The Jigsaw Method and Cooperative Learning

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The jigsaw method is an effective way to increase student engagement through group work that facilitates peer-to-peer learning. Dr. Barbara Tewksbury of Hamilton College offers the following description of the jigsaw method: "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 his/her 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" (1995, p. 322).

As a form of cooperative learning, the jigsaw method is a teaching strategy that helps students to develop skills for working effectively in teams, an important competency for socio-environmental synthesis (S-E synthesis). Grounded in social interdependence theory (Deutsch, 1949; Johnson & Johnson, 2005), cooperative learning is an established educational approach robustly supported by over 1,200 research studies (Johnson & Johnson, 2009). The central tenet of cooperative learning is that rather than competing with each other or being indifferent to each other, students engaged in cooperative learning "work together to maximize their own and each other's learning" (Cooperative Learning Institute, n.d. para.5) Typically, when undergraduate students are organized into groups to accomplish a learning task or assignment, few if any supports are offered to help the group manage itself. Group dynamics are often left to chance and as a result group members may or may not learn from each other. Cooperative learning is an approach that organizes and structures student groups based on three essential features that help students learn from each other: positive interdependence, individual accountability, and simultaneous interaction (The Foundation Coalition, 2001). This article focuses on a single cooperative learning strategy, the Jigsaw Method, applied in the context of teaching for socio-environmental synthesis (S-E synthesis); broader information about principles and strategies for using cooperative learning in undergraduate learning environments is included in the Additional Resources section below.

The Jigsaw Method Applied in Socio-Environmental Case Studies

Based on the case studies in the SESYNC collection from 2013-2015 (http://www.sesync.org/for-you/educator/case-study-collection), we find that the jigsaw method is commonly used as a tool/approach for teaching S-E synthesis. There are a few distinct ways in which the jigsaw method is implemented in these case studies:

- Students are initially divided into discipline-specific groups to perform tasks from a disciplinary perspective and then reconvene to share ideas across disciplines
- Students are initially divided into groups to gain particular subject matter knowledge and then reconvene to share knowledge across subjects
- Students are initially divided into stakeholder groups to understand perspectives of those groups and then reconvene to share stakeholder perspectives

The Jigsaw Method and S-E Synthesis Competencies

One of the key features of the jigsaw method in relation to its use in the SESYNC case studies collection is that by definition it engages deeply in the boundary crossing competencies that are critical for S-E synthesis research. Because the jigsaw approach requires students to work in groups in a cooperative learning fashion, students must build skills in effective collaboration and communication across different perspectives in order to complete case study tasks and activities successfully. The jigsaw method can also facilitate student self-reflection on their personal contributions to group dynamics and their own process of learning and growing.

The jigsaw method may also be used to address other S-E synthesis competencies depending on the idiosyncrasies of the individual cases. Socio-cultural competencies that help students to understand an S-E problem in the appropriate context are likely to be addressed in cases that use a jigsaw approach to explore and represent a variety of stakeholder perspectives. For example, several cases (i.e., The Minnesota Wolf Hunt Case Study (2013-9)) use the jigsaw approach to assemble students into groups to research a particular stakeholder perspective; this research typically requires students to understand the socio-cultural context of their assigned stakeholder group. Then the groups are reshuffled so that peers share their single stakeholder findings and attempt to represent, or negotiate among, multiple stakeholder viewpoints and the socio-cultural contexts embedded in those viewpoints.

Systems thinking competencies can also be developed using the jigsaw method: it can be used to help students construct a synthetic understanding of the structure and behavior of the system defined by the particular S-E problem. One mode that is used in several cases (i.e., When it Rains it Pours, A Socioenvironmental Approach to Understanding Coastal Flooding (2014-5)) is to assemble students into groups to construct a concept map of a subset of system components. Then students are reshuffled into new groups that must synthesize those pieces into a master concept map that describes the structure and behavior of the entire system.

The jigsaw method can also be used to build research skills in working with data by requiring students to gather and/or analyze data sets generated by different disciplinary research methods and then reshuffle to determine how to synthesize understanding across multiple types of data sets (qualitative and quantitative; ecological and sociological data collected at different spatial and temporal scales; etc.).

A critical element of the S-E synthesis process is the synthesis of ideas and/or data from different disciplines and sources; the jigsaw method can help students to practice these synthesis skills and to develop the necessary competencies to successfully navigate this process. When reshuffled teams undertake a task that requires contributions from all the aspects explored by each team member (e.g. all data sets, all stakeholder perspectives, etc.), teams must figure out how to orchestrate the convergence of these aspects. For example, even when stakeholder perspectives are in conflict, the jigsaw method requires teams to identify an actionable solution that is sufficiently equitable for all the stakeholders represented. This process of negotiation obligates students to evaluate compromises from the perspective of various stakeholders, necessitating students to make defensible choices across various sources of information, types of data, socio-cultural beliefs, epistemologies, and other facets particular to each stakeholder perspective. Similarly, other types of jigsaws may require students to orchestrate the convergence of subject matter knowledge or various discipline-specific research findings. While the synthesis competency domain ultimately targets students' capacity to orchestrate all components and interactions involved in seeking to resolve an S-E synthesis problem, the jigsaw method offers an opportunity to practice synthesis skills on a reduced scale.

Benefits of the Jigsaw Method

There are many benefits of using jigsaws in the classroom including the following:

- Improves team and class dynamics by helping to build trust, creating a space for candor and for respectful disagreement, and making a safe space for taking emotional risks.
- Helps build cohorts (i.e., within majors) by enabling students to really get to know each other in one class, which can translate to more interactions outside of class in departmental and campus activities.
- Fosters student engagement through peer learning and more equal participation by everyone in the group by empowering individual students to share their own "expertise" or contribution to the jigsawed group.
- Requires students who are shy or quiet to participate more fully in active ways.
- Efficiency (time saving): possible to cover more material rapidly when students are assigned different readings/roles/etc. and then teach each other in the jigsaw.

Constructing Groups

When forming groups, it is important to recognize that each student will possess a particular constellation of skills and prior knowledge related to the assigned tasks. Differences in academic preparation may result in varying levels of familiarity with relevant concepts and abilities to perform necessary skills. Further, students often bring a wide variety of personalities, life experiences, personal responsibilities, and a plethora of other variables impacting students' readiness and commitment to undertake assigned tasks. For example, differences in cultural competence may result in some students feeling uncomfortable representing the views of particular stakeholder groups in a jigsaw role play, such as when a white student with limited cross-cultural experience is responsible to represent an indigenous perspective. Such student differences may lead to inequitable distributions of work and time requirements within teams. Moreover, these types of student differences may result in friction underpinned by personality conflicts or differences in work ethic.

To proactively equip teams to manage differences and avoid unproductive conflict, it is important to establish norms and ground rules for group interactions. A useful strategy is for students to co-develop guidelines for group discussions, such as agreeing that no one needs to defend their right to have an opinion or that silence is okay. Extending this idea further, students can negotiate a team contract that delineates how team members will keep each other accountable and what consequences will follow should someone fail to complete their contribution on time. Also, using self and peer evaluations to document individual contributions can help to identify dysfunctional group dynamics, and can trigger the instructor to ask a team to work out a simmering conflict before it fully emerges. In exceptional situations, the instructor may choose to facilitate a team discussion to resolve difficult group dynamics. Such circumstances are rare, however, because the jigsaw approach involves rearranging students into new groups and thus naturally offers an opportunity to reset group dynamics.

When organizing students into teams, it can be helpful to intentionally place team members heterogeneously according to student differences in order to distribute various types of background knowledge and expertise across teams. When the instructor does not yet know the students individually, it can be helpful to collect learner profiles that inquire about students' familiarity with key concepts, prior skills, and learning preferences. In instances where classes are simply too large for such an undertaking, assigning students randomly to teams

may be the most feasible solution. Numbering off can be used to establish random teams in a jigsaw format, but a deck of playing cards can offer a clever alternative. Each student selects a playing card at random and records both the suit and the number. The card suits are used to determine which of four readings, stakeholder viewpoints, data sets, or other tasks each student will undertake. Students with like card suits assemble to discuss their work on the same task. At a later time, students assemble into new teams grouped by their playing card number; the resulting teams will be comprised of four students, each representing one of the four tasks. This strategy requires the instructor to put the deck in order by card number, and to limit the quantity of cards to the number of students present. When a class roster does not divide evenly into a multiple of four, face cards or joker cards can be used as wild cards that permit those students to join any team, resulting in redundancies that can be helpful to remedy problems associated with student absences.

Dealing with Student Absences

One of the challenges with the jigsaw method is that students are dependent on each other to be present in class and to arrive prepared to share individual contributions within reshuffled teams. When a student representing an "expert" perspective is absent or arrives to class unprepared, his or her mixed group will lack that perspective. However, this challenge can addressed in a number of ways. For example, instructors can require that each "expertise" group create documents (such as powerpoint slides) with voice-overs to explain the information their team of experts developed. If a student from a particular expert group is missing when the jigsaw occurs, the other students can be directed to the documents to get that perspective. One of the strengths about jigsaws, however, is that usually there are several students in each expert group (typically at least 3-4 unless the class is very small). So, if one student is missing, groups can simply combine (making them slightly larger) in order to make sure that all groups have every expert perspective represented.

Various proactive measures can serve to discourage student absenteeism. For example, incentives such as participation points can enhance student engagement in active learning exercises such as jigsaws. Peer and self-evaluation of individual contributions can not only be helpful for ironing out emerging group dynamics, but can also function as an incentive for student to come to class and arrive prepared. If jigsaws and other group work will be used frequently during the semester, it may be helpful for students to decide in advance how each team will handle absences and include this in the team's accountability contract.

A final recommendation about what to do if a student is absent during a jigsaw is to use it as a teachable moment and have all groups proceed even if one group is missing a student. When the groups report back to the whole class, everyone can discuss whether the lack of a particular expert perspective impacted the way the activity proceeded and/or the final product or result. Depending on the situation, it may or may not matter a great deal if one perspective is missing.

Additional Resources

Science Education Resource Center at Carlton College. (2016). Pedagogy in Action: Jigsaws. Retrievable from: http://serc.carleton.edu/sp/library/jigsaws/index.html
Multiple resources for using jigsaws in undergraduate courses including how to design effective jigsaws and examples of use.

Tewksbury, B. J. (1995). Specific Strategies for Using the "Jigsaw" Technique for Working in Groups in Non-lecture-based Courses. Journal of Geological Education, 43, 322-326. Retrievable from: http://d32ogoqmya1dw8.cloudfront.net/files/nagt/jge/abstracts/using_jigsaw_method.pdf
This short article offers practical information and useful tips for using the jigsaw method in undergraduate courses.

Felder, R. (2016) Resources in Science and Engineering Education . Retrievable from: http://www4.ncsu.edu/unity/lockers/users/f/felder/public/RMF.html
Dr. Richard Felder, North Carolina State University, has posted a plethora of research-based teaching resources for faculty interesting in student-centered, active learning. Includes several publications and resources focused on cooperative learning in post-secondary learning environments, such as "Effective Strategies for Cooperative Learning" retrievable at : http://www4.ncsu.edu/unity/lockers/users/f/felder/public/Papers/CLStrategies(JCCCT).pdf

Johnson, D., Johnson, R., & Smith, K. (2006). Active Learning: Cooperation in the College Classroom. 8th ed., Interaction Book Co., ISBN: 0-939603-14-4
"A comprehensive view of the use of formal cooperative learning lessons, informal cooperative learning groups, and cooperative base groups in the college classroom. Numerous specific lesson structures are included."

The Foundation Coalition. (2001). Positive Interdependence, Individual Accountability, Promotive Interaction: Three Pillars of Cooperative Learning. Retrievable from: http://www.foundationcoalition.org/home/keycomponents/collaborative_learning.html
Explains three key elements of cooperative learning and why they are essential. Includes examples for integration into course activities.

References

Cooperative Learning Institute. (n.d). What is cooperative learning? Retrievable at http://www.co-operation.org/what-is-cooperative-learning/

Deutsch, M. (1949). A theory of cooperation and competition. Human Relations, 2, 129-152.

Johnson, D.W. & Johnson, R.T. (2005) New developments in social interdependence theory. Genetic, Social, and General Psychology Monographs, 131(4), 285-358. DOI: 10.3200/MONO.131.4.285-358. Retrievable from: https://www.researchgate.net/publication/6609956_New_Developments_in_Social_Interdependence_Theory

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