique for Working in Groups in Non-Lecture-Based Courses

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ABSTRACT

The "jigsaw" technique is a versatile strategy that can be used in many different ways to increase the involvement of students in their own learning and to create an effective learning environment in a course that de-emphasizes lecture. Teams of students are assigned to investigate different aspects of the same problem or issue. Each team might, for example, analyze a different but related data set or read an article on different aspects or viewpoints on the same topic. Once each team member thoroughly understands his/her team's aspect of the problem, new groups are formed, with at least one representative from each original team. Each individual then explains her/his team's aspect of the problem to the new group. In this way, every student learns every aspect of the problem. Each group then uses the combined information to evaluate a summary issue. The technique works most successfully if 1) there are different but overlapping assignments for different teams, 2) individual students prepare before teams meet, 3) individual summary assignments are based on group work, 4) there is variation in what students do during class time, 5) there are penalties for absences from class, and 6) the instructor makes clear the goals and advantages of this type of class structure.

Keywords: Geology – teaching and curriculum; education – undergraduate; education – general; education – geoscience.

Introduction

Many of us have been impressed at one time or another over the last several years by compelling articles or talks at professional meetings that make it quite plain that lecturing is a comparatively ineffective means of fostering student learning. This is particularly true if we are concerned about long-term retention, critical-thinking skills, problem-solving, and ability to ask questions in the discipline. Translating belief into action and moving past the pep talks can be difficult, however. Many faculty members are convinced of the need for more effective learning environments in classrooms but are stymied by a lack of experience. What works best? What doesn't work at all? The need exists for clear descriptions of strategies that do work, both to encourage faculty members to move away from lectures and to minimize time-consuming reinvention of the wheel.

This article will outline specific steps for employing a specific strategy (the "jigsaw" technique) for working with groups in class. Although this technique was originally described in the literature by Aronson and others (1978), many faculty members (including the author) have independently stumbled on and refined the same general technique. In addition to outlining the strategy, this article will underline the critical ingredients needed to make the technique successful and will provide several specific examples for using the strategy in various types of courses.

General Strategy and Goals

In this technique, teams of students are assigned to investigate *different* aspects of the same problem/issue. Once teams have completed their assignments, members of each team then disperse among new groups and teach group members from other teams¹ about what they have learned (see Table 1). Each person makes up part of the "jigsaw puzzle," hence the nickname for the technique. This technique can be used equally well in classes involving data analysis or field work and in classes involving reading.

Repeated use of the technique gives all students 1) the opportunity to engage the material themselves (hence learning it better) instead of having material presented to them, 2) practice self-teaching, which is the most valuable of all the skills we can help them learn, 3) practice in peer teaching, which requires that they understand the material at a deeper level than students typically do when simply asked to produce on an exam, and 4) a chance to contribute meaningfully to a discussion, something that is difficult to achieve in large-group discussion.

Specific Steps

Step 1: Divide the class into teams of 3-5 people.

Step 2: Devise 3-5 different team assignments. The number of assignments depends on how many teams you want to have, because each team must receive a *different* assignment (see Table 1). Assignments may involve different reading, different data sets, samples, maps or problems, different issues for discussion, different field sites, and so on.

Step 3: With a small class, give a different assignment to each team. If there are four different assignments, there will be four teams. For a larger class, create several #1 teams, several #2 teams, and

¹I use the term "team" throughout to mean a number of students working on the *same* thing. A "group" consists of members from various teams.

Team A (aspect X): students 1,2,3
Team B (aspect Y): students 4,5,6
Team C (aspect Z): students 7,8,9
Group J: students 1,4,7
Group K: students 2,5,8
Group L: students 3,6,9

Table 1. Arrangement of students into teams studying different aspects of a problem and groups of students teaching each other.

so on. Give all the #1 teams the same assignment, and so forth.

Step 4: Unless you plan to give teams time to work during class, ask each student to prepare individually before class. I commonly give focus questions to accompany the assignment and require that students prepare written responses to those questions. As a variation, each team member could be asked to prepare a different aspect of the material. If, for example, you have assigned four thin sections to each team, each member could prepare an analysis of one thin section before class, allowing the team to spend its working time together during class comparing sections and discovering whatever you want them to discover about the group of sections. Students bring two copies of their written responses/ analyses to class, one to turn in and one to use during team sessions. If you don't do something like this, some students won't come to class prepared.

Step 5: Rather than asking students to prepare ahead of time, you can set aside time during class for students to work in teams to do the reading/analysis (this works if the reading/analysis is short and *does* guarantee that all students do the reading or analyze the data). If there are several teams of the same number (for example, four #1 teams), each team should meet separately, not as a large group.

Step 6: Give each team time in class to discuss the reading, results, issues, or whatever and to develop a strategy for teaching the material to members of other teams. It is the responsibility of each team to make sure that all of its members understand the material thoroughly and are prepared to teach it. It helps to provide guidelines for what you mean by "teach."

Step 7: Don't assume that individual teams will head in the right direction without some guidance. You need to make sure that each team is prepared to teach a mixed group and that students will make the points that you want them to make. You or an assistant needs to check in with each team at least once during the discussion session to make sure that the team has not missed the boat. Be gentle and *listen* – nudge, don't shove. As long as the team is on the right track and is prepared to address the main issue adequately, let them digress and explore. What

strikes them as significant might open your eyes to something you have missed.

Step 8: When all teams are ready, reassemble the class in mixed groups. There should be enough groups so that each member of a group has a different team number. Odd numbers may mean that a few groups have one extra member. In a class of 64 with four different assignments, for example, there might have been four team #1s, each with four people, four team #2s, each with four people, and so on. Each mixed group would have a #1, a #2, a #3, and a #4, for a total of four people. There would be 16 mixed groups in such a class.

Step 9: Each member of the group will then teach the rest of the group whatever was discussed or prepared by his/her team. The rationale, of course, is that a person only really learns something well when he/she has to teach it to someone else. Each person in the group is responsible for learning from the others in the group.

Step 10: Some type of written assignment should result from the peer teaching effort, and students should have that assignment in mind as they work in their groups. A written assignment might involve comparing work done by a student's own team with that done by a different team. Alternatively, an assignment might ask a student to take all of the information presented by each team and use it to address a new/different/summary issue.

Step 11: Evaluate students in the group setting. Sit in on a group session and evaluate each person's ability to teach the rest of the group. Fill out the evaluation form during the session so that students can have feedback immediately after class. This is a very useful tool for helping students improve, particularly if you outline clearly what your criteria are for assigning each level in your grading scale. Knowing that they could be evaluated at any time gives students a real incentive to come prepared, and a carefully done evaluation gives them guidelines on how to improve. It helps if you and several student assistants can simultaneously evaluate several groups in order to evaluate as many students as possible during a single session, but you can evaluate one group at each session by yourself. In a larger class, you simply won't evaluate any individual as often. If you can work out a way to evaluate everyone at every session early in the course, however, you will see faster progress in students' abilities to teach one another.

Step 12: Ask each group to have a general concluding discussion and to make a list of important points. You can also periodically evaluate these kinds of group discussions to make sure that all people are contributing. Consider using the following "pass-pad" technique for making lists during group discussions. Start the pad at one point in the group circle. When

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someone makes a point, the person with the pad writes down that point, confirming with the speaker that the point is accurately recorded. The pad then moves to the next person, who records the next main point. The advantages are two-fold. First, a single group recorder typically does nothing but record, contributing little to the discussion. To make matters worse, the same people commonly wind up being recorder over and over again (unless, of course, you have developed specific rules preventing that). Second, passing the pad encourages a round-table style discussion and makes it a little harder for one individual to dominate. At the very least, the dominant person will get the pad at some point and will be forced to shut up and listen.

Step 13: Bring everyone back together toward the end of the class, and ask each group for its most important point. Make a list of main points on the board, going around a second time to each group if people still have points to make. Use the time to elaborate (a little! don't turn it into a lecture!) or to emphasize important issues. This way, you can be sure that you drive home the most important points. This also serves to confirm for the students that they have done a good job in recognizing the important points. If you have student assistants, ask them for additional points. This is a way to give your student assistants credibility and also to have a "plant" in the audience in case (and it *does* happen) one of your favorite points is not raised by one of the groups. As an aside, I keep careful track of those points, because, for one reason or another, students have missed them and will need different reading, direction, or something the next time in order to catch the point, if it is indeed as important as I had originally thought.

Critical Ingredients

Different, but overlapping, assignments for different teams: The jigsaw technique revolves around discussions by small groups of students who have prepared different team assignments. The rationale for this is simple. When all students in a group prepare the same assignment, one of two things typically happens. On the one hand, group discussion can degenerate into an explanation session for those who did not understand the assignment by the ones who did. After several such sessions, well-prepared students typically begin to resent having to come to class to bail out the underprepared. On the other hand, if everyone is well-prepared, discussion can be desultory, particularly if everyone is simply asked to "discuss the article." The advantage of a different team assignment for each member of a discussion group is that each member of the group must learn something from every other member. In addition, students are exposed to more aspects of the assignment than they could successfully prepare for on their own.

The best team assignments are overlapping ones. If no common elements exist among the team assignments, group discussion degenerates into a series of mini-lectures given by unskilled lecturers. If, on the other hand, assignments overlap in some way, each person can be engaged in comparison and extension of his/her assignment.

Individual written preparation, due before teams and groups meet: The jigsaw technique will not work if students do not come to class prepared. Inducing students to come prepared, however, is a notoriously difficult business that is compounded by the fact that most students do not know what "coming prepared" really means, particularly when the assignment involves reading. Far too many students believe that reading from the first to the last word of an assignment is adequate preparation for a discussion. What most students don't realize is that, in order to be adequately prepared to explain the assignment to someone else, they must process the information in one way or another. Having students prepare individual written responses to carefully selected questions based on their team assignments forces students to think in ways that will prepare them adequately for discussion. Collecting and grading the written preparation serves as an incentive.

Individual summary assignment based on group work: Student oral presentations are a common component of many courses, particularly at upper levels. Oral presentations during an ordinary class typically suffer from two things. First, students giving oral presentations are prone to focusing on the mechanics of presentation and agonizing over whether they will forget what to say, whether they will become confused and embarrass themselves, and so on. Student presenters typically do *not* focus on whether they are actually *teaching* anyone anything. Second, students in the audience do not perceive the student giving the oral presentation as having much authority, and the audience commonly tunes out during a presentation, each student worrying more about how he/she will do when it is his/her turn.

In the strategies outlined in this paper, asking students to prepare a written summary assignment based on what they have learned in the group does several things to circumvent the pitfalls of standard student oral presentations. First, an upcoming written assignment places the focus on *learning* during group discussion, rather than on presentation. In the group work described in this article, the point is *teaching*, and success is measured by how well a student helps others learn what he/she knows. Second, the prospect of a written assignment forces students to pay attention to other students. A student cannot be disengaged while another student is talking if he/she knows a written assignment depends on the information. Third, the prospect of the written assignment puts the responsibility of learning on

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each student. If a member of the group is muddling along and not teaching clearly, it is up to the other members of the group to prod and question until they have learned enough to do the written assignment.

An individual summary assignment has other values as well. First, such an assignment forces a student to *process* the information learned in the group so that he/she really learns the material. Second, an individual assignment allows the instructor to evaluate what each student has learned, something that can be difficult in a class that revolves around group work.

Varying what students do during class time:

While students will sit for endless hours, class after class listening to lecture, students fairly rapidly tire of the same innovative technique used day after day in a course. If you develop a non-lecture-based style of teaching, you will have better success if you use a variety of techniques, such as the jigsaw technique, debates, role-playing exercises, poster presentations, group discussion without jigsaw, the occasional summary lecture or mini-lecture, and so on.

Class attendance: The aims of in-class group work cannot be met if students do not come to class and participate. Different schools have different cultures when it comes to class attendance. If students at your school tend to be casual about class attendance, you will probably need to establish some kind of incentive to make sure that students come to class. Students also need to understand that a stiff attendance policy is not merely a whim but arises from the fact that in-class learning is vital in a non-lecture-based course.

Being up front with students about the reasons for the course structure: Many students have developed highly successful strategies for dealing with a standard course that revolves around lectures and exams, and they react negatively to course structures with which they are not familiar. Few students have any idea about how people learn, nor have they considered the fact that a lecture setting is not an ideal learning environment. From the first class meeting, students must be told not only what the course structure will be but, more importantly, *why* the course is not lecture-based. They must see that you are convinced that they will learn more, retain more, and develop better life-long learning skills than they would if you lectured to them. The harder you work at getting students to buy into your scheme, the less trouble you will have with resistant and unhappy students.

Examples

I have successfully used the strategies outlined in this article for several years with students in an introductory geology course (30 students), in an upper level elective course in planetary geology (18-24

students), and in a required course in structural geology (18-24 students). In the following section of this paper, I will briefly outline several specific examples drawn from these courses.

Example of short-term team assignments to study a series of readings: After students learn several techniques for measuring strain in real rocks in structural geology, I assign a different research article from the published literature to each of four teams. Before class, each student reads his/her article and prepares written answers to a set of questions, which I collect in class. I meet briefly with each team to make sure that no important points have been missed. In mixed groups, each person teaches the rest of the group about his/her article, and the group

has a discussion on which articles show the best examples of 1) establishing volume loss during deformation, 2) establishing whether deformation involved pure shear, simple shear, or compound strain,

3) establishing the orientation of foliation with respect to the principal directions of the strain ellipsoid, and 4) establishing what variables appear to govern foliation development in rocks. Each person is responsible for learning enough from the other group members to write an individual summary explaining two examples for each of the four points.

Example of short-term team assignments to study two different viewpoints on the same topic: In the section on mineral resources in an introductory course on the Geology and Development of Modern Africa, students investigate prehistoric mining and smelting of iron in Africa. Half the class reads an article outlining the metallurgical aspects of ancient iron smelting, concentrating on the chemistry of smelting and the function of the furnace. The other half of the class reads an article outlining the anthropological aspects, concentrating on the ritualistic and mystical side of ancient iron smelting. Each person prepares answers to written questions, which are collected in class. During class, students pair up and describe their respective sides of the iron smelting story. Each pair of students then sorts out which aspects of the smelting ritual have a basis in scientific fact and which appear to be ritual not actually contributing to the success of the smelting process. Each person writes an individual summary of the comparison, which is due the following class.

Example of short-term team assignments to analyze several data sets: In the section on the Sahara and Sahel in an introductory course on the Geology and Development of Modern Africa, students investigate the evolution of climate in the Sahara over the last 10,000 years. I divide the class into four sets of teams, each of which receives a stratigraphic column, radiocarbon dates, pollen data, and information on fossils from one of four paleolakes scattered across what is now the Sahara. During class, each team must use the geologic data to establish the

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nature of the climate and vegetation at its site in the Sahara at various times between 10,000 and 3,000 ybp and to develop a picture of the evolution of climate over time. During a second class, members of mixed groups share the results of their paleoclimate analysis, emphasizing the evidence for their conclusions. Each group then compares the paleoclimate records for the four paleolake sites and decides what the data suggest about climate evolution in the Sahara as a whole and changes in the position of the Sahara/Sahel boundary over time. A whole-class discussion follows, with each group arguing its main points. Each individual then writes a summary analysis that is due at the start of the next class meeting.

Example of long-term team assignments for investigating several aspects of a topic: For six weeks of a semester-long course in planetary geology, I use a variation of the jigsaw approach to cover the records of volcanism, impact cratering, and tectonism on the Moon, Mars, and Venus.

I begin by dividing the class into two Moon teams (A and B), two Mars teams (A and B), and two Venus teams (A and B). At the beginning of week one, I give a short background lecture on the topic, for example, plains volcanism. Before our two-hour Wednesday class, the A teams each prepare oral team presentations on plains volcanism on their respective planets, while the B teams each prepare a written outline for the same topic for their respective planets. At the Wednesday session, each A team gives its oral presentation, while each B team is responsible both for raising points that they believe the A team has missed and for summarizing the important points at the end of the A team presentation. The audience is responsible for learning enough about the topic on each of the planets that each team can write a report comparing the topic on each of the planets. Team comparative reports are due the following Monday. During week two, the roles of the A and B teams are reversed.

Conclusion

The biggest joy in using this technique comes from standing back and listening to students "talking geology" with one another in a fluent, knowledgeable way. They argue with conviction, and I have even

had students get up and use the board or the overhead projector in order to convince the rest of the class they are right. Students argue fluently in writing as well, and they turn in work with deeper levels of understanding than I have ever received in short answers or essays on exams. Students also work very hard in courses designed in this fashion – no one can come to class and tune out, nor can students float along doing little, occasionally cramming for exams.

While I personally love to lecture, I have become convinced by experience that lecture will form only a very small part of the courses I will teach for the remainder of my career. After all, a great lecture doesn't mean much if the students aren't really learning.

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Food for Thought

Whether it arose by chance cannot be known, but like a paranoid ethos, ethnocentrism is probably rooted in quite basic, if not necessarily adaptive, attributes of the human mind – fear and mistrust of strangers. From our postnuclear perspective, we can readily see the need to eradicate ethnocentrism if the world is to survive, but as events the world over so dramatically demonstrate, ethnocentrism is as widespread and virulent today as at any time in history.

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