Activity Based Cooperative Learning in an Introductory Statistics Course

Julie M. Clark
Hollins University
jclark@hollins.edu
Desirable Features of an Introductory Statistics Class

- Promotion of active learning on the part of students
- Emphasizes conceptual understanding of fundamental statistical ideas
- Utilizes technology
- Stresses communication skills (reading, writing and discussion)
- Uses cooperative learning
What Is Cooperative Learning?

- A significant amount of the course work is done in cooperative groups
- A positive esprit de corps exists within the groups
- Team members share a feeling of mutual responsibility for each other
- Group work is included in the evaluation process
- Group membership is permanent and stable
What Cooperative Learning Is Not:

- Having students sit side-by-side and talk with each other as they do individual assignments
- Individual tasks with instructions that those who finish first should help slower students
- Assigning a report to a group where one student does all the work
RUMEC

- Project CLUME
  - (Cooperative Learning in Undergraduate Mathematics Education)

- Research in Undergraduate Mathematics Education Community

- SIGMAA on RUME
  - (Special Interest Group of the Mathematics Association of America on Research in Undergraduate Mathematics Education)
Theoretical Analysis Using APOS Theory

- Action
- Process
- Object
- Schema
Action

- An action is a physical or mental transformation of mathematical (statistical) objects that is performed by the subject according to a specific algorithm.
Process

When the whole action can take place in the subject’s mind without having to necessarily run through the specific steps of the algorithm, we say the action has been interiorized into a process.
Object

- When an individual can transform a process by some other action, the process has been encapsulated into an object. One has an object conception of a concept when he or she realizes that the result of this particular process is an object with properties.
Schema

- An individual’s schema for a certain piece of mathematics (statistics) is a coherent collection of actions, process, objects, and possibly other schemas that can be invoked to deal with the problem situation.
Mean – APOS Results

- Penny: An average. Well, the mean is when you would add all the numbers involved and divide by that number, and that would give you the mean.

- Fran: It’s … you have a certain amount of numbers, and you take all of those numbers, and add them together, and divide by the number of numbers to get the mean.
Mean – APOS Results

- 11/17 “A” students were limited to process conceptions.

- Remaining students exhibited very weak object conceptions.
Standard Deviation – APOS Results

- Beth: Oh gosh, standard deviation is, I’m not sure really why you do it exactly. I just know… I don’t even know if I can remember the formula but the way I was taught was just like given a formula and I can work out a problem.

- Fran: I figured it out, but I could never remember what the purpose of it was.
Standard Deviation – APOS Results

- Penny:
  - std. Dev. Of \{2,3,4\} = 1.
  - Std. Dev. Of \{1,2,6\} = 2.5.

- Cindy: How far apart a certain piece of data falls from the mean. How far away it falls. If you had a certain test grade or a certain quiz grade of 8, you could find the standard deviation of how far off from the mean this grade was.
Solution

- ACE Teaching Cycle
  - Activities
  - Classroom Discussion
  - Exercises

- Based on constructivist theory of learning

- Role of teacher changes from “source of information” to “facilitator of learning”
Activities

- Workshop Statistics: Discovery with Data (and Minitab)
  - By Allan J. Rossman and Beth L. Chance
  - Robin Lock (Fathom)
  - James H. Albert (Bayesian Approach)
  - J. Barr Von Oehsen (Graphing Calculator)
  - Key College Publishing (www.keycollege.com)
Sample Activity

- Construct a set of data (using the integers between 0 and 100) of 10 scores such that:
  - 90% of the scores are greater than the mean
  - The mean is greater than twice the mode
  - The mean is less than 2/3 the median
  - The mean equals the median, but the mode is greater than twice the mean
  - The mean does not equal the median, and none of the scores are between the mean and median
Sample Activity

Give each group some different data sets or plots of data, and then the following instructions:

- In your group discuss each of the four measures of center you read about in chapter 4. Make sure that everyone understands what each measure is and how it is calculated.
- Discuss the advantages and disadvantages of using each of the four measures to summarize a data set.
Sample Activity, Cont.

- For each of the distributed data sets, determine which measure of center would be most appropriate as a single number summary and why.
- Turn in one written summary of your discussion. Be sure to include a description of each measure and how it is calculated, advantages and disadvantages of each measure, and a discussion of which measure of center is most appropriate to use in representing each data set and why.
Sample Activity

- Find a numerical measure that indicates the differences between the following data sets:
  - A = \{2, 3, 4, 5, 6, 14, 15, 16, 17, 18\}
  - B = \{2,10,10,10, 10, 10, 10, 10, 10, 18\}
  - C = \{2, 2, 2, 2, 3, 16, 18, 18, 18,18\}
  - D = \{2, 4, 10, 10, 10, 10, 10, 10, 10, 16, 18\}
  - E = \{2, 3, 5, 5, 6, 10, 15, 18, 18, 18\}
  - F = \{2,4, 8, 9, 10, 10, 12, 16, 18\}
  - G = \{8, 9, 9, 9, 10, 10, 10, 10, 11, 11, 12, 13\}
  - H = \{8, 8, 9, 9, 11, 11, 11, 11, 11, 11\}
Sample Activity

- For each of the following properties, try to construct a data set of 10 hypothetical exam scores that satisfies the property. Also produce a dotplot in each case:
  - Fewer than $\frac{1}{2}$ of the scores fall within one standard deviation of the mean
  - All of the scores fall within one standard deviation of the mean
  - The standard deviation is as large as possible
  - The IQR is as large as possible, but the standard deviation is not as large as possible
Sample Activity

Here are excerpts from a newspaper article…

– What population is being surveyed?
– What is the sample size?
– What is the confidence level?
– What is the point estimate for the proportion?
– How many people in the sample agree with (a given position)?
– What is the standard deviation?
– What is the margin of error?
A brand of oven is built to reach 400 degrees Fahrenheit in ten minutes. We want to know how consistent this brand of oven is, and how well it does at achieving this target temperature in a given amount of time. Fifteen ovens, all of this brand, are randomly selected. Each oven is set at 400 degrees. Ten minutes later, the temperature of each oven is recorded by observing a thermometer set inside each oven.
Activity cont.

● Does this brand of oven achieve the target temperature overall? What statistic would we calculate to answer this question? Explain.

● Is this brand of oven consistent? What statistics would we use to calculate this answer? Explain.

● Some of the variation in temperatures may be due to the way the measurements were taken. Design a procedure for taking the measurements that would help to minimize this variation.
Name one source of variability in oven temperatures that could not be controlled by the person doing the experiment.
Sample Activity

- Select one person in your group who you think can distinguish between Coke and Pepsi.
- Design (and conduct) an experiment to determine how well this person can actually distinguish between the two types of drinks.
Additional Activity Sources

- Journal for Statistics Education
Thank you.

- If you have any questions, please email me, Trig, or Thagy at jclark@hollins.edu
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Hollins University
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References


Web Sites:

CHANCE Database: http://www.dartmouth.edu/~chance/ChanceLecture/AudioVideo.html
Data and Story Library: http://lib.stat.cmu.edu/DASL/
Julie Clark: http://lazarus.ehc.edu/~jmclark
Math Forum: http://forum.swarthmore.edu/discussions/co-learn/
Project CLUME: http://vms.www.uwplatt.edu/~clume/
RUMEC: http://www.cs.gsu.edu/~rumec/
The Nuts and Bolts of Using Cooperative Learning in Statistics Classes

Julie M. Clark
Hollins University
Roanoke, Virginia
jclark@hollins.edu

References


Math 160: Introductory Statistics
Emory & Henry College - Spring 2001
Syllabook

Instructor: Dr. Julie Clark
Office: Miller 207
Office Hours: Mondays 1:30-3:00, Tuesdays 3:00-4:30, Wednesdays 9:00-10:30, 1:30-2:30, and by appointment and by chance.
E-mail: jmclark@ehc.edu
Web Site: http://lazarus.ehc.edu/~jmclark/math160spr01.html

Please check the course web page frequently for updates in the schedule and other comments or important information.

Phone Numbers:
Course Schedule: Mon., Wed. 8:00-8:50 Tues., Thurs. 8:00-9:20
Location: Miller 108

Text:

Overview:
Statistics might be defined as the science of numerical reasoning from data. Its purpose is to aid people in making decisions based on the analysis of numerical information. Data and numerical arguments abound not only in science and social science disciplines but also in almost every field of academic inquiry. Moreover, most people encounter statistical reasoning in everyday life. It is therefore exceedingly appropriate and important for all liberally educated citizens to undertake the study of fundamental principles and methods of statistics.

Course Principles:
The following principles guide my teaching of this course and may help you to understand what I think the course is about:

1. Statistics is not math B it is not number crunching. Contrary to its popular perception as a black box collection of arcane magic tricks, statistics involves much more than numerical computations. The emphasis of this course will be on understanding statistical concepts and on interpreting and communicating the results of statistical analyses. In other words, you will be expected to learn to construct and analyze numerical arguments. In contrast to most mathematics courses, we will be using phrases such as Athere is strong evidence that...@ and Athe data suggest that l...@ rather than Athe correct answer is ...@ and Ait is therefore proven that ...@. To alleviate the computation burden, we will often use the computer program Minitab (and/or our calculators) to perform calculations and produce visual displays.

2. Understanding results from investigation and discovery. As opposed to passively taking notes while I lecture, you will spend the vast majority of class time actively engaged with the material. You will work through activities carefully designed to lead you to discover fundamental statistical ideas for yourself. You will be encouraged to work collaboratively with group members on most of these activities. My role during class will be to mill about the classroom, answering your questions and prodding you toward a better understanding of the material. I will also lead class discussions and present mini-lectures and explanations where appropriate.

Course Goals:
My primary goals for this course are to help you develop:

$\$$ the ability to **read data critically** and with comprehension;
$\$$ the ability to **produce data** that provide clear answers to properly posed questions;
$\$$ the ability to **apply and interpret** the results of a variety of **statistical techniques**, including both exploratory and inferential methods;
$\$$ an **understanding** of many of the **fundamental ideas of statistics**, such as variability, distribution, association, causation, sampling, experimentation, confidence, and significance;
$\$$ a **critical perspective** with which to **analyze and assess statistical arguments** such as one encounters in the popular press as well as in scholarly publications; and
$\$$ the ability to **successfully communicate** the conclusions of statistical studies.

**Prerequisites:**
There are no formal prerequisites for this course. Certainly, no prior knowledge of statistics is expected. The mathematical level of the course is that of high school algebra. Although we will use computers extensively, you need not have prior familiarity with them. I will provide you with detailed instructions concerning the use of the computer and the statistical package Minitab. What you do need to bring to the course are an open mind for tackling numerical questions in a conceptual manner and a willingness to participate actively in class. You should also plan to spend 2-3 hours of work outside class for each hour spent in class.

**Group Work:**
You will do much of the work in this course in cooperative learning groups of three to four students. You will be working with your group on in-class activities as well as on homework problems. Each group is to act as a team in which EACH PERSON IS ACCOUNTABLE for each other person=s learning with no one person dominating or doing all the work. Groups should sit together for each class and **will need to meet together outside of class**! Working well in a group is an important skill that is essential for many of the jobs for which E&H graduates apply. Some of you may enjoy group work more than others.

The objective of group work in this course is two-fold:
$\$$ To give you moral support while you are working problems or exploring ideas, and
$\$$ To develop skills in working effectively as part of a team.

**Participation:**
Regular class attendance is an indication of your interest in this course. **You are expected to attend class every day.** Some of the material in this course has a well-deserved reputation for being difficult. If you miss a class, you are expected to find out from your group members what happened, **BEFORE THE NEXT CLASS!!!!** Each week you will fill out a CLASS PARTICIPATION form. I will collect these and use them to check attendance, respond to your self-evaluation, and give you a score for class participation.

If you miss more than 3 classes you will be withdrawn from the course. If you attend all classes for the semester, you will receive 5 bonus points on your final exam. (There are no excused or un-excused absences allowed for these bonus points!)

**The Grade:**
Your grade in this course will be determined as follows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Tests:</td>
<td>45%</td>
</tr>
<tr>
<td>Quizzes, Worksheets (group work)</td>
<td>25%</td>
</tr>
<tr>
<td>Course Participation</td>
<td>8%</td>
</tr>
<tr>
<td>Final Exam (Comprehensive)</td>
<td>22%</td>
</tr>
</tbody>
</table>

You will have daily worksheets/homework assignments, all of which will be group assignments. For each of these assignments, please hand in ONE copy per group. The signature of each group member
who participated in solving the problems should be recorded on the first page of the assignment. A group MUST NOT ALLOW a group member to sign if he or she did not participate fully in doing that worksheet! LATE WORK WILL NOT RECEIVE A GRADE - NO EXCUSES!

Test Dates:
There will be three in-class tests, tentatively scheduled for the following classes:

Tuesday, February 6th    Thursday, March 8th    Thursday, April 19th

The date and time of the final exam for this course will be posted on the course web page as soon as they are available.

If you are unable to take a test for any reason, you must notify me in advance! This can be done by speaking with me in person, over the phone, or via email. There will be NO make-up tests or quizzes given- NONE! If you miss a test without contacting me in advance, you will receive a zero grade for that test.

Academic Honesty:
The work on tests and some quizzes must be your own. If you knowingly copy someone else=s answers, or knowingly let someone else copy your answers, you will receive an F(0) on the test/quiz and a 0 for the class participation grade. A second infraction will result in failure of the course.

Suggestions:
I offer the following suggestions for how to do well in this course:

1. **ASK QUESTIONS** (of me and your classmates) !!
2. Continually review the material throughout the semester.
3. Don=t get behind.
4. Don=t get overconfident.
5. Come to class.
6. Use my office hours.
7. Work together.
8. Practice the material in new situations.
9. Read carefully B before and after each class.
10. Write well.
11. Have fun!
12. THINK!

A common theme emerges from this list: You are responsible for your own learning. As your instructor, I view my role as providing you with contexts and opportunities that will facilitate the learning process. So if you ...

Need help?
Please feel free to come by my office or call me at home anytime to help you with this learning process. Success in this course requires a team effort. At a minimum that team consists of you, your group members, and me. If you need help - **ASK!!!!!!** If my office hours are not convenient for you, I am quite willing to set a time that is convenient for both of us B just **ASK!!!!!!** Moreover, please don=t wait until you have been having problems for two or three weeks. Understanding the material as we go along is crucial to success in this course.
Weekly Course Participation/Evaluation Form

Your weekly course participation form should include the following information:

1. Name, Date, and Course

2. Days present during the week

3. A list of at least one significant contribution to the group made by each member this week (including yourself), and any concerns/problems within the group or with individual members this week.

4. A rating of your own performance in this course this week (A, B, C, D, or F) and an explanation of your rating. This explanation should consider such things as: did you come to class late, early, or on time; were you prepared for class; did you: listen to others, ask questions, offer ideas, answer questions, attempt problems, participate in group discussions, disrupt the class, leave early, distract others in your group? How much productive work did you do outside of class?

5. A careful summary of what you learned in the course this week. Use complete sentences and include such things as: the most interesting/exciting idea of the week, the most confusing idea of the week, what concepts need more explanation. Whenever possible create examples (different from the ones in your text) to illustrate the various concepts learned during the week. "I learned about the standard deviation is insufficient!!!

6. You may also wish to include some suggestions for what your instructor could do to make next week's class better.

Your weekly summaries should serve as top-notch review sheets that you can use to prepare for tests and quizzes.
Sample Course Participation Form

1. Name: February 27, 2001 Math 160

2. I was present every day this week.

3. I think we covered a lot in our group this week. We all made sure that each group member understood the material covered in Chapters 9, 10, and 12. For example, Huie helped me to understand how to calculate coefficients of the least squares line. I think working in groups help me to understand how to do the problems more quickly and thoroughly than I would if I were working alone.

4. This week I would give myself a B+ for the week. I really made an effort to be on time to class this week. I was rather late the day it snowed, but the roads were quite treacherous coming from Damascus. I really felt that it was important to be in class. I am going to spend more time independently reviewing the work because I want to make sure I thoroughly understand the material. There is a lot of new material we covered.

5. This week in class we worked on chapters 9, 10, and 12. The activities we did in chapter 9 were a reinforcement of the concepts we learned earlier in chapter 9, concepts I covered I the previous week=s class participation sheet.

In chapter 10 we learned about the least squares regression, a formal mathematical model used to describe the relationship between two quantitative variables. In the equation of the least squares or regression line, y = a + bx, y is the response variable plotted on the vertical axis, and x is the explanatory variable plotted on the x-axis. The sample data determines the slope coefficient b and the intercept coefficient a. Least square means to choose the line that minimizes the sum of the square vertical distances from the point to the line B choose the line that produces the smallest sum of squared errors in those predictions. The regression line is used a method of prediction to predict the value of the y variable relation to the given variable of the x variable. Be careful of committing extrapolation. This big word means that one is trying to predict y for values of x beyond those contained in the data.

Each data point can be thought of as having two parts. One part is called the fit, the actual part explained by the statistical model. The second part is called the residual, which is the result of a chance variation, or of variables not being measured. With regard to least squares regression, the fitted value is the y value predicted by the regression line for the x value. To find the residual to measure the vertical distance from the observed y value, find the difference between the actual y value and the fitted one.

The proportion of variability (r squared, the square of the correlation coefficient) shows how closely the points fall to the least squares line and shows how accurate the predictions can be.

I liked and understood chapter 12 much better. (I may have to come ask you about chapter 11. I am still working everything out in it.) Chapter 12 dealt with sampling. Population is an entire group from which information is desired. One example could be ladybugs. The world is filled with a huge population of ladybugs, and most are in my house. Data on where the ladybugs live (my house) derived from a study would be a census. A sample is a small part of the population of ladybugs. My house would not contain a representative sample as it contains a large and disproportionate number of bugs. The number of observational units in a representative sample of bugs would be a sample size.

A sampling procedure is biased (which it would be if I went by just my house) when it systematically overrepresents and underrepresents sections of the population. Convenience samplesreach data which is readily accessible. Another problem with bias is voluntary response, leading to nonresponse, occurring when members of the population can choose whether or not to participate. (Clearly, the ladybugs could not choose this option). The sampling frame is the list used to select the subjects and may not accurately represent the population.

How does one avoid bias? Give every member an equal chance of being selected by using simple random sampling. A good way is to use a computer-generated table of random digits. Hopefully resulting from an unbiased sample, a parameter is a numerical characteristic of the population, and a statistic is a numerical characteristic of the sample? Question: would data from the U.S. census, which should be from the entire population be a parameter? A statistic can also be thought of as an unbiased estimate of a parameter. This is possible only if the statistic=s values, found from different samples, are centered at the parameter value.
Getting Started with Cooperative Learning Strategies

Changing the way we teach, particularly for successful teachers with many years of experience, is hard work. Here are a few suggestions for getting started. And remember that change is gradual processes, not an event, so don’t try to change everything all at once. Y

- When implementing a cooperative learning strategy, give very clear, step-by-step directions and check to make sure that students understand. Worksheets or handouts may be beneficial. These directions are crucial for the first few times that students try a given strategy; once they are experienced with it, directions can be minimal. The instructor needs to be flexible and sensitive to the class. If a question baffles most students, the instructor should resist the temptation to answer it directly; instead restate and redirect the question to the groups, or ask a simper version, or ask a question leading up to the original question.
- If an activity is not completed in the class period, the expectation that it be completed outside of class before the next class period, either individually or as a group, should be clear and explicit.
- Look for opportunities within the regular curriculum to use groups. Some of the time normally spent in lecture or traditional testing can be changed into group work. Look for regular textbook problems that lend themselves to group activities or strategies. Some texts are specifically designed to encourage cooperative learning, but even a traditional textbook will contain topics adaptable to group work.
- Expect that group activities will not necessarily go smoothly at first; it usually takes several weeks for students to begin functioning well in groups, even if the instructor is experienced and confident in using cooperative learning.
- An instructor new to cooperative learning may worry that group activities can allow weaker students to hide behind stronger ones and that an instructor might lose his sense of how well individual students understand the material. Our experience is that in most cases just the opposite occurs. The increased involvement demanded by cooperative learning makes students’ strengths and weaknesses more readily apparent. From watching the groups at work, an observant instructor usually will have a strong sense of who understands what and how well. This is frequently apparent to other students as well, providing strong motivation for greater efforts. Y Wandering around and listening to students’ working conversations can be very illuminating. At first this may inhibit the dialog, but if done regularly, students soon will learn to ignore the instructor (a disquieting but probably healthy phenomenon.)
- Consider informing your colleagues about what you are doing and why you are doing it. If possible find a support colleague who will try similar methods. Two faculty members working together can provide mutual support and can collaborative on designing activities. Even if your colleagues isn’t using cooperative learning in [her] own classes, having someone to talk to about your efforts to implement new pedagogical strategies is valuable.

After some time, many faculty members experience a qualitative leap in their comfort and ability with cooperative learning. They spontaneously begin to mix and match structures to fit their own personal style and the particular constraints of their teaching situation. This can create a dynamic and exciting classroom environment.

The ‘Nuts & Bolts’ of Cooperative Learning

Julie M. Clark
Hollins University
jclark@hollins.edu
References

References

References

Cooperative / Collaborative Learning

- A significant amount of the course work is done in cooperative groups
- A positive *esprit de corps* exists within the groups
- Team members share a feeling of mutual responsibility for each other
- Group work is included in the evaluation process
- Group membership is permanent and stable
Practical Implementation Issues

- Classrooms and computer laboratories
- Student orientation
- Groups
- Assessment
Classrooms and Computer Laboratories

- Need space –
  - To work as a group
  - To take notes
  - To work individually
  - For instructor to move between groups
- Clear view of board
Student Orientation

- The first few days of a course are crucial for establishing student attitudes and expectations.
- Group work is a mandatory, integral part of the course.
- Use community building group activities as a way of introducing students to cooperative learning and each other.
Student Orientation - Syllabus

- **Group work:**
  You will do much of the work in this course in cooperative learning groups of three to four students. You will be working with your group on in-class activities as well as on homework problems, each group is to act as a team in which EACH PERSON IS ACCOUNTABLE for each other person’s learning with no one person dominating or doing all the work. Groups should sit together for each class and **will need to meet together outside of class!**
Working well in a group is an important skill that is essential for many of the jobs for which Hollins University graduates apply. Some of you may enjoy group work more than others.

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- To give you moral support while you are working problems or exploring ideas, and
- To develop skills in working effectively as part of a team.
Groups

- Duration
- Size
- Formation / maintaining / monitoring
Groups - Duration

- Permanent –
  - Stable groups encourage responsibility and develop camaraderie
  - Can encourage better attendance

- Temporary / varying
  - May be necessary because of high attrition or absenteeism
Groups - Size

- 2
  - Absenteeism
  - Lack of diverse ideas and strengths

- 3 or 4 – ideal!

- More than 4
  - Scheduling (particularly out of class)
  - Seating
  - Division of work / members shirking work
Groups - Formation

- Random selection
  - Usually produces heterogeneous groups
- Pseudo-random selection
- Instructor selection
  - Surveys
- Student selection
Survey Criteria for Forming Groups

- Major or area of study
- Geography
- Social characteristics
- Weekly time schedule
- Academic background
- Previous cooperative learning experience
- Computer / keyboarding experience
- Student preferences
Characteristics of an Effective Group:

- Organizational skills
- Conflict resolution
- Expertise with technology
- Writing skills
- Quantitative skills
- Common times to meet outside of class
Helpful Group Behaviors

- Listening carefully to others
- Including everyone
- Disagreeing in an agreeable way
- Contributing ideas
- Being respectful and patient
- Checking for understanding
Nonproductive Group Behavior

- Dominating discussions
- Poor attendance / leaving early / arriving late
- Losing papers
- Being unreliable
- Being overly critical / afraid to disagree
- Being reluctant to contribute
Tasks / Roles of Individual Group Members

- Manager
- Recorder
- Conflict mediator
- Skeptic
- Quality controller / educator
Group Names

- Having each group choose a name for itself can promote a sense of unity and group identity, and allows the instructor to call on groups in class
  - Positive
  - Short
  - No profanity
Assessment

- Positive interdependence
- Individual accountability
Assessment: Fostering Group Cohesion/Responsibility

- Group grades – worksheets, quizzes, tests, projects
  - One grade per group
  - Average of individual grades
  - Weighted average of group and individual grades
Assessment: Maintaining Individual Responsibility

- Exams and quizzes
- Course participation form
Problems

- Groups working at different pace
- Slackers & skipping class
- Dominating members
- Refusal to work in groups
- Group fracturing in midterm
Good Luck!

jclark@hollins.edu