Teaching Strategies

For Instructors

Taiebeh Hosseinali, Ph.D.

Lincoln Land Community college

Below, you will find brief descriptions of teaching strategies that promote active engagement and participation of students in the classroom, plus some sample assignments and activities for using each strategy successfully. Please feel free to check the resources for more complete information on each strategy.

The Jigsaw Technique

Have you struggled with group work in class? The jigsaw technique can be a useful, well-structured template for carrying out effective in-class group work. The class is divided into several teams, with each team preparing separate but related assignments. When all team members are prepared, the class is re-divided into mixed groups, with one member from each team in each group. Each person in the group teaches the rest of the group what he/she knows, and the group then tackles an assignment together that pulls all of the pieces together to form the full picture (hence the name "jigsaw").

Why use jigsaws?

The jigsaw is an effective way of engaging students both with course material and with each other. The peer teaching aspect requires that each student understands the material well enough to teach it to others (individual accountability), and each student is required to contribute meaningfully to a group problem-solving component (group goals). Research on this and other cooperative learning techniques shows significant benefits for students not only in terms of level of learning but also in terms of positive social and attitudinal gains.

How to use jigsaws

Designing an effective jigsaw requires different, but overlapping, team assignments and a meaningful group task, plus attention both to how students will prepare effectively for peer teaching and how the instructor will evaluate what individual students have learned.

Examples of jigsaws

The jigsaw is a hugely versatile structure that can be used in class, in the field, or in lab. Team assignments can be based on samples, data sets, field exposures, graphs, equations, maps, photographs, articles from the literature, and more.

Hallmarks of a good jigsaw topic

- **A good topic has team assignments that are related.** If team assignments are not related, the peer teaching component becomes nothing more than a series of unrelated mini-presentations.

- **A good topic has team assignments that students can complete successfully.** This sounds silly, but it isn't. A team assignment that only some students will "get" without significant help is not a good one for jigsaw, because it will be difficult for students to be well-prepared for peer teaching. This doesn't mean that the assignment has to be trivial or easy. It might, in fact, involve significant work and thought. But you have do be confident that most students will "get it", or you should pick a different topic.
- **A good topic for a jigsaw is one that doesn't required students to know each team assignment equally well.** In a jigsaw, individuals know their own assignments better than any of the ones presented by their peers. This is true partly because students must know their own assignments well enough to explain them and partly because their peers are typically not skilled presenters. This is an unavoidable aspect of the jigsaw technique. If you are considering a topic, and you realize that each student must know all aspects of the topic equally well, choose a teaching strategy other than jigsaw.

An effective group task is crucial for a jigsaw

- **Include a group task that follows the peer teaching.** Without a group task that requires analysis and synthesis to put the whole picture together, the activity is simply not a jigsaw. More importantly, though, without the requirement to be intellectually engaged in solving a group problem, students have little incentive to learn anything from one another during the peer teaching session. And solving a problem as a group is more intellectually engaging than just having to learn what the other group members know.
- **Design the group task to go beyond simply summarizing the team assignments or having each person learn all the team assignments.** A group task that merely summarizes the individual presentations is akin to describing each individual piece in a puzzle without putting the pieces together into a picture. A group task that involves analysis or synthesis using components from all of the teams provides the kind of group goal that promotes learning.

Students must be well prepared for the peer teaching component

- **Formalize the preparation.** Making a vague assignment to "prepare to teach someone about this topic" is rarely adequate. Requiring students to prepare something in writing, even if the team preparation happens in class, can be very helpful both for them and for you. This might include answering a set of guiding questions, writing down observations and interpretations, annotating graphs or figures, and so on.

- **Make sure that students are actually prepared.** You must make certain that what students will teach is not wrong-headed. If students are preparing something in writing during their team time (see above), you can circulate and read what they have written as they are working. You can also stop at each team and ask students to summarize their thoughts. After you've done a particular jigsaw more than once, you will discover the places where students will likely go astray, and you can home in on those aspects. Collecting and grading written preparation and having the peer teaching/group task portion during a subsequent class is also a possibility, although the immediacy of engaging the topic is lost.
- **Give students guidance in how to prepare for peer teaching.** Students commonly do not prepare for teaching the way a faculty member does. When asked to teach others about the team's topic, students are very likely to read off the answers to the guiding questions you have asked ("the answer to question one is....."). Students have little practice in stepping away from a topic and asking what the big take-home messages are and how they might frame their teaching around those ideas. Having each team member fill out a simple question sheet (***below***) can reap big dividends during peer teaching. For a jigsaw where students prepare outside of class, having students fill out the teaching prep sheets in teams at the start of class allows teams to talk about how to teach the topic well, gives team members a chance to clear up difficulties, and gives you some time to circulate and check on individual preparation before dividing the class into mixed groups.

Name Team # & topic _____

Getting ready to teach your team assignment
Step back and think about what you have learned as a team.

1. **What are the *most important messages* that you want to convey about your team assignment?** Write 3-4 sentences below that summarize what you think is important. Be sure to organize the ideas in a logical sequence.

2. **What is the evidence supporting your statements above?** Make a bulleted list for each statement above that contains what you need to include (observations, data, etc.) in your explanation to someone else in order to elaborate on your summary statements and to provide ***evidence*** that what you are saying is reasonable.

Students learn more if they are held individually accountable

- **Incorporate a mechanism for individual follow-up.** It's harder for students to "skate" in a jigsaw than in many other types of group activities, because students are individually responsible for peer teaching. Students will be more actively engaged in the group task, however, and will learn more as a result, if they know that they will have to do individual follow-ups based on the group task. Follow-ups might range from simple bulleted lists to incorporation of the results of the group task into a major semester synthesis assignment.
- **Remember that students will know their own team assignments the best.** Take this into account by designing follow-ups that do not require students to know all of the team assignments equally well.
- **Consider rewarding the group for the quality of individual performance.** Some research work (Slavin, 1996) suggests that rewarding the group when all members perform well on individual follow-up tasks/assignments improves the overall achievement of individuals in a jigsaw setting. Even though students receive individual grades on their follow-up synthesis assignments, choosing a mechanism to also reward the group (*e.g.*, via bonus points) can have benefits in terms of overall learning.

The Gallery Walk

The gallery walk is a cooperative learning strategy in which the instructor devises several questions/problems and posts each question/problem at a different table or at a different place on the walls (hence the name "gallery"). Students form as many groups as there are questions, and each group moves from question to question (hence the name "walk"). After writing the group's response to the first question, the group rotates to the next position, adding to what is already there. At the last question, it is the group's responsibility to summarize and report to the class.

What is Gallery Walk? --a discussion technique for active engagement

Gallery Walk gets students out of their chairs and actively involves them in synthesizing important concepts, in consensus building, in writing, and in public speaking. In Gallery Walk teams rotate around the classroom, composing answers to questions as well as reflecting upon the answers given by other groups. Questions are posted on charts or just pieces of paper located in different parts of the classroom. Each chart or "station" has its own question that relates to an

important class concept. The technique closes with a oral presentation or "report out" in which each group synthesizes comments to a particular question.

Why use Gallery Walk? --promotes higher order thinking, oral/written presentation skills, and team building

Gallery Walk is flexible and has many benefits. Gallery Walk can be organized for a simple fifteen minute ice breaker or for a week long project involving graded oral and written reports. The technique encourages students to speak and write the language of earth science rather than just hearing it from the instructor. In addition to addressing a variety of cognitive skills involving analysis, evaluation, and synthesis, Gallery Walk has the additional advantage of promoting cooperation, listening skills, and team building.

How to use Gallery Walk? --student teams rotate between posted charts

In Gallery Walk student teams rotate to provide bulleted answers to questions posted on charts arranged around the classroom. After three to five minutes at a chart or "station" the team rotates to the next question. Gallery Walk works best with open ended questions, that is, when a problem, concept, issue, or debate can be analyzed from several different perspectives. In this section find a variety of instructional resources such as preparing students for this technique, a step by step guide for using Gallery Walk, evaluation rubrics, and challenges in implementing the technique.

Gallery Walk examples --a variety of sample questions for a variety of earth science topics

Find examples of Gallery Walk questions for the following categories: Atmosphere, Biosphere, Climate System, Earth History and Time, Earth Surface, Energy and Cycles, Human Dimensions, Hydrosphere and Cryosphere, Oceans, Solar System, Solid Earth. Complete sample exercises are also included for a Gallery Walk involving weather map analysis and soil morphology.

Effective Discussion

Discussion is an excellent way to engage students in thinking and analyzing or in defending one side of an issue, rather than listening to lecture. Students must also respond to one another, rather than interacting intellectually only with the instructor. Good discussion can be difficult to generate, however.

Techniques

There is no one recipe for successful discussion in class. Here are a number of suggestions:

- Be sure that it is clear in your mind why you are having the discussion and what you hope students will gain from the discussion.
- Select a discussable topic. Constructing a discussion by asking students to “discuss the reading” or “discuss the answers to the homework” is difficult.
- A topic with a number of possible sides or answers makes a good discussable topic. Choosing a topic that is relevant to students increases the likelihood that students will actively participate in the discussion.
- If an issue has two “sides”, consider assigning half the class to one side and half to the other side of the issue. Have each defend his/her side in the discussion.
- If you have students prepare for the discussion outside of class, consider using the preparation as a springboard for discussing a related or extended topic during class, rather than having students simply discuss their preparation. You might, for example, ask students to apply what they have learned to analyze a new topic or a new aspect of the topic during discussion in class. Or you might ask students to read two articles in preparation and ask students to compare the articles during discussion in class. While each student will have done the same reading, each will be asked to go beyond the homework assignment during class discussion. Discussion then advances past mere recitation of a prepared assignment.

Benefits

The primary benefit is intelligent discussion by students during a class in which students are engaged in thinking and analyzing or in defending a side, rather than in listening to lecture. Students must also respond to one another, rather than interacting intellectually only with the instructor.

Drawbacks

This technique has several potential drawbacks:

- The primary drawback is that the technique can consume more time than lecture would for a comparable amount of material to be delivered. In discussion, though, students actively engage the material.

- Some students tend to dominate discussions. Some students come poorly prepared, no matter what the incentive.

- Discussion can go astray from the intended topic. This does not necessarily mean disaster, if the discussion leader can either steer the discussion back on track or profit from the digression.

- Assessing student learning associated with a discussion is potentially difficult. Ways of dealing with this include 1) giving students a grade for the discussion based on quality of comments, 2) asking questions about the topics on an exam, 3) giving a follow-up written assignment, and 4) grading the written preparation for the discussion.

Critical aspects for success

- Students must be prepared for the discussion. If they are not prepared, discussion will not work. One solution is to select a topic for which students do not need to make preparation in advance. Another solution is to have students prepare individual written responses to carefully selected questions in advance (a work sheet or a list of questions), which forces students to think in ways that will prepare them adequately for discussion. Collecting and grading the written preparation is an option that serves as a stick. Giving a short quiz before discussion starts is effective but is less in keeping with the spirit of discussion and the notion of making students more responsible for their own learning.
- Structure the room so that students talk to one another, rather than to the professor, during the discussion. Avoid standing at the front of the room. Instead, sit to one side, where you will be less likely to serve as a magnet for student eyes and attention or to be tempted to interfere as “the authority”.
- Come to a mutual agreement with the class about what the mechanics will be for the discussion (*e.g.*, who talks when, etiquette about disagreeing, and so forth). Many instructors find it useful to have students develop these rules for discussion. Requiring students to make reference to a previous student comment can help keep a discussion from becoming scattered.
- Avoid the temptation of butting in to the discussion unless the class is completely stymied. If you bite your tongue and hold out for a bit, one or more students are likely to offer a reasonable answer.
- Many students may still be reticent to participate in a class discussion, even when they are prepared. Adding a session of think-pair-share (described under

interactive lecture) before the whole-class discussion can help solve the problem by first involving all students in small-group discussion, thus giving students the support of a partner or a group when it is time for whole-class discussion.
- Above all, do not be arrogant or insensitive to wrong-headed comments during the discussion. Students will clam up if humiliated.

When this works the best

This technique works best is classes smaller than 30-35. In larger classes, students can more easily disengage and hide during an all-class discussion. Small-group discussion followed by by whole-class discussion can be effective for conducting discussions in larger classes.

Short example

Paper or plastic? In a large introductory geology class, the instructor asks students whether they ask for paper bags or plastic bags at the grocery store and why. As students give their responses, the instructor records the reasons in either the paper or the plastic column on an overhead transparency. Once the class is satisfied with the list, the instructor conducts a discussion about whether paper or plastic is actually more environmentally "friendly". This topic requires no preparation on the part of students and allows the instructor to have the class address the complex issue of environmental impact *(Kenneth Verosub, U.C., Davis)*.

Concept Sketches

Concept sketches (different from concept *maps*) are sketches or diagrams that are concisely annotated with short statements that describe the processes, concepts, and interrelationships shown in the sketch. Having students generate their own concept sketches is a powerful way for students to process concepts and convey them to others. Concept sketches can be used as preparation for class, as an in-class activity, in the field or lab, or as an assessment tool.

What is a concept sketch?

- A concept sketch is a simplified sketch illustrating the main aspects of a concept or system, annotated with concise but complete labels that (1) identify the features, (2) depict the processes that are occurring, and (3) characterize the relationships among features and processes.
- A concept sketch is more than a labeled diagram. We have attached several examples of concept sketches – a brief study of these diagrams will show how significantly they differ from the standard diagrams that appear in textbooks or

that we, as instructors, commonly draw on the board in class.

- In concept sketches, concept captions are connected to particular parts of the sketch with what are called *leaders*, which are short straight or curved line segments. Many people are tempted to connect concept captions to the sketch with arrows, but research has shown that people associate arrows with movement. Arrows should be reserved for places in the concept sketch where movement occurs (*e.g.*, plate motion, groundwater flow direction, river flow, etc.).

Using concept sketches in class

- In-class use of concept sketches is most successful in terms of student learning if students are actively involved at least in construction of the concept captions, if not the sketch as well.
    - Presenting students with a completed concept sketch doesn't provide much of a learning opportunity for students.
    - Having students simply copy down concept captions as the instructor lectures and fills in the blanks isn't much better.

- In-class development of concept sketches can be done successfully in a number of ways:
    - Provide a read-made sketch as a handout or drawn in class on the board. Providing a sketch saves time, can be useful early in the semester to model how to create a sketch, and can be particularly valuable for complex diagrams or abstract concepts.

    - Have students do the sketch during class. This is more time-consuming but allows students to make decisions about what to draw, which forces them to think more deeply about the concepts.
        - Providing "prompts" before students sketch is critical. Prompting materials might be photos, textbook-style illustrations, computer animations, video clips, in-class demonstrations, hand samples, or maps.
        - Before students sketch, ask students to:
            1. list what they think are the key features and processes, versus those things that they observed but that are not essential,
            2. decide how various aspects are related,
            3. brainstorm how to depict the system, and
            4. draw and annotate the sketch.
        - Use the sketching process as an opportunity for students to discuss their ideas with others in the class. Have them compare lists in step 1, share ideas from steps 2 and 3, and compare final concept sketches from step 4.
        - Many in-class techniques can be integrated with the process of creating concept sketches:

- Have selected students put their concept sketches on the board or on an overhead for discussion, comparison, and critique.

- Use the jigsaw technique to have groups of students do different but related sketches for comparison.

- In an upper level class that is discussion-based, having pairs of students create concept sketches of critical diagrams, graphs, and tables from an article to be discussed can be a very useful way to clarify confusing points

.

- Follow up development of the concept sketch by having students use the sketch to solve a problem. For example:
  - Ask students conceptual questions that hinge on the understanding that should be portrayed in the concept sketch.
  - As students to use their concept sketch to make a prediction.
  - Ask students to think about how the system might fail or function abnormally, what the consequences would be, and how it might be “fixed”.
  - Ask students to think what might happen if aspects of the system were changed.

Using concept sketches on homework assignments

- Having students prepare for class by doing a reading assignment is commonly not very successful. Students read from the first word to the last word but don’t internalize much. Asking students to provide written answers to questions helps, but many students are prone to writing down strings of words that they don’t really understand.
  - Concept sketches can be a very useful way to have students prepare for a class session. Once a student has done a reading assignment, successfully completing a concept sketch requires a deeper level of understanding of the reading.
  - For courses in which students read in the literature, concept caption annotation of selected figures in an assigned article can really force students to address whether they truly understand what they’ve read.

Using concept sketches in the field

- Using concept sketches on field trips is a terrific alternative or supplement to

traditional field notes. In the field, many students take field notes and dutifully draw sketches, but many students think of notes as a place to write rock descriptions and record orientations of structures and sketches simply as a record of what they saw. Having digital cameras in the field emphasizes the perception that a sketch or a photo is a record.

- Asking students to make concept sketches in the field forces them to address the question of what *processes* they see evidence for in the outcrop, what interpretations they can make about development of features, and what evidence supports their interpretations.
- Making concept sketches in the field forces students to observe more carefully and make decisions about what is and what isn't important to record in a sketch.
- Students leave the outcrop having committed to a level of understanding of process and outcome that typically doesn't appear in the written notes that a student takes in the field.

Using Case Studies

Case studies have been used successfully for many years in business school and in medical school for actively engaging students in problem-solving relevant to the discipline. The primary hallmark of a case study is presentation of students with a problem to solve that revolves around a story (the "case"). In medical school case studies, the "story" typically involves a sick patient. In science case studies, "stories" can range from public policy issues to science research questions. Good case studies give the students considerable latitude in deciding how to solve the problem, rather than leading them through the problem by the nose, and provide excellent opportunities to engage students in the classroom.

Cases serve as springboards to student-designed investigations.

Students structure their own learning using the "story" of the case as a problem space. Although the case defines the general area of geoscience under investigation, students generate questions based both on their interests and prior knowledge that relates to the topic of study. Investigative cases are useful for lifelong learning because they are open-ended and draw from a broad range of situations in which scientific reasoning can be applied. Investigative cases necessarily shift the focus of student learning beyond the facts to include using scientific knowledge to frame questions and to answer them.

Cases engage students and faculty in collaborative problem posing, problem solving, and persuasion.

Instructors as well as students are collaborators in this process. As students pose problems, try to solve them, and present conclusions that represent their own findings to others, both the instructor and other students may serve as resources. This collaboration aids learners in defining potential strengths and weaknesses in the design of the problem statement and the investigation. The resolution (or clarification) of the problem and its presentation to other students as well as to the instructor extends opportunities for student practice in utilizing and evaluating scientific approaches to problem solving.

Debates

Debates can be a very useful strategy for engaging students in their own learning. Debates force students to deal with complexity and "gray areas", and they are rich in imbedded content. Debates can also help provide relevancy of course material to everyday issues, which can improve student learning. Debates also improve student's oral communication skills.

Why do debates in a class?

- They force students to deal with complexity and “gray areas”
- They improve student’s oral communication skills
- They are rich in imbedded content
- They can help provide relevancy of course material to everyday issues

Debate Design Issues:

- The choice of debate topics is THE key factor. Design questions that are not too broad.
- Spend time discussing the format of debates: how you “win,” how to use the rebuttal period, the importance of a strong closing statement, etc.
- Be sure to include one or two assignments in advance of the debate itself, for example, an annotated bibliography. Students may not realize that they need to know what their opponent will also be saying, so they need to also familiarize themselves with this material.
- A debate team should be no larger than 2 people (per side)
- You may wish to talk with a colleague who works with your campus debate team for more hints on how to conduct a successful debate

Sample Debates

Evolution Debate

Pollsters say that more than half of the American public does not believe in evolution, yet it is arguably – along with quantum theory – one of THE most important scientific theories of all time. Why is the theory of evolution so misunderstood? We will try and understand this by studying some of the key questions that arise in the evolution debate.

We will conduct a debate on the subject of evolution in order to accomplish several goals. At the end of this assignment you will be able to: (1) synthesize the principles of evolution, (2) evaluate what specific parts of evolutionary theory are misunderstood by the public, (3) evaluate what the various creationist theories say, and (4) speak in public, specifically, present and defend a position.

We will conduct the debate by dividing into two groups. Within each group will be the following representatives: (1) a scientist; (2) a “young earth” creationist; (3) an “Ideal Design” creationist. You will have to research and understand the perspective of the individual you represent for each of the questions we will debate. In a debate you do not have to personally believe the perspective you are advocating, what is important is your ability to convincingly present and argue the perspective you represent, and critique your opponents.

Just-in-Time Teaching

Just-in-Time Teaching (JiTT) was developed as a way of engaging students in course material before class and preparing them to come to class and participate actively during class. Clicking "more information" below will take you to a discussion, at the Starting Point site, of using Just-in-Time teaching.

What is Just-in-Time Teaching (JiTT)?

Just-in-Time Teaching focuses on improving student learning through the use of brief web-based questions (JiTT exercises) delivered before a class meeting. Students' responses to JiTT exercises are reviewed by the instructor a few hours before class and are used to develop classroom activities addressing learning gaps revealed in the JiTT

responses. JiTT exercises allow instructors to quickly gather information about student understanding of course concepts immediately prior to a class meeting and tailor activities to meet students' actual learning needs.

Why use Just-in-Time Teaching?

Just-in-Time Teaching improves student learning and increases in-class teaching efficiency and effectiveness. JiTT does this by incorporating research-based knowledge about effective teaching and learning practices. Specifically, JiTT:

- Improves students' preparation for class
- Enhances student motivation for learning
- Promotes ongoing formative assessment of student learning (by both instructors and students)
- Informs in-class activities that target student learning gaps

How to use Just-in-Time Teaching

A key to successful JiTT implementation is developing a set of effective questions that will be posted online for students to answer before the next class. JiTT questions are generally open-ended and require students to do something - read a textbook chapter or article, analyze a video, complete a simulation, or analyze data - related to material that will be addressed during the next class period. For each JiTT exercise, instructors post JiTT questions in a course management system and students respond online a few hours before class. After the posting deadline - but before class begins - instructors examine students' responses, group them into clusters reflecting similar thinking processes, and select a representative sample of responses to show in class. The instructor also uses the student responses to develop interactive in-class activities targeting learning gaps identified in the JiTT responses.

- JiTT - La Brea Tar Pits
  1) What is "tar" and how does it form? 2) List the animals that have been uncovered in the tar pits that you didn't know were native to North America. Why do you think these animals are now extinct? ...

- JiTT - The Big 5 Extinctions and Then Some
  1) What are the three leading ideas for the cause of the Permian mass extinction? What is the evidence for and against each? 2) Why are tropical forest species going extinct the quickest? 3) What are the ...

- JiTT - Groundwater and Archaeology
  1) What is causing the groundwater to rise to the foundations of Egypt's archaeological structures? What damage is the groundwater doing? 2) Describe at least two different solutions that have been proposed to ...

- JiTT - The Future of Africa's Health with Technology
  1) What are the benefits and opportunities handheld technology can offer the health sector in Africa? Answer the question from the viewpoint of a health care provider and a patient. Does anyone else benefit? ...

- JiTT - Water Issues and the Aswan High Dam
  1) What are some of the GOOD changes for the environment and positive impacts on the local people from construction of the Aswan High Dam? 2) What are some of the BAD changes for the environment and negative ...

- JiTT - Dam Removal - A Good Idea or Not?
  1) What are some of the biological effects of dam removal (good and bad)? 2) What are some of the more pressing/compelling reasons to remove a dam? Explain. 3) The Stanley and Doyle (2003) article states that, ...

- JiTT - The Future of Global Climate
  1) According to NASA, why is Earth's climate warming? 2) Is the Geritol solution the solution to global warming? Explain what the "Geritol solution" is, and then state your opinion as to why you ...

- JiTT - Ethics of Fossil Collecting
  1) What do you think it means for a fossil resource to be "abused"? 2) What's the issue with fossil hunting on federal land (such as National Parks)? Explain what your interpretation of the conflict ...

- JiTT - The Legs of Snakes and Whales
  1) What are the adaptations needed to move from water to land (whether it be an arthropod or a "pioneering amphibian")? 2) Could snakes be linked to marine lizards? What your view and interpretations of ...

- JiTT - Threats to Biodiversity
  1) How is climate change a threat to biodiversity? 2) What are the impacts of pesticides on animals (including insects) and humans? 3) Can human population growth really impact biodiversity? Explain your viewpoint.

Role Playing

Role-playing and simulations in class can be an excellent way to engage students. A well-constructed role-playing or simulation exercise can emphasize the real world and require students to become deeply involved in a topic. Clicking "more information" below will take you to a discussion, at the Starting Point site, of teaching with role playing.

What is Role-Playing?

In most role-playing exercises, each student takes the role of a person affected by an issue and studies the impacts of the issues on human life and/or the effects of human activities on the world around us from the perspective of that person. More rarely, students take on the roles of some phenomena, such as part of an ecosystem, to demonstrate the lesson in an interesting and immediate manner.

Why Use Role-Playing?

Role-playing is simultaneously interesting and useful to students because it emphasizes the "real-world" side of science. It challenges them to deal with complex problems with no single "right" answer and to use a variety of skills beyond those employed in a typical research project. In particular, role-playing presents the student a valuable opportunity to learn not just the course content, but other perspectives on it.

How to Teach Using Role-Playing

The instructor needs to decide the context for the exercise and the role(s) that the students will play. If the students are taking human roles, the context is generally a specific problem such as global warming or dealing with an active volcano. Lessons need to be carefully explained and supervised in order to involve the students and to enable them to learn as much as possible from the experience. However, a well-done scenario never runs the same way twice, teaches people things they might not ordinarily have learned, and tends to be fun for all involved.

Examples of Role-Playing

What Should We Do About Global Warming?
The students will summarize the issue in a mock debate or a presentation.

Changing With the Tide
This lesson plan is written around a brief role-play in which students learn about and act out plants and animals in a salt marsh habitat as the tides change.

Coral Bleaching: Making Our Oceans Whiter

This lesson plan deals with coral reefs and the recent crisis of coral bleaching. It suggests that students engage in a role-playing debate about modifying human activity to protect reefs.

Rescuing the Aral Sea: use of Case Method

A case based upon the environmental devastation of the Aral Sea that illustrates economic concepts of opportunity cost and social marginal cost.

References

Aronson, E. (1978) *The jigsaw classroom*: Beverly Hills, Sage Publications.

Artut, Perihan Dinc and Tarim, Kamuran (2007) *The effective of jigsaw II on prospective elementary school teacher*s: Asia-Pacific Journal of Teacher Education, v. 35, no. 2, p. 129-141.

Bonnet, Claudie (2000) *The relevance of role playing in environmental education.* Proceedings of the International Union of Biological Sciences Commission for Biological Education: International Symposium no Biological Education IUFM Versailles, Centre de Cergy, France

Burkhardt, John and Turner, Peter R. (2001) *Student teams and jigsaw techniques in an undergraduate CSE project course*: 31st Frontiers in Education Conference, v. 2, pp. F3D-12-17.

Cage, M.C. (1997) *Role-Playing Replaces Spreadsheets in College Accounting Courses.* The Chronicle of Higher Education v42 n21 pA10

Carroll, David W. (1986) *Use of the jigsaw technique in laboratory and discussion classes*: Teaching of Psychology, v.13, no. 4, p. 208-210.

Colosi, J.C. and Zales, C.R. (1998) *Jigsaw cooperative learning improves biology lab courses*: Bioscience, v. 48, no. 2, p. 118-141.

Creed, Tom (1997) *Extending the Classroom Walls Electronically* In: *New Paradigms for College Teaching*, eds. William E. Campbell and Karl A. Smith, 149-184. Edina, MN: Interaction Book Co.

Dallman-Jones, Anthony (1994) *The Expert Educator* Three Blue Herons Publishing, Inc.

Duveen, J. and Solomon, J. (1994) *The Great Evolution Trial: Use of Role-Play in the Classroom*. Journal of Research in Science Teaching v32 no5 p575-582

Esiobu, G.O. and Soyibo, K. (1995) *Effects of concept and mappings under three learning modes on students' cognitive achievement in ecology and genetics*: Journal of Research in Science Teaching, v. 32, p. 971-995.

Fink, L. Dee (2004) *Beyond small groups*: harnessing the extraordinary power of learning teams, *in*, Michaelsen, Larry, Knight, Arlettea, and Fink, Dee, (eds.), Team-based learning: a transformative use of small groups: Sterling, VA, Stylus Publishing, p.

Francis, P.J. and Byme, A.P. (1999) *The Use of Role-playing Exercises in Teaching Undergraduate Astronomy and Science.* Publications of the Astrononomical Society of Australia v46 no2 p203-211

Harwood, W.S., McKinster, J.G., Cruz, L., and Gabel, D. (2002) *Acting Out Science: Using Senate Hearings to Debate Global Climate Change.* Journal of College Science Teaching v31 no7 p442-447

Havholm, Karen Gene (1998) *An Activity to Introduce the Geoscience Perspective***.** Journal of Geoscience Education v46 no2 p137-140

Johnson, David W. and Johnson, Roger T. (1999) *Making cooperative learning work*: Theory into Practice, v. 38, no. 2, p. 67-73.

Johnson, David W., Johnson, Roger T., and Holubec, Edyth Johnson (1998) *Cooperation in the classroom*: Edina, MN, Interaction Book Company.

Lowe, R. (1989) *Scientific diagrams: How well can students read them? What research says to the science and mathematics teacher*: Volume 3: Perth, Australia, Key Centre for School Science and Mathematics, Curtin University of Technology.

Lowe, R. (1993) *Constructing a mental representation from an abstract technical diagram*: Learning and Instruction, v. 3, p. 157-179.

Michaelson, Larry K., Fink, L. Dee, and Knight, Arletta (1997) *Designing effective group activities*: lessons for classroom teaching and faculty development, *in*, DeZure, D., ed., To Improve the Academy: Resources for Faculty, Instructional and Organizational Development, Stillwater OK, New Forums.

Novak, G. & Middendorf, J. (2004) *Just-in-Time Teaching In: Volume IV - What Works, What Matters, What Lasts.* Project Kaleidoscope.

Novak, G.M & Patterson, E.T. (1998) *Just-in-Time Teaching: Active Learner Pedagogy with WWW* . Paper presented at IASTED International Conference on Computers and Advanced Technology in Education, May 27 -30, 1998 Cancun, Mexico

Novak, G.M & Patterson, E.T. (2000) *The Best of Both Worlds: WWW Enhanced In-Class Instruction* . Paper presented at IASTED International Conference on Computers and Advanced Technology in Education, May 24-27, 2000 Cancun, Mexico

Novak, Gregor M., Patterson, E. T., Gavrin, A. D., and Christian, W. (1999) *Just-In-Time-Teaching: Blending Active Learning with Web Technology* , Prentice Hall.

Novak, J.D. (1998) *Learning, creating, and using knowledge*: Concept maps as facilitative tools in schools and corporations: New Jersey, Lawrence Erlbaum Associates, p. 17.

Novak, J. D., and Gowin, D.B. (1984) *Learning How to Learn. New York and Cambridge, UK*: Cambridge University Press, 199 p.

Patterson, E.T. (2005) *Just-in-Time Teaching: Technology Transforming Learning – A Status Report, Invention and Impact*

Perkins, David V. and Saris, Renee N. (2001) *A "jigsaw classroom" technique for undergraduate statistics courses*: Teaching of Psychology, v. 28, no. 2, p. 110-113.

Rhem, James (2005) *Just-in-Time Teaching Tomorrow's Professor* listserv posting, originally published in the National Teaching and Learning Forum Newsletter, Volume 14, Number 1.

Schwartz, D.L. (1993) *The construction and analogical transfer of symbolic visualizations*: Journal of Research in Science Teaching, v. 30, p. 1309-1325.

Simkins, Scott and Maier, Mark (Eds.) (2010) *Just in Time Teaching: Across the Disciplines, Across the Academy*, Stylus Publishing.

Slavin, Robert E. (1991) *Synthesis of research on cooperative learning*: Educational Leadership, v. 48, no. 5, p. 71-82.

Slavin, Robert E. (1996) *Research on cooperative learning and achievement*: what we know, what we need to know: Contemporary Educational Psychology, v. 21, p. 43-69.

Springer, Leonard, Stanne, Mary Elizabeth, and Donovan, Samuel S. (1999) *Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology*: a meta-analysis: Review of Educational Research, g. 69, no. 1., p. 21-51.

Taylor, P. (2001) Gallery Walk, 2004., *http://www.cct.umb.edu/gallerywalk.html*

Tewksbury, Barbara J. (1995) *Specific strategies for using the "jigsaw" technique for working in groups in non-lecture-based courses* : Journal of Geoscience Education, v. 43, no. 4, p. 322-326.

Wedman, J.M. (1996) *The effect of jigsaw teams on pre-service teachers' knowledge of reading pedagogy and concerns about group learning in a reading methods course*: Reading Improvement, v. 33, no. 2., p. 111-133.