Assessment of the use of the Jigsaw Method and Active Learning in Non-majors, Introductory Biology

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*Abstract:*This project involved the use of two small, closely matched non-majors introductory biology classes to test the use of the Jigsaw method of teaching vs. a passive, instructor-oriented model of teaching. In this study, the Jigsaw method was used as a jumping off point for the teaching-learning of the material. Students were to learn the concepts of the chapters through the Jigsaw method and their understanding of the material was then reinforced by active learning techniques in which they would use these concepts by applying them to solve problems as a group in active learning exercises. These students were compared to students in another, equally matched section of the class, who were taught exclusively by passive learning. In this study, there was no major difference between the sections taught by active learning or passive learning. One potentially important difference that did arise was that the active learning section did significantly better on a posttest, however, this result may be an artifact of the different way that the posttest was given in the two sections. Further study needs to be done to refine the technique to include group and individual goals aside from the individual performance on exams.

Keywords: Jigsaw method, assessment, active learning

Introduction

This project involved the use of two small, closely matched non-majors introductory biology classes to test the use of a variation of the Jigsaw Method of teaching against a passive, instructor-oriented model of teaching.

I originally undertook this project because of my experiences trying to use active learning techniques in the class. Studies have shown that students learn better when they are actively involved in the teaching-learning process (Ebert-May et. al. 1997, Paulson, 1999, Johnson et. al. 1998, Udovic et. al. 2002). There are many different types of active learning, all of which involve the students engaged with the material, rather than passively listening to lectures. Most active learning techniques involve some form of cooperative learning in which students work together in groups toward some goal.

The idea behind the active learning technique in the present study is the belief that the students can learn the content of the chapters on their own by reading the chapters in the book. Class time should be dedicated to active learning exercises that help the students to learn and understand the material better. However, this system breaks down when the students don't read the chapters before coming to class. This course is a general education elective that is designed for first semester freshmen. As such, most of the students have poor study skills and low interest in the material. For this reason, attempts at teaching via active learning are hampered because the majority of students come to class unprepared. The content of the subject is often unlearned and the activities fall flat because of the students' inability to participate. In the end, half the class time is spent lecturing to impart the necessary content and the other half doing active learning exercises. As a result, both content and active learning suffer.

In the present study, the Jigsaw Method was used as a way to engage the students with the content in the text before it was discussed in class. The Jigsaw Method is a cooperative learning technique that was originally developed by Aronson et. al. (1978). It involves dividing content into 4 sections and assigning a subgroup of the class to each section. These subgroups then meet and become "experts" in their assigned material. These subgroups are then broken up to form four person teams that have one person from each subgroup. The teams are therefore composed of an expert from each of the four areas; this expert teaches the others on the team the material. Various studies have shown that learning improved (Lucker et. al. 1976, Aronson et. al. 1978)

or showed no difference (Moskowitz, et. al., 1985, Palmer and Johnson 1989, Thomsons & Pledger, 1998) using this method. Better results were obtained when it was modified (Jigsaw II) to include a reward for a group goal and public accountability for each member's contribution to the goal (Mattingly & VanSickle, 1991). Further modifications of the method (Jigsaw II, Jigsaw IV) enhanced the academic achievement (Holliday 2000).

The teaching method used here was somewhat different from the way that the Jigsaw Method has been used in the past. Previous studies have used this method as the end point of the teaching model; in this study, the Jigsaw Method was used as a jumping off point. Students were to learn the concepts of the chapters by taking notes and teaching each other the important content. Their learning by this method was then reinforced by active learning techniques in which they would use these concepts by applying them to solve problems as a group in active learning exercises. Exam scores of students in this section of the class were compared to the exam scores of students who were taught the same material by a traditional, lecture-style approach (i.e., passive learning).

Methods

Class Comparisons

Two sections of Concepts in Biology (BIO103) were tested in this study. Section A (25 students) had 9 freshmen, 5 sophomores, 6 juniors, and 5 seniors. Section B (27 students) had 13 freshmen, 9 sophomores, 2 juniors, and 3 seniors. Section A met Monday, Wednesday and Friday from 9:00 to 9:50 and Section B met Tuesday and Thursday from 9:30 to 10:45. The students who agreed to participate in this study were asked to sign an informed consent waiver that stipulated that the information that they gave was confidential, and that their anonymity would be preserved. . The absentee rates for the two classes were not significantly different (3.6±0.4 and 3.1±0.6 absences per student, per semester).

Course content

Concepts in Biology is a one-semester introductory course. The content was organized around the theme of "Information flow: DNA $\rightarrow$ RNA $\rightarrow$ protein $\rightarrow$ trait." The textbook used was <u>Essential Biology,</u> (Campbell et. al., 2004). The first exam was on the scientific method, biochemistry, and cell biology and covered Part of chapter 1 (Introduction: Biology Today) Chapter 4 (The Molecules of Life), and Chapter 4 (A Tour of the Cell). The second test covered cell division (Chapter 8, The Cellular Basis of Reproduction and

Inheritance) and Mendelian genetics (Patterns of Inheritance). The third test was evolution and it covered microevolution (Chapter 13, How Populations Evolve), macroevolution (Chapter 14, How Biological Diversity Evolves) and human evolution (part of chapter 17, The Evolution of Animals). For the final test, I gave them the option of choosing 2 chapters from among the physiology chapters in the textbook. They chose Nutrition and Digestion (Chapter 22) and Circulation and Respiration (Chapter 23).

The Jigsaw Method

The Jigsaw Method used in Section B was a variation of Jigsaw methods used in the past. First the class was taught how to take good notes. They were shown that the chapters are organized into an outline format, how to determine the most salient information in the text, and how to fit the material into the general outline format. This was done through in-class note taking of one chapter of the first test material to ensure that everyone was familiar with this method. For this reason, most of the first test material was presented in a passive way, i.e., notes were taken in the class and the time in class was spent primarily on course content.

For the second and third tests, the students took notes from the chapter as homework before the class met to discuss it. To do this, the class was divided into 4 Teams of 6 to 7 students each and the chapter was also divided into 4 sections. Each Team was assigned one section of the chapter from which to take notes. In the next class, Groups of 4 students were formed with one student from each of the original 4 Teams. In this way, each Group had a complete set of notes for the chapter. For the first half-hour of this class, each Group passed shared notes from the chapter and the note taker from each Team discussed the important points of that section. This was followed by active learning exercises in the remainder of the class and for the next two class periods.

For the fourth test, Section B was taught in the same passive manner as Section A.

Active Learning exercises

The most common active learning activity was to have the Groups work jointly on problem sets. These were essay questions similar to what they would eventually see on the test. After a period of time for Group discussion, the quizzes were discussed as a class. Often one member from a Group would be chosen to make a short presentation of the answer to the class. A similar exercise was to ask them to come up with good essay questions from

the chapter being discussed. These were then written on the board and answered by the groups.

Another active learning technique used was to have the students meet in a computer lab to do on-line activities related to the course material. There are many activities available for some topics (especially genetics) that are very useful in this setting.

A personal response system was also used in this class. This is system where the students have infrared transmitters that emit a signal to a receiver in the front of the class. Software on the computer analyzes the responses and displays a histogram of the results. Using this system, students would work in groups and compete against each other while taking a multiple-choice quiz.

Passive Learning

Section A was taught strictly by passive methods. Students were lectured on the material and given copies of the notes via email. Any quizzes given to Section B were also given to Section A, however they were given as uncollected homework or as un graded in-class quizzes. When quizzes were given in class, the students worked individually and were given the correct answers by the lecturer after the quiz. On-line exercises done by Section B were also given to Section A, but were to be offered as self-study

Testing

A pre-test was given on the first day of class. The pretest consisted of 9 essay questions covering the variety of biological topics that were to be covered in the class during the semester. This was graded, although their performance did not affect their grade in the class. During the semester they were given 4 regularly scheduled tests. Half of each test (50%) was multiple-choice (20 questions) and half of each test was essay (six to eight questions). At the end of the semester, a post-test was given that was identical to the pre-test. The students in each class also filled out a subjective assessment questionnaire after the class to determine their impressions of the class and the teaching method.

Results

Scheduled Exams

The inherent abilities of the two sections of this class were evaluated by comparing the test results when they were treated the same. Neither class was aware that they would be given a pretest and therefore did not prepare for it.. Also, for Exams I

and IV, both classes were taught by passive lecturing. The results of both the pretest and these two exams showed that the two sections were evenly matched in ability (figure 1).
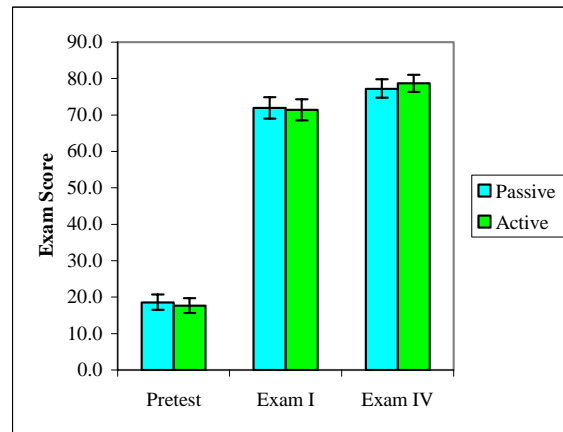

Figure 1. Comparison of the two sections irrespective of the teaching method. The two sections are compared via a pretest and when they were both taught by passive lecturing. There was no significant difference between the sections.

Exam II was the first exam in which section B was taught exclusively by the Jigsaw Method and active learning techniques. The chapters covered were on cell division and Mendelian genetics. The exams were broken down and analyzed for differences between the sections in content (cell division vs. genetics) format (multiple choice vs. essay) and for total grade on the exam. As shown in figure 2, the only criterion that showed a significant difference between the groups was the cell division portion of the test; the section taught by passive learning did significantly better in this section (P<0.02). The active learning section did slightly better in the genetics section, although this difference was not significant (P=0.15). There was no difference in the overall scores on this exam.

The third exam covered evolution and was divided into microevolution, macroevolution and human evolution. Again, section A was taught passively and section B was taught by the Jigsaw method. There were no significant differences between the passive and active sections in any of the criteria analyzed (figure 2).
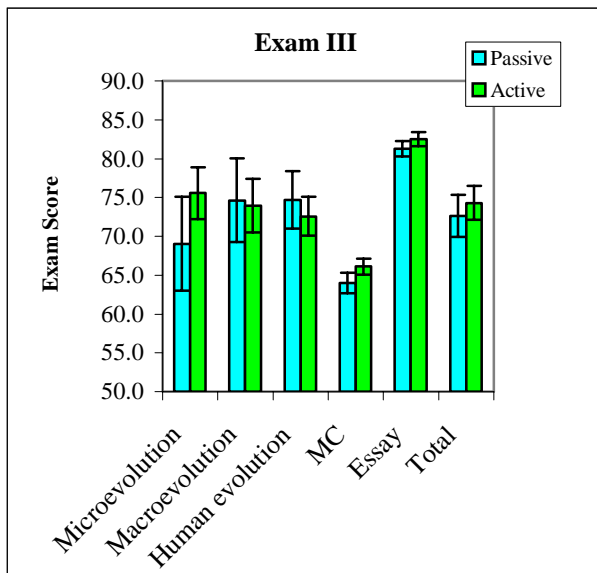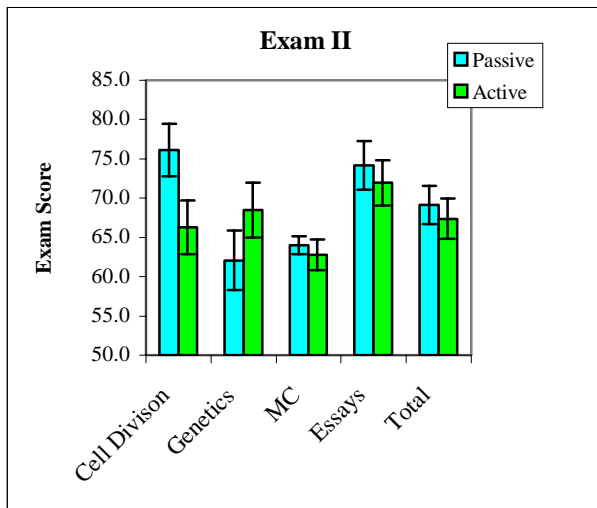
Exam II

Exam III

Figure 2. For Exams II and III, Section B was taught exclusively by the Jigsaw Method and Section A by Passive learning. The exams were analyzed for differences between the groups in content, format (multiple choice vs. essay) and for total grade on the exam. The only criterion that showed a significant difference between the groups was the cell division portion of the Exam II; the section taught by Passive learning did significantly better in this material (P<0.05).

Pretest/Posttest

At the end of the semester a posttest was given that was identical to the pretest. Both sections did significantly better on the posttest than on the pretest (figure 3). However, section B, which was taught by active learning, improved more on its pretest score and its score on the posttest was significantly higher than that of the passively lectured section (P<0.01).

However, there was a discrepancy in the way the posttests were given in the two sections. In section A (passive) the posttest was given directly after the fourth exam. In section B (active) the posttest was given on the last day of class, the week before the fourth exam. This was not planned, but was due to a logistical problem.
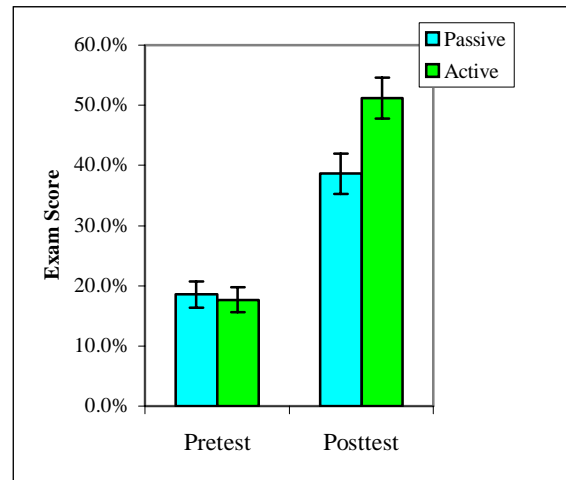

Figure 3. Identical pretest and posttests were given. Both sections did significantly better on the posttest than on the pretest (P<0.00001). However, the Active learning section scored significantly higher than the passively taught section on the posttest (P<0.01).

Because of the difference in the way the posttest was given to each class, further analysis of the pretest/posttest data was done to determine if the results above were an artifact. An unplanned aspect of the pretest/posttest allowed for this analysis. Three of the nine questions included on the pretest concerned topics that were not covered in class because of time constraints. These served as an internal control of the testing method. Any increase or decrease in scores on these questions should not be due to the way material was presented during the class (since it wasn't), but rather may be due the discrepancy in the way that the tests were given in the two sections. Figure 4 shows the comparison of the results of each section on material covered in class and not covered in class. The active learning group did significantly better than the passive group on questions from material covered in class (P<0.05) as well as questions on material not covered in class (P<0.01). However, when pretest vs. posttest data for the passive group is compared, this group did significantly worse in the posttest on material not covered in class (P<0.000005). In addition, there were more questions left totally blank on the tests in the passive group (2.4±0.35 per test) than in the active group (1.3±0.31 per test); this difference was statistically significant (P<0.05).
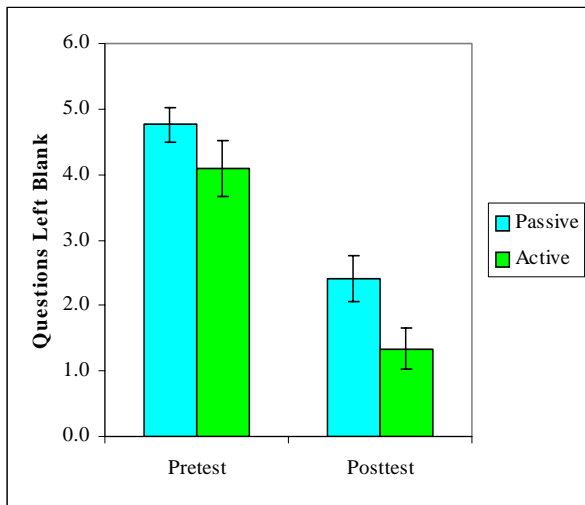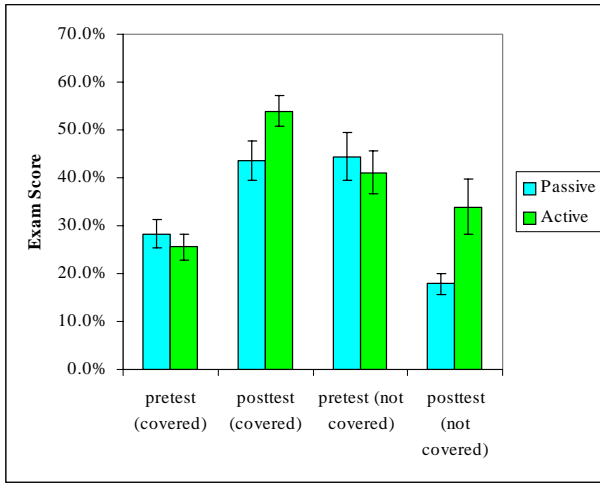
Figure 4. Assessment of the Pretest/Posttest Data. The two sections were compared based on questions from material covered vs. not covered in class. On questions from the test on material that was covered in class, that active section did slightly better (P<0.05). On material that was not covered in class, the active section did better than the passive section (P<0.01). There was no difference between the pre- and posttest results of the active group on this material, but the passive group did significantly worse on the posttest (P>0.000005). Also, there were twice as many blank questions on the passive group's tests compared to the active group's tests (2.4±0.35 vs. 1.3±0.31 per test, P<0.05).

Subjective Assessment

The class that was taught by the Jigsaw Method was resistant to the change in format at first. The

students generally disliked working in groups because slackers tended to take advantage of the students who did the work. This is especially a problem in the Jigsaw Method because a group with one or two slackers misses out on important material. This problem was partially rectified by segregating slackers into their own group, which took the notes during class instead of sharing pre-written notes. However, absenteeism and lack of initiative had an effect on the morale of the groups.
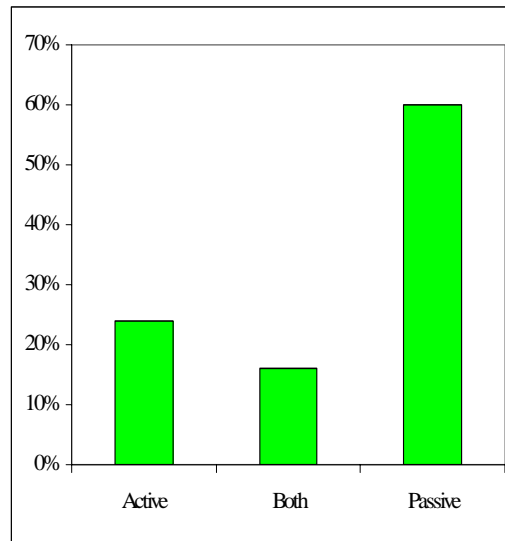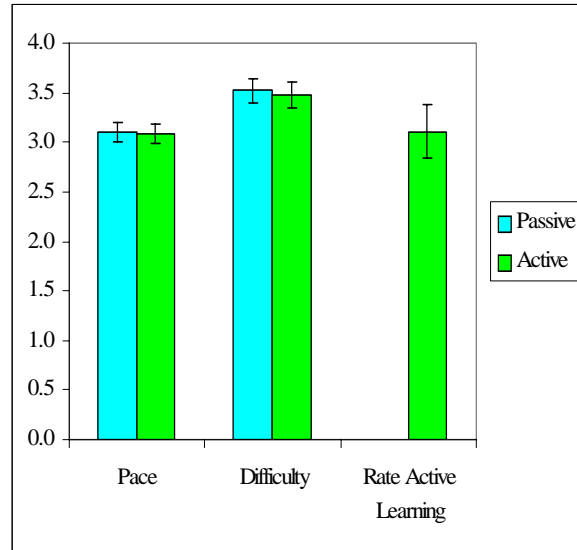

Figure 5. The students were asked to fill out a questionnaire on their feelings about the class, rating it on a scale of 1 to 5. There was no difference between the two sections in their perceived pace of the material or the difficulty of the class. The active learning section was asked how they would rate the active learning approach on a scale of 1 to 5. This section was also asked whether they preferred active learning, passive learning, or a mix of both.

After taking the fourth exam the students were asked to fill out a questionnaire on their feelings about the class (figure 5). Two questions were the same in the two sections and pertained to the pace of the material and the difficulty of the class on a scale of 1 to 5, (1 the lowest, 5 highest). There were no differences between the sections in their responses to the first two questions. They saw the pace of the material to be average (3.1± 0.1) and the difficulty of the class to be slightly above average (3.5± 0.1). The active learning section was asked two questions that specifically pertained to their manner of instruction. When asked how they would rate the active learning approach, the average response was 3.1±0.3. When what type of instruction they would prefer, 24% chose active learning, 60% chose passive lecture, and 16% chose a mix of both.

Discussion

Comparison of the two groups on the pretest and on Exams I and II (i.e., when they were treated the same) show that they were equally matched (figure1). During the experiment, when they were treated differently, the only exam score that showed a significant difference was in the cell biology section where the passive learning section scored higher. This may be because this was the first chapter when Section B used the Jigsaw Method and they were unfamiliar with the method. All other scores, whether assessed by content or type of question (essay vs. multiple choice), were the same. This showed that, although the Jigsaw Method showed no improvement in learning, at least it did no worse.

Analysis of the posttest data showed that both sections increased their scores from their pretest results, suggesting that they retained some of the knowledge gained during the semester. One important difference that did arise between the scores of the two sections was on the posttest. The two sections did the same on the pretest but the active learning section did significantly better on the posttest. One interpretation of this is that the active learning section retained more that the passive learning group. This is a potentially important result, however it may be an artifact of the different way that the posttest was given in the two sections.

In an analysis three questions on the posttest that pertained to material that was not covered in class, the passive class did significantly worse than the active class; also, the passive class did significantly worse than they had on the same questions in the pretest and left more questions entirely blank than the active class. This suggests that the passive class wasn't trying as hard and that they were giving up easily. This calls into question the conclusion that there were long-term gains by the active class over the passive class.

The subjective assessment of the course showed that both sections saw the class as equally challenging. Active students said that, while they rated the Jigsaw method about average (3.1±0.3 out of 5), only 24% preferred to be taught that way and 60% preferred the passive lecture model. In written responses, many students paradoxically said that they felt that they learned more by the active method, but preferred passive learning. One of the problems is that students, in general, dislike working in groups; the main complaint is that slackers take advantage of students who do the work. For this reason, care must be taken to hold each student responsible for the work.

Although the Jigsaw Method was not shown to be superior in this study, previous studies have shown increased learning using the method (Lucker et. al. 1976, Aronson et. al. 1978, Mattingly & VanSickle, 1991, Holliday 2000). One difference between those studies and the present one is that the more successful studies included group and individual goals and accountability after each exercise. While there were group goals in the present study (preparing good notes from the chapters for the exams and working through answers on a quizzes), there was no accountability of the individual to the group (slackers were allowed to take advantage of the group) or of the individual to a daily standard of achievement (i.e., quizzes weren't graded). These aspects need to be addressed in order to see gains by this method.

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