How-To-Do-It

Cooperative Learning as a Tool To Teach Vertebrate Anatomy

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Active learning and increased motivation to learn are common benefits of time spent in laboratory during a science course. Hands-on learning is an important aspect of the laboratory experience and increases comprehension of material learned during the lecture portion of college science courses. When the content of a course is extensive, such as that often found in biology courses, students may respond by increasing their study time or by feeling helplessly overwhelmed by the material (Woolfolk 1990). Group work can serve both of these types of students by providing an additional means of study as well as support and motivation (Caprio 1993). Cooperative group learning also provides students with an opportunity to use many aspects of their intellect not often accessed in typical lecture courses or "cookbook" labs. Specific abilities that can be exercised include social interaction skills within teams and small groups, exploratory time, teaching skills, and creativity. Literature on cooperative learning is abundant for the elementary and secondary school levels (Slavin 1990), but is more limited at the college level (Purdon & Kromrey 1995), especially in the biological sciences (Caprio 1993; Tewksbury 1995).

To a vertebrate zoologist, the opportunity to explore and compare the anatomy of the major vertebrate groups (jawless fishes, bony fishes, cartilaginous fishes, amphibians, reptiles, birds and mammals) is a particularly instructive and enlightening experience. However, traditional laboratory exercises in courses that have a component on comparative vertebrate anatomy rarely provide such opportunities and most often consist of individualized memorization and recognition of structures. The focus is more on learning the specific structures and less on comparing the anatomy across vertebrate taxa. We were interested in including more investigative exercises that fostered an environment for cooperative learning in our introductory laboratories that focused on vertebrates.

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In our majors-oriented Introductory Biology course, students are introduced to the diversity of organisms. In addition to learning general concepts, the students are expected to learn numerous technical terms to provide background for future courses. Because many students in previous years complained of having too much rote memorization, we decided to try a cooperative learning technique similar to the Jigsaw II method (Slavin 1990; Bykerk-Kauffman 1995). The "Jigsaw" method refers to a technique of breaking down a large concept into smaller pieces of information, in which small teams are responsible for becoming experts on their "chunk" and teaching this information to other teams. We used this method to make students more proactive in the gleaning of information on the morphology of the vertebrates.

By breaking down a task that may seem daunting to students who think they are expected to know "everything about everything", the challenge becomes more manageable. When students feel overwhelmed, their motivation to learn decreases. This is especially true of topics, such as anatomical terms, that promote more complacency and less satisfaction than others (Caprio 1993). In addition, limited lab time available for dissection and a desire to minimize the numbers of animals used for dissection make group work more important for an anatomy lab.

Our technique fosters collaborative learning by facilitating interaction between students as they become experts on their representative vertebrate and teach their vertebrate's structure to other members of the team. By providing a variety of animals but limiting the number of each type, we encourage students to appreciate the diversity among animals without the potential tedium of dissecting one after another. Providing each pair the freedom to choose what parts they would teach their peers (with some guidance from the instructor) allowed students to explore each animal in depth and then to compare it to the other animals in lab. Limiting the number of parts to know by providing students a target number of structures on each animal kept the rote knowledge required at a manageable level without reducing student understanding of anatomical function. With this method, the students were able to use lab time efficiently and effectively, taking an active part in their own learning.

The Process of Cooperative Learning

A Brief Overview

In our version of the Jigsaw II technique, we allowed pairs of students to explore a specific organism and to choose the 10 most important and interesting parts (with assistance from the instructor) of the organ system under study each week to teach to their fellow team members. Teams were composed so that a pair of students was assigned to a representative of each of the major vertebrate groups. Open laboratory times were scheduled to provide students with ample opportunity to continue their studies. Students were tested by standard laboratory practical exams and provided a grade based upon their individual achievement in learning the new information.

Step 1—Team Formation

A pair of students (seven pairs total) was assigned to each major vertebrate taxon. The representative specimens selected for each taxon were those readily available in medium or large body sizes from most commercial biological suppliers. Vertebrate specimens included: lamprey (jawless fishes), yellow perch (bony fishes), dogfish shark (cartilaginous fishes), mudpuppy (amphibians), red-ear slider turtles (reptiles), pigeon (birds), and fetal pig (mammals). Each pair of students was to serve in the role of expert for their vertebrate specimen. The team of 14 students determined which pair of students would be responsible for each vertebrate taxon so that the whole team was exposed to each of the seven major vertebrate taxa.

Step 2—Attainment of Expert Status

The initial 75 to 90 minutes of each laboratory period were reserved for students to explore the organ systems (skeletal, respiratory, circulatory, digestive, excretory, reproductive, etc.) that were the focus of that week's meeting. Each pair of students was provided a commercially available dissection guide for reference. The instructor and undergraduate teaching assistants traversed the classroom to provide further assistance as needed. However, guidance beyond basic techniques for dissection was discouraged in order to force students to explore the organism to identify structures rather than have structures identified for them. As students explored their specimen, they were asked to determine 10 structures that they felt must be taught to their team as well as an additional feature that was somewhat unique (especially pronounced or modified) about their animal. This exercise required students to explore the specimen and make subjective decisions about what structures to teach. To attain "expert" status, each student pair was required to verify their "Top 10 Lists" with the instructor, permitting a step in which quality control could be practiced.

Step 3—Peer Teaching

Student pairs were provided about 30 minutes to compile and photocopy a list and diagram of their "Top 10" structures for distribution to each of the 14 team members and to the instructor. The remainder of the laboratory period was spent with student "expert" pairs teaching their structures to other members in the team and then rotating to the next specimen. The instructor or a teaching assistant supervised each of the teaching sessions. Any time that remained at the end of a laboratory period, as well as ample open lab time (four hrs/week), also enabled students to hone their skills.

Step 4—Evaluation of Students

Students were evaluated through standard laboratory practicums that emphasized the identification of the structures learned during the laboratory periods. Because different groups may have slightly different lists, the laboratory practicums must be tailored slightly for each group within a single class. We accomplished this by providing some stations at which more than one specimen was found and labeled for the appropriate group. Most often, however, only a single specimen at each station was required for there was generally strong congruence between the lists of each group.

Evaluation of the Method

Protocol

Students and undergraduate teaching assistants anonymously evaluated the efficacy of the technique by responding to seven statements (Table 1). Strong agreement with the statement was signified with a 5, while strong disagreement was denoted by a 1. We analyzed student responses (n = 33) using a one-sample *t*-test that assessed whether the mean student response was different from 3 (which indicated a neutral response to the statement) and considered the results to be statistically significant if $p \leq 0.05$.

Student Responses

Students strongly endorsed the cooperative technique with 84.8% of the opinion that the cooperative technique was superior to learning anatomy by the traditional method (12.1% preferred the traditional method and 3.1% did not prefer either method). Many students felt they enjoyed learning about their organism more because of the time allowed to explore the animal, although they wished there had been more time available for the group teaching component and some additional review. Comments included: "It (the cooperative learning method) allowed students to explore on their own and actually think about what they were looking at. It kept their interest more." and "... it is more enjoyable, and students learn better when they have to teach others what they have found. For students who put some effort into it, this is certainly the best way to learn a lot and have fun with it."

Table 1. Survey results summarizing student impressions of the cooperative learning technique.

Question #	*Statement*	*N*	*Average Response*	*t*-value
1.	The cooperative learning technique was effective in facilitating my ability to learn vertebrate anatomy.	33	4.03	6.70*
2.	The cooperative learning technique was effective in building camaraderie in the laboratory.	33	4.03	7.31*
3.	The experience of teaching my organism to others increased my ability to learn.	33	4.09	8.19*
4.	The experience of teaching my organism to others increased my enjoyment of the laboratory exercise.	33	3.85	6.84*
5.	I enjoyed learning from my classmates.	33	3.70	4.07*
6.	The cooperative learning experience caused me to investigate the organism more than if I had been given a list of required characters at the start of the period.	33	4.27	6.84*
7.	I learned more vertebrate anatomy from the cooperative learning experience than I would have using a more traditional approach in which I received a list of structures and worked individually.	33	3.91	4.42*

*Significant at the $P < 0.05$ level.

The general feeling among students (Table 1) was that the cooperative learning technique was effective in helping to learn vertebrate anatomy (Questions 1 and 7) and promote increased investigation of the organism (Question 6). The peer teaching was also enjoyed (Questions 4 and 5) and seemed to foster a greater diligence in learning the information (Question 3).

Students successfully practiced social skills and were able to work cooperatively rather than competitively and agreed that the technique was effective in building camaraderie within the laboratory setting (Question 2). "The approach allowed the groups to interact and learn from other people's way of looking at things. I also think it helped promote some group bonding," wrote one student. This group bonding is especially important since these students will be working together in other classes as they complete their degrees. By forming support networks early in their college years, these students will be able to help each other with the more difficult material to be encountered in the future. Cooperative learning also encourages the cooperative and collaborative attitude necessary for successful work in biological research and teaching careers.

Additional Benefits

The use of cooperative learning also effectively addresses the concerns of many students with ambivalent feelings toward dissection. The technique minimizes the number of preserved specimens used so that a class of 28 students working in pairs requires only two specimens of each vertebrate rather than the 14 necessary for every pair of students to dissect each vertebrate (of course, this also greatly reduces the cost of running the laboratory as well). In practice, we usually order an additional specimen or two for lab practical exams and to demonstrate sexual dimorphism. Furthermore, students who have difficulties completing a dissection on their own can pair with a classmate who prefers to handle the animal. Both of these benefits have enabled us to effectively address student concerns.

Potential Pitfalls

While the use of cooperative learning techniques to teach vertebrate anatomy has many benefits, several potential pitfalls exist. High rates of attendance are required for student pairs and teams to work effectively. The instructor must take the lead in generating a sense of commitment to the team among students. Our students were excellent in this regard with only a few absences on medical grounds; however, part of a student's grade could be based upon attendance and/or a peer evaluation. In cases where a partner did not attend, some students preferred to continue with the dissection on their own while others preferred the companionship of another student or teaching assistant.

Quality control of peer teaching is necessary as well. A few students expressed disappointment with some of their peers not putting enough effort into the exploration to make their contribution worthwhile. These comments were: "Not all students took the exercise as seriously. Some picked obvious structures and didn't explore. Some might have been better off with some structure (in the dissection)" and "Some could have gone into more depth in their teaching." We are considering ways of making student pairs more responsible for their efforts in teaching their fellow classmates. Several methods are mentioned in the literature (Slavin 1990; Temperly 1994; Applegate 1995), many of which seem applicable but none ideal for this laboratory situation. The most likely means to increase accountability would be to introduce a system of peer, self and faculty review of presentations which has worked for us successfully in another course (Koprowski 1997).

Conclusions

The use of cooperative learning techniques such as the Jigsaw II approach (Slavin 1990) in scientific laboratory courses can be useful because such techniques enable students to take an active role in their learning. We have also used this method in recent laboratory investigations of organismal diversity in microbes, plants and invertebrates with similar success. Cooperative learning techniques likely are applicable to a great number of situations in the biological laboratory but clearly are effective for teaching vertebrate anatomy. In our experience, students perceived the technique to be preferred when applied to a setting in which vertebrate anatomy was the focus; and they enjoyed the experience. The technique also retains the rigor of the more traditional methods. The organ systems that are covered can, of course, vary with the level of the course and the instructor's emphasis; however, we have typically used five major groupings of structures: external, circulatory, respiratory, digestive, and excretory/reproductive. With 10 structures selected for each of these systems across seven vertebrate specimens, the number of structures that students are challenged to master in our classes is 350 over a five-week period.

Additional benefits of the technique are that students also hone their communication skills, learn the importance of collaboration in scientific laboratories, and appreciate the need to organize their thoughts for a short teaching session. We estimate that the contact time with students is similar between this approach and a more traditional one. Additional effort is required in arranging laboratory practical exams and working with students to provide quality cooperative teaching experiences; however, this increase in time is offset because students are encouraged to explore an organism first and to be self-sufficient while the instructor serves as a safety net. Students and instructors agree that cooperative learning techniques can be used effectively to enhance comparative anatomy experiences and to facilitate a truly comparative approach to vertebrate anatomy.

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