

THE IMPACT OF ABILITY GROUPING ON COLLEGE STUDENT'S PERFORMANCE  
IN INTRODUCTORY GEOLOGY LABS AT A MIDWESTERN UNIVERSITY

by

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## **Abstract**

There have been numerous studies done during the past hundred years on ability grouping. The majority of research has focused on the elementary and secondary levels, with very little done at the post-secondary level of education. Research shows at the K-12 levels high achieving students have a greater level of learning when placed in groups together. Mid-level students also show higher achievement in homogeneous groupings. Both high and mid-level students benefit from heterogeneous grouping, but with smaller gains. Lower ability students placed in homogenous groups have shown significant gains, but still perform better when grouped heterogeneously compared with classes that are not grouped by ability. All students show increases in learning when placed in small groups of any kind. Mid-level and low achieving students have higher levels of learning when they are taught by someone determined to close the gap, who takes the students' abilities into consideration, and focuses on increasing those abilities. Unfortunately, this often does not happen, and when students are grouped by ability, the higher achieving students do well, and the rest fall further behind.

This graduate research looks at the impact of skill grouping at the university level. Rather than separating students into different classes by ability, students were placed in purposeful groups within the class. Overall both homogeneous and heterogeneous groupings performed better than the control self-selected sections. One homogeneous quartile showed significant improvement in performance compared to the heterogeneously grouped students, but another homogeneous quartile showed a significant decline in scores. Gains in one subset of student should not come as a detriment to another subset of students, so homogeneous grouping is not recommended. Of the three grouping methods, only heterogeneous grouping showed significant increases in scores without harm to other students, and for this reason, this study recommends using a heterogeneous method of grouping students in future GEOL 103 classes.

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## **CHAPTER 1 - Purpose**

Classrooms are becoming increasingly diverse. Students have a broad range of goals, backgrounds, abilities, and needs. It has always been difficult for teachers to meet those needs, and increasing diversity and larger class sizes make the challenge even more difficult. In order to meet that challenge, teachers are constantly looking for ways to better meet the educational needs of their students. While ability grouping has been tried many times over the years, there have been enough positive outcomes to keep trying. Combining ability grouping with small-group instruction allows teachers to more specifically address the different issues their students face.

### **Ability grouping methods**

There are two ways to group students by ability. Homogeneous grouping is defined as dividing students into groups of similar ability, creating separate groups of high ability students and low ability students. Heterogeneous grouping is defined as mixing high and low ability students together. Students can either be grouped as an entire class, i.e. having all high ability students in one classroom and low ability students in another, or by separating students within a classroom into small ability groups. The latter is called within-class grouping and is the method used in this study.

### **The question to be answered**

While thousands of studies have been done with ability grouping on elementary and secondary students, few have researched the practice on college and university students. A search on the Education Resources Information Center (ERIC) database found only 15 peer-reviewed journal articles when prompted with “higher education” and “ability group” or “ability grouping” as search words. Only two of those results were written about science students. One studied misconceptions and put students into groups based on those they brought with them into their first-year biology course. The other was a study on how bias affects ability tests used in order to group students. Not a single article covered any of the specific topics found in this

graduate research. Broader database and internet searches found a similar lack of applicable research.

Many hundreds of students enroll in GEOL 103 every semester as one of the very few science classes they will take at the university level. With natural disasters and other geologic issues such as global warming and limited petroleum resources in the news on a daily basis, students will be dealing with concepts covered in the GEOL 103 course for the rest of their lives. It is the goal of this course that students learn about geology in a manner that will enable them to make informed decisions on where to locate a future business, on purchasing the materials they use in homes they build, and on avoiding injury in the event of earthquake or volcanic eruption.

To reach this goal, it is important to maximize student learning. This study focuses on the following: does ability grouping, organizing classrooms to combine those of similar ability, have an impact on student performance in the GEOL 103 labs?

## **CHAPTER 2 - Context**

### **History of ability grouping**

The practice of ability grouping is thought to have started in 1867 when W. T. Harris began to separate out the brightest of his students, more quickly promoting them through elementary school. Soon after, in what is known as the Santa Barbara Concentric Plan, elementary schools began to separate each grade into A, B, and C sections. The A section's work was more extensive than the B section, the B section's work more extensive than the C section (Kulik and Kulik, 1982). Thousands of studies on ability grouping have been done since, with a wide variety of results, and it is considered to be one of the most controversial issues in education (Slavin, 1990). In each of the following studies, the control group was a comparable non-grouped classroom(s).

The first serious research on homogenous grouping was done in 1916. Guy M. Whipple studied a class of 13 boys and 17 girls, chosen by their late elementary school teachers to participate in the first 'gifted' program. Whipple created special classes for these students and compared their performance with students in 'extra-dull' classes (Kulik and Kulik, 1982).

In Salt Lake City, Utah, in 1927, researchers identified and preassessed two equivalent groups of elementary students. Students in one group were separated by ability and placed into homogeneous classes while students in the other group were assigned to mixed-ability classes. Students were tested again at the end of the school year and those in the homogeneous group scored approximately two grade equivalents higher in mathematics than did similar-ability students in the heterogeneous class (Tieso, 2003).

By the late 1950s and 1960s, teachers would divide a class into ability-based reading groups and sometimes ability-based groups for mathematic instruction (Petty, 1954). In the 1970s and 1980s, teachers emphasized cooperative learning and often would divide students into heterogeneous groups (Lou et al, 1996). Studies during that time found that students performed better in the cooperative learning groups because others depended on their input; the group could not succeed without each student completing his or her task (Abrami et al, 1995).

Values have changed over time; during the 1950s, "excellence" was an education buzzword, and ability grouping within-class was viewed as beneficial for high ability students.

By the 1960s and 70s, equal opportunity was seen as more important than “excellence” for the few. Between-class grouping (separate classes based on ability) raised concerns for lower ability, disadvantaged students (Good and Marshall, 1984; Kulik and Kulik, 1987) with this subgroup separated from higher achieving students and therefore not benefiting from the collaborative exposure. Both of these concerns are still valid today.

### **Many approaches in grouping students**

Grouping for instruction can be made in a variety of ways. Teachers can assign students to groups, students can self-select their own groups, or groups can be established randomly. Grouping is, of course, not always based on student ability. Groups can be formed on student interests, common skills, or preexisting friendships. Conversely, groups can be formed specifically for diversity, with students of varying interests, skills, and friendships (Lou et al, 1996). Teachers must consider many factors when assigning students to instructional groups; clearly individual students’ needs and developmental level are the most important (Wilkinson, 1986). Adapting curriculum materials to the needs and abilities of students in the groups is essential, otherwise it is pointless to group them at all (Kulik and Kulik, 1987).

### **Arguments for and against ability grouping**

The arguments for and against ability grouping are as vast as the number of researchers who have studied it:

#### ***Homogenous grouping***

Homogenous grouping takes individual differences into account by allowing students to advance at their own rate with others of similar ability, and by offering them methods and materials geared to their level. More individual attention from teachers is possible. Students are challenged to do their best in their group, or to be promoted to the next level, within a realistic range of competition. It is easier to teach and provide materials for a narrower range of ability (Esposito, 1973).

Students attempt to keep pace with others in the group, especially if they have formed friendships as a result of the grouping. When groups are established on the basis of diverse interests, learning may be enhanced due to multiple perspectives (Lou et al, 1996). Medium and

high achieving students especially benefit as they are not required to slow their own pace of learning for lower achieving students (Mullen and Copper, 1994). Gifted students' feelings of superiority are tempered when in groups with others equally capable or even more knowledgeable about given topics than they are (Fiedler, Lange and Winebrenner, 2002).

Homogenous grouping allows the teacher to increase the pace of content instruction to the higher achieving students and give more repetition, review, and individualized attention to the lower achieving students. Also, because the students in each homogenous grouping are well matched in academic ability, they are more likely to engage in peer helping, debating, discussing content, and discovering solutions on their own (Lou et al, 1996). This social aspect in cognitive growth emphasizes higher order thinking skills (Piaget, 1954; Vygotsky, 1978). By working together, students learn to cooperate instead of compete, an aspect of learning that many students prefer. And in working closely with other students, they develop social and communication skills that may have otherwise not developed in the classroom (Lou et al, 1996).

Saleh, et al. (2005), studied 104 fourth graders in a Kuwait elementary school and found that middle and high ability students were found to have better outcomes in homogeneously grouped classrooms. Homogeneous grouping resulted in more collaboration and motivation for the middle and high ability students. Low ability students in homogeneous groups had increased student-teacher dialog, asking eight times as many questions as average ability students, but no significant increase in performance. Teachers were able to spend more time with the low ability students, as the average and high ability groups worked well independently.

However, it is impossible to achieve truly homogenous grouping, even along a single achievement variable, since test data are not generally reliable or valid enough for this type of distinction. Homogeneous grouping may provide less sensitivity to individual differences in children by giving the teacher the false sense that students are similar in social needs, achievement, and learning style. It tends to segregate children along ethnic and socioeconomic lines as well as ability. Homogeneous grouping affects the self-concept of all children adversely by placing a stigma on those in lower groups while giving high-group children an inflated sense of their own worth. (Esposito, 1973). Teachers must decide on what basis to form the homogeneous groups; academic factors are not always the most important, as developmental levels heavily influence learning as well (Wilkinson, 1986).

Additionally, if groups are maintained too long, students can miss out on opportunities to learn from others with different skills and talents and some groups will more quickly learn how to accomplish the tasks than others (Lou et al, 1996). Adjustments must be made as the students in homogenous groups learn at different rates. Groups need to be reformed often to accommodate the changes in individual student achievement (Ireson, Clark and Hallam, 2002b)

### ***Heterogeneous grouping***

Most adult life experiences do not occur in homogeneous settings, and students must learn to work with a wide range of people (Esposito, 1973). Heterogeneous groups may foster learning through the use of more elaborate explanations, as the teacher attempts to cover material in more than one way. The more advanced students gain teaching experience themselves by helping the lower ability students understand the material. Mixing students from various ability groups, groups they have likely been placed in for years, may better integrate students from all social circles, may avoid outcast situations, and may teach students tolerance and acceptance of all of their peers (Lou et al, 1996).

Burris et al. (2006), worked with 985 middle school students where mathematics instruction was accelerated using heterogeneous ability grouping. Their results showed that the probability of completion of advanced math courses increased significantly in all groups, including minority students, students of low socioeconomic status, and students in all initial achievement levels. Additionally, the performance of initially high achievers did not differ significantly in heterogeneous classes relative to previous homogeneous grouping, and rates of participating in advanced placement calculus and test scores improved.

Another Burris study (Burris et al, 2008) examined the long-term effects on the achievement of students in a diverse suburban high school on Long Island, New York, after all students were given accelerated mathematics in a heterogeneously grouped middle school. Struggling learners were supported with after-school workshops four days a week. Teachers stressed high expectations for all students, with a focus towards supplying enriched resources and curriculum. Science scores showed improvements as well, and the district decided to move all subjects to heterogeneous groupings. As a result, there was a 70% increase in the number of students earning an International Baccalaureate diploma, with a three-fold increase for White and

Asian students and a 26-fold increase for low socioeconomic minorities. Average scores remained high, even as the enrollment in International Baccalaureate classes increased.

There are drawbacks to heterogeneous groupings as well. Group members often turn to the most able student in the group for help. When this occurs, little interaction and engagement with the material can lead to students getting answers right and yet not understanding the concepts taught (Noddings, 1989). If the nature of the assessment is completely lower-level thinking skills, lower achieving students may miss out on learning entirely. However, if higher-level thinking skills are needed to answer the question, those students might still learn from the most able student as the thought process is more involved and students need to work harder to understand the explanation (Webb, 1989).

Another unintended result of heterogeneous grouping is an increase in highly gifted students' feelings of superiority (Fiedler, Lange and Winebrenner, 2002). These students, repeatedly getting the answers right and being able to offer complex ideas far ahead of other students in class discussions, often become arrogant. Without being challenged by intellectual peers, the possibility that they will develop an elitist attitude would increase.

### **Studies show mixed results**

One school district in Scotland allowed secondary schools to decide for themselves how to group classes in the English department (Boyd, 2007). One school retained the current heterogeneous grouping, three grouped the students homogeneously, and one maintained heterogeneous grouping but reduced class sizes. The teachers in the new higher level homogeneous classes were able to study more intensive works at a higher conceptual level and reported the new students as 'a joy to teach.' The teachers of the lower ability classrooms reported a slower pace of learning, poor student motivation, and more discipline problems. The school that remained heterogeneous showed good progress of all students, as did the school that reduced the size of their heterogeneous classrooms. In addition, the teachers of the reduced size classes reported higher student motivation and achievement and lower discipline referrals. The school district chose to return all schools to the heterogeneous grouping method with an effort to reduce class sizes when possible.

A study of math and science classes at fifty-one American middle schools produced typical results (Hoffer, 1992). Hoffer found that homogeneous grouping has no significant overall benefits in either science or mathematics. In both subjects, students in the high ability groups learn somewhat more (improvements of 18 to 26%) and students in the low ability groups learn less (decreases of 32 to 36%) than comparable students in heterogeneously grouped schools. Though the positive effects are weaker than the negative effects, more students are in the higher groups than the lower ones, and the overall effect of grouping turns out to be about zero. He states that homogeneous ability grouping in seventh- and eighth-grade mathematics and science is clearly not an optimal arrangement compared with the heterogeneous alternative, for low-group students are 'significant losers.'

In contrast, research on gifted students has shown that the highest ability students lose out the most if not placed homogeneously. These students, when placed full-time in special enriched or accelerated programs, show substantial gains in achievement. Rogers (2002) argues that gifted learners need some form of homogeneous grouping to 'effectively and efficiently' accomplish their academic goals. Most meta-analyses that recommend heterogeneous grouping for all students (Slavin, 1990; Kulik and Kulik, 1987; Gamoran, 1986) remove data from those in the top 5% of the school population. The omission of gifted students in research studies can lead to overgeneralizations by those who interpret the results.

Another study compared a homogeneously grouped gifted program with a heterogeneously grouped school in the same district to determine whether there were any significant differences in academic achievement, student attitudes, and student perceptions (Shields, 2002). Academically, the gifted program scored the expected higher performance one would expect. However, the differences in students' attitudes and perceptions were not so obvious: students in homogeneously grouped classes indicated greater development of career interests and students in the heterogeneous classes demonstrated greater academic self-confidence, even though their academic scores were lower than those in the gifted program. Students in the gifted program identified significantly higher teacher expectations, higher levels of teacher feedback, increased academic learning time, and more homework; at the same time, students in the heterogeneous classes reported lower teacher expectations, had less time spent on academic learning, and received less homework. There were no differences in student reports of peer relations, enjoyment of school, student autonomy, or independent development.



William and Bartholomew (2003) followed a cohort of 709 students over four years in six secondary schools in England. The students were grouped homogeneously in four divisions. The highest group scored half a grade higher on their end of year test than similarly able students had in the past. In addition, the lowest group scored half a grade lower on the test than expected. The groups in the middle showed minor improvements in scores. However, the researchers found that the teachers teaching the bottom group were the least qualified to teach and had lower expectations of their students, frequently gave their students undemanding lower-skill work, and used a narrower range of teaching approaches. Teachers in the highest group, while very qualified, often set the bar too high and students had difficulty keeping up. The same teachers of both grouping methods, when teaching heterogeneous classes, used a wider range of approaches and took greater account of individual differences.

A study by Ireson, et al. (2002a) interviewed teachers in 45 British high schools. Within all subjects grouped homogeneously, teachers reported a tendency for lower ability classes to have less access to the curriculum and to be taught in more structures ways, with more repetition and less discussion. In heterogeneous classes, teachers provided a greater variety of activities and more differentiated work. Teachers considered mathematics to be the least suitable subject for heterogeneous grouping. The humanities were considered the most suitable. Student performance in this study mirrored teacher beliefs, as only higher-level mathematics students showed gains in learning when grouped homogeneously. No academic gains were found in homogeneously grouped English or science classes when compared to heterogeneously grouped classes. The study found that the expectations of the teachers were influenced by the type of ability grouping in their classrooms and the performance of the students resulted directly from those expectations.

When secondary student preferences are studied, researchers found that the majority would choose to be grouped homogeneously (Hallam and Ireson, 2006). Sixty-percent of students in 45 high schools in Britain expressed a preference for homogeneous grouping. Even students currently enrolled in heterogeneously grouped schools showed a majority preference for homogeneously grouped classrooms. Students want the ability to choose classes at different levels for different subjects; results showed a desire to take lower level classes in subjects students did not feel confident in, yet also be able to take higher level classes in subjects they

enjoyed. Forty-seven percent of students chose homogeneous groupings in order to take classes with others at the same ability and be pushed further academically.

Student preferences are based on self-esteem and self-respect as much as academic achievement. One recommendation on how to fill classrooms is to allow students to choose their own grouping method. This would allow those typically under-represented in higher level homogeneous groupings the chance to see if they could succeed in such a classroom. Terwell (2005) argues that institutional barriers, feelings of inadequacy, and the wish not to leave the 'safe places' in lower ability groups may lead such students to avoid higher level classes even if given the choice. It is his opinion that schools should move away from offering homogeneous groupings entirely.

### **Ethics of ability grouping**

There is a concern that it is unethical to stigmatize lower-ability students by using ability grouping due to the fear that lower-ability students will be denied opportunities to learn and will be unmotivated to learn because of lower performance expectations by their teacher, their peers, and themselves (Oakes, 2005; Allan, 1991). Additionally, grouping by ability may actually serve to increase the already present divisions along racial, ethnic, and class lines (Rosenbaum, 1976).

It is also unethical to hinder the achievement of higher-ability students by assigning them to heterogeneous groups due to the likelihood that they will have already mastered the material given to them and because the pace of learning is below their capability; they are placed in the group not to learn themselves, but to teach others in the group (Oakes, 2005; Allan, 1991). Gifted students have just as much right to be challenged academically as other students. Including them in heterogeneous groupings to act as tutors for the other students is impeding their own right to a rigorous education (Fiedler, Lange and Winebrenner, 2002).

Hanushek and oßmann (2006) studied students in 4<sup>th</sup> and 8<sup>th</sup> grade across 26 countries and found that early homogeneous grouping increases educational inequality. Their research found that some countries based their grouping on family background, further solidifying the cycle of poverty and underachievement. Not a single case found overall improvement in scores; both high and low achievers had negative effects when students are placed in ability groups in

early elementary classes. In fact, initially low achieving students lost even more ground in achievement than high achieving students. Obviously, this is a strong ethical case against ability grouping.

A National Science Foundation study in 1986 (Oakes, 1990) found that schools most often place their least qualified mathematics teachers in low ability classes and their most qualified teachers in high ability classes, especially at the secondary level. The study also found that teachers of higher level courses spent more time preparing for class and appeared to be more enthusiastic and more willing to push their students to stretch academically than teachers of lower ability students. In heterogeneously grouped classrooms, lower ability students received less teacher time and were asked a fewer number of process-oriented questions. All of these results leads to larger gaps in learning, to the severe detriment of the lower ability students.

### **Literature review results**

The results of these thousands of studies are varied but there is a general consensus that higher ability students generally excel in homogeneous groupings and lower ability students generally do poorly in homogeneous groupings unless the quality of the instruction is a main focus (Kulik and Kulik, 1982; Slavin, 1990; Gamoran, 1986; Gamoran, 1992). Mid-level students also show higher achievement in homogeneous groupings. Lower ability students placed in smaller homogenous groups have shown significant gains, but still perform better when grouped heterogeneously. On average, homogeneous grouping is superior to heterogeneous grouping in small group instruction, but no one method of grouping was uniformly superior for promoting the advancement of learning for all students (Lou et al, 1996).

Small group instruction, regardless of type of instruction, results in across-the-board increases in student positive attitude, achievement, and self-concept compared to classes without grouping (Lou et al, 1996). Students learn interdependence, how to contribute to an overall group goal, and receive some sort of group reward. Differentiated instruction, teaching specifically towards the needs of each individual small group, brings the greatest gains in learning and achievement (Kulik and Kulik, 1987). Several studies of mathematics instruction have shown that homogeneous regrouping, formerly heterogeneous classes regrouped into homogeneous classes based on mathematics and reading achievement scores, had positive effects on mathematics achievement when materials appropriate for the students' level of performance

were used (Davenport, 1993). However, this is difficult on a long-term scale because it is expensive, time consuming, and requires much more training for teachers (Lou et al, 1996).

This graduate research differs from most of those in the literature, in that the instruction is consistent across all sections of the course, regardless of the grouping in each individual section. The sections are initially heterogeneous, as they're filled by the students as they enroll for the semester without any consideration for ability, and the groupings are done within-class rather than between-class. A few studies have covered this method, and have found that students assigned to groups within a heterogeneous classroom have found that such grouping clearly benefitted the students (Allan, 1991).

## **CHAPTER 3 - Study Population and Setting**

Kansas State University was founded as a private college in 1858 and became the United States' first land-grant school during the Civil War in 1863. It is now a large public research university with an enrollment of around 23,500. K-State has 60 academic departments in nine colleges, with over 250 undergraduate majors and degrees (Kansas State University, 2008). Undergraduates are primarily Arts and Science majors (34.2%), Engineering majors (15.6%), Business majors (13.5%), Agriculture majors (10.4%), or Education majors (7.7%). The Colleges of Architecture, Human Ecology, Technology and Aviation, and Veterinary Medicine make up the rest of the university's undergraduate enrollment. The graduate school offers approximately 100 degree programs. Overall, 53% of K-State students are male; 47% are female (Kansas State University Registrar's Office, 2009).

Students at K-State are predominantly Caucasian (81.3%), with small minorities of African American (3.5%), Hispanic American (3.2%), Asian American (1.4%), Native American (0.7%), multi-ethnic American (0.7%), and international (6.1%) students (Kansas State University Registrar's Office, 2009).

### **Course description**

The undergraduate geology laboratory course, GEOL 103, is taken by a wide variety of students. It is a required course for many different majors. Enrollment priority at K-State is based on seniority; because of this, there are more upperclassmen than one would expect in a 100 level course. Enrollment is limited to 24 students per section. The course is classified as an Undergraduate General Education course and is one of only two stand-alone science laboratories offered. Because of these two reasons, hundreds of students enroll in the course to meet the science requirements for their degree. For most students, this one of the few science courses they will take at the university level; it is critical that the course is taught well.

GEOL 103 is a required course for geology majors; however, there were no geology majors involved in this study.

## Student demographics

Data for this study were collected during the Spring 2008 semester. A total of 214 students were initially involved in the research. Data was collected using the 8 demographic items on the MBST. The demographics for the 200 students that remained in the study for the entire semester are as follows (totals vary due to non-responses):

**Table 3.1 Gender**

Male	n=64	34.6%
Female	n=121	65.4%

**Table 3.2 Age**

18-21 years	n=148	80.4%
22-26 years	n=27	14.7%
27-32 years	n=4	2.2%
33-40 years	n=27	14.7%
>40 years	n=3	1.6%

**Table 3.3 Ethnicity**

Caucasian	n=156	85.7%
Multi-ethnic	n=15	8.2%
African-American	n=4	2.2%
Hispanic	n=3	1.6%
Asian	n=1	0.5%
Other	n=3	1.6%

**Table 3.4 Class year**

Freshman	n=44	23.9%
Sophomore	n=75	40.8%
Junior	n=41	22.3%
Senior	n=24	13.0%

**Table 3.5 Major**

Arts, Humanities, Social Sciences	n=79	42.9%
Education	n=48	26.1%
Business Administration	n=41	22.3%
Science/Math	n=11	6.0%
Engineering	n=5	2.7%

**Table 3.6 Mother's education**

Did not graduate high school	n=3	1.6%
Graduated high school	n=41	22.3%
Attended some college or vocational school	n=59	32.1%
Has a bachelors degree	n=50	27.2%
Attended college beyond a bachelors level	n=31	16.8%

**Table 3.7 Father's education**

Did not graduate high school	n=3	1.7%
Graduated high school	n=30	16.6%
Attended some college or vocational school	n=57	31.5%
Has a bachelors degree	n=48	26.5%
Attended college beyond a bachelors level	n=43	23.8%

### **Setting**

There were 15 sections of GEOL 103 in the Spring 2008 semester. The course is taught by Graduate Teaching Assistants (GTAs). Each GTA is assigned to teach three sections of the course that work the best with his or her class schedule. There were a total of five GTAs teaching the course; three participated in this study.

The laboratory has four large student tables in the center of the room with six chairs per table. There are more tables around the outside of the room, with a large teacher's table at the front near the chalkboard and projector screen. Each table holds a group of six students that generally work together to complete assigned work. The optimal size for group learning is three to four students; groups larger than six do not show significant improvement over non-grouped classrooms (Kulik and Kulik, 1987).

The course includes a series of laboratories designed to teach students about the basic principles of physical geology, including plate tectonics, minerals, rocks, fossils, weathering and

erosion, geologic time, geologic structures, topographic and geologic maps, volcanoes, earthquakes, and petroleum geology. Course assessment includes individually-completed quizzes given at the start of class based on material the students were to have read for that day's class, labs that are handed in separately but worked on as a group, and two individually-taken exams. Success in the course is based on student performance on the labs (11), quizzes (10), and two exams (midterm and final). Student final grades are the summation of all of these assessments.



## **CHAPTER 4 - Methods**

Students were administered a basic math skills test during the second week of class, after most enrollment issues were settled. Students were assigned to groups based on their scores on the math instrument. Within and between each type of grouping (homogeneous, heterogeneous, and self-select), individual grades throughout the semester (quizzes and exams) were compared to group grades (laboratory assignments) to determine the effect that grouping had on their learning.

### **IRB approval**

In accordance with K-State regulations, an application for approval to conduct research on human subjects was submitted at the start of the study semester, Spring 2008. Students read and signed consent forms agreeing to participate in the research. All students were over 18 years of age, so no parental permissions were required. The IRB Committee granted an exemption and approved the project (IRB# 4555).

### **Section selection**

Three of the five GEOL 103 GTAs were selected to participate in the study. GTAs were chosen based on their interest and willingness to participate in the project. Each GTA taught three sections, assigned to accommodate their own class and research schedule. Two, both male, were experienced (GTAs 1 and 2) and the third was teaching her first semester (GTA 3). Each GTA taught sections that used each of the three grouping types. The nine sections were scattered throughout the week (Table 4.1).

**Table 4.1 Sections selected for study**

Section	GTA	Type	Day	Time
1	1	SS	Mon	AM
2	1	HO	Mon	noon
3	2	SS	Tues	AM
4	3	HO	Tues	PM
5	1	HE	Wed	noon
6	2	HO	Wed	PM
7	2	HE	Thurs	AM
8	3	HE	Fri	AM
9	3	SS	Fri	noon

### **Math Proficiency Basic Skills Test**

The GTAs distributed a Mathematics Proficiency Basic Skills Test (MBST, Appendix A) in class to all of their students at the beginning of the semester. The instrument was co-created by Dr. Iris Totten and the Office of Education, Innovation and Evaluation at K-State. It includes three sections: 1) 29 multiple choice mathematic calculations, 2) 23 five-point Likert-scale self-efficacy questions, and 3) 8 personal background/demographic items. Students recorded their responses on scantron forms and returned it to the GTAs. The data were then entered into an Excel spreadsheet for analysis. Student responses to the 23 five-point Likert-scale self-efficacy questions were not examined in the study.

Previous studies have linked math skills and ability in science (Benbow and Minor, 1986; Britton et al, 2005). Benbow and Minor found that high school students who were mathematically talented tend to have favorable attitudes towards science and have higher achievement than those not as strong in math skills. Britton et al. studied the ability of first year university students to transfer their understanding of mathematics concepts into scientific contexts: “confirming the obvious prediction that students who score well in mathematics would tend to score better in science.”

The MBST itself was composed of 29 questions. Questions 1 through 4 required students to identify the numeric position of a point along a number line. Questions 5 through 7 consisted of addition problems, with nine or ten 2- to 4-digit numbers lined up appropriately in a column. Questions 8 through 14 tested students understanding of simple fractions, both in the abstract (numerator and denominator definitions) and in practice (dividing one number by another).

Questions 15 through 19 required students to calculate the mean (average) of a set of numbers. Questions 20 through 25 asked about concepts of powers, including what the exponent is called and basic computations on the powers of 0, 1, 2, 3, and 4. The last four questions, 25 through 29, required students to calculate the numerical equivalence for base-10 logarithms.

### Student removal from study

A total of 214 students completed the consent form and MBST. Fourteen students were removed from the study for the following reasons: nine students dropped the course in the first month, one student missed the midterm exam, and four students did not take the final exam. These students did not have the full set of course grades necessary to be included in the study. The first nine stayed in the class only through the first few labs and the last five missed one of the two exams. Because of the small number of exams, the score of only one exam reports their understanding of only half of the course.

### MBST student scores

The following tables show student scores on the MBST for each section. Figure 4.1 illustrates student scores on the assessment.

**Table 4.2 Self-select sections**

Section	Scores, in order from highest to lowest										
1	1	2	3	4	5	6	7	8	9	10	11
	96.55	96.55	93.10	93.10	89.66	86.21	82.76	82.76	82.76	79.31	79.31
	12	13	14	15	16	17	18	19	20	21	22
	75.86	75.86	75.86	72.41	72.41	68.97	68.97	65.52	65.52	58.62	48.28
3	1	2	3	4	5	6	7	8	9	10	11
	96.55	86.21	82.76	82.76	82.76	82.76	79.31	79.31	79.31	79.31	75.86
	12	13	14	15	16	17	18	19	20	21	22
	75.86	75.86	75.86	68.97	62.07	55.17	48.28	31.03	27.59	NA	NA
9	1	2	3	4	5	6	7	8	9	10	11
	100.00	100.00	100.00	96.55	96.55	93.10	93.10	89.66	86.21	86.21	86.21
	12	13	14	15	16	17	18	19	20	21	22
	82.76	82.76	79.31	79.31	79.31	75.86	72.41	72.41	68.97	65.52	44.83

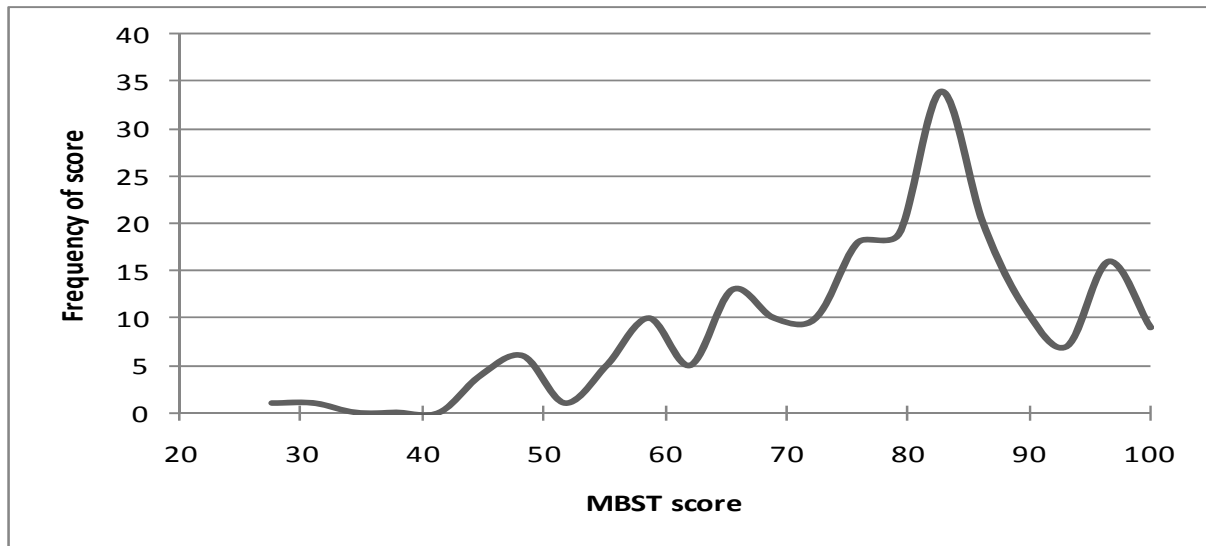
**Table 4.3 Heterogeneous sections**

Section	Scores, in order from highest to lowest											
5	1	2	3	4	5	6	7	8	9	10	11	12
	96.55	89.66	89.66	86.21	86.21	86.21	82.76	82.76	82.76	82.76	82.76	82.76
	13	14	15	16	17	18	19	20	21	22	23	24
	79.31	79.31	79.31	75.86	75.86	72.41	68.97	65.52	65.52	58.62	58.62	55.17
7	1	2	3	4	5	6	7	8	9	10	11	12
	100.00	96.55	96.55	96.55	86.21	82.76	82.76	82.76	82.76	82.76	82.76	82.76
	13	14	15	16	17	18	19	20	21	22	23	24
	79.31	75.86	75.86	68.97	65.52	62.07	55.17	44.83	27.59	NA	NA	NA
8	1	2	3	4	5	6	7	8	9	10	11	12
	100.00	100.00	89.66	89.66	86.21	86.21	86.21	82.76	82.76	82.76	82.76	82.76
	13	14	15	16	17	18	19	20	21	22	23	24
	79.31	75.86	75.86	72.41	68.97	65.52	65.52	65.52	62.07	51.72	NA	NA

**Table 4.4 Homogeneous sections**

Section	Scores, in order from highest to lowest											
2	1	2	3	4	5	6	7	8	9	10	11	12
	100.00	100.00	100.00	86.21	86.21	82.76	82.76	82.76	79.31	75.86	75.86	72.41
	13	14	15	16	17	18	19	20	21	22	23	24
	68.97	68.97	68.97	58.62	48.28	62.07	58.62	55.17	48.28	NA	NA	NA
4	1	2	3	4	5	6	7	8	9	10	11	12
	96.55	96.55	89.66	89.66	86.21	86.21	93.10	82.76	79.31	79.31	79.31	75.86
	13	14	15	16	17	18	19	20	21	22	23	24
	75.86	72.41	72.41	72.41	65.52	65.52	65.52	58.62	58.62	58.62	48.28	48.28
6	1	2	3	4	5	6	7	8	9	10	11	12
	96.55	96.55	96.55	96.55	96.55	93.10	93.10	89.66	89.66	89.66	86.21	86.21
	13	14	15	16	17	18	19	20	21	22	23	24
	86.21	86.21	82.76	82.76	82.76	79.31	65.52	62.07	58.62	58.62	44.83	NA

**Figure 4.1 MBST Frequency**



**Establishing groups**

Student scores on the MBST were listed in order from highest (#1) to lowest (#24); homogeneous and heterogeneous groups were established as shown in Table 4.5. Students in self-select sections chose their own seats. The average score on the MBST was 77.41%. 67% of the sample scored above a 75%. Only 13 students (6.5%) scored below 50%. Nine students (4.5%) scored 100%.

**Table 4.5 MBST score grouping**

Homogenous			
Table A	Table B	Table C	Table D
1, 2, 3, 4, 5, 6	7, 8, 9, 10, 11, 12	13, 14, 15, 16, 17, 18	19, 20, 21, 22, 23, 24

Heterogeneous			
Table A	Table B	Table C	Table D
1, 24, 5, 20, 9, 16	2, 23, 6, 19, 10, 15	3, 22, 7, 18, 11, 14	4, 21, 8, 17, 12, 13

Each GTA had one section grouped homogeneously, one grouped heterogeneously, and one self-selected (Table 4.1). Students who did not agree to participate (i.e. did not sign the consent form) were seated apart from the other students to avoid contaminating the results of the study. The GTAs ensured that these groups were maintained through the semester.

## **Method of instruction**

This research does not study variations in the method of instruction. All three groupings, homogeneous, heterogeneous, and self-select, were taught the same way. The GTAs did not know how each section was grouped. The groupings were established specifically to control for teaching and grading variation by assigning every GTA one of each of the three types of groups: homogeneous, heterogeneous, and self-select.

## **Retrieval of course grades**

The GEOL 103 course grades are maintained on the K-State Online website. At the end of the semester, all quiz, lab, and exam grades were downloaded from the website and saved to Excel. The results from the MBST were added to the spreadsheet. Once student grades and MBST results were correlated, student numbers replaced names to create complete anonymity for the participants.

## **Statistical methods**

Mean, median, mode, and standard deviation were calculated using Microsoft Excel. Comparative statistical analyses were completed using SPSS with the help of Yoonsung Jung, a doctoral candidate in the K-State Statistics Department. Further t-test calculations were completed in Microsoft Excel. ANOVA and t-test (Least Squares Difference) analyses were used to find p-values to the 95% confidence level. At a 95% confidence level, the p-value equals 0.05. Anything that is below this value is considered significant. For the purposes of this graduate research, a 1-tail, type 2 t-test was used.

The SPSS Generalized Linear Model (GLM) procedure used the method of least squares to determine if there was a statistical difference between the nine GEOL 103 sections.

## CHAPTER 5 - Results

### MBST scores

An ANOVA test was used to statistically compare the nine GEOL 103 sections at the start of this study. There was no overall significant difference ( $p = 0.0924$ ). However, there were a few sections that were statistically similar. On average, the four section pairs that exhibited significance did not override the other thirty-two section pairs with no statistical similarity, leaving an overall non-significance for the data. Table 5.1 shows the difference between the averages of student MBST scores between each of the nine sections when compared with each other. Areas of statistical significance are highlighted in gray. Sections three and nine were self-select sections; sections four and six were homogeneously grouped.

**Table 5.1 Difference between section averages –MBST**

Sections	1	2	3	4	5	6	7	8
9	7.053	4.385	11.708	10.242	5.576	0.455	7.397	6.076
8	0.977	1.690	5.632	4.167	0.500	6.531	1.322	
7	0.345	3.012	4.310	2.845	1.822	1.322		
6	7.508	4.840	12.163	10.697	6.031			
5	1.477	1.191	6.132	4.666				
4	3.190	5.857	1.466					
3	4.655	7.323						
2	2.667							

### Descriptive statistics

Microsoft Excel was used to calculate the average, median, mode, and standard deviation for each of the three grouping types. The three self-select sections were compiled as a group, as were the three heterogeneous sections. The homogeneous sections were compiled as a group, but also separately by quartile.

### *Self-select sections*

Self-selected (SS) section statistics (n= 64) were compiled as a group (Table 5.2). The self-select sections did not score the highest average, median, or mode on any of the assessments compared to the other grouping methods.

**Table 5.2 Self-select descriptive statistics**

	MBST	Lab	Quiz	Exam	Total
Average	76.72	91.53	84.60	82.60	86.81
Median	79.31	93.18	86.67	84.63	87.70
Mode	82.76	93.18	92.22	85.00	94.31
St. Dev.	15.19	5.33	10.07	9.08	5.94

### *Heterogeneous sections*

Heterogeneous (HE) section statistics (n= 67) were also compiled as a group (Table 5.3). The heterogeneous sections did not score the highest average, median, or mode on any of the assessments compared to the other grouping methods.

**Table 5.3 Heterogeneous descriptive statistics**

	MBST	Lab	Quiz	Exam	Total
Average	76.97	94.14	81.34	83.16	87.18
Median	81.03	83.50	95.23	87.78	88.24
Mode	82.76	95.23	94.44	85.00	94.71
St. Dev.	13.73	10.89	4.14	12.88	6.77

### *Homogeneous sections*

Table 5.4 shows homogeneous (HO) sections (n=69) data when compiled as a group. The homogeneous sections compiled as one group scored the highest median and mode on lab scores, the highest average and mode on quiz scores, the highest average and mode on exam scores, and the highest average and median on total course scores when compared to the heterogeneous and self-select sections.

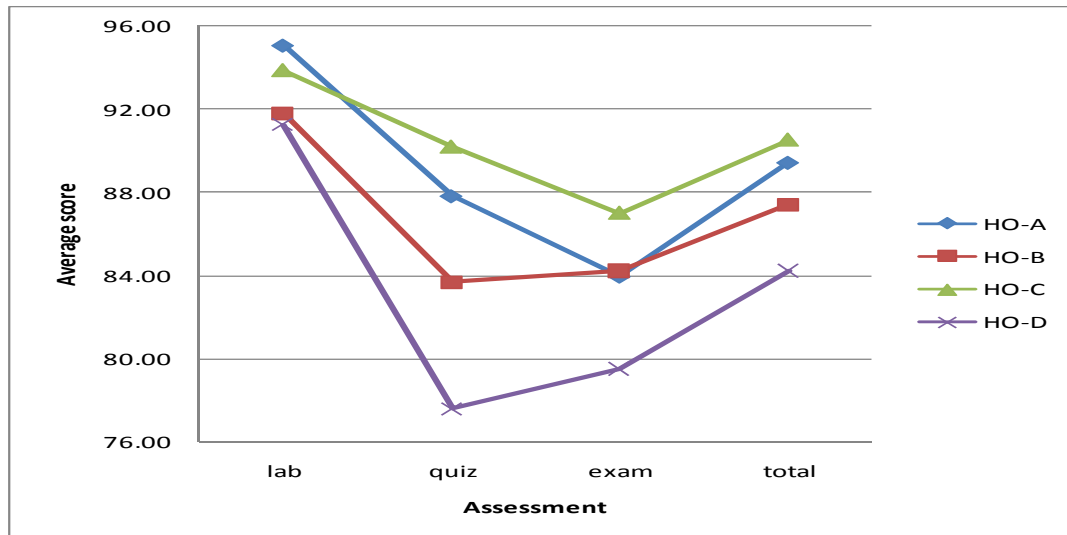


**Table 5.4 Homogeneous (Total) descriptive statistics**

	MBST	Lab	Quiz	Exam	Total
Average	78.16	93.01	84.86	83.71	87.93
Median	82.76	95.68	88.89	86.00	90.20
Mode	86.21	96.14	100.00	93.50	93.63
St. Dev.	14.93	7.77	12.29	10.02	7.72

However, the students in these sections were grouped so that each table held a specific quartile of the class. Therefore, Table A consisted of the highest quartile of scores on the MBST. Table B consisted of the second quartile, and so on. Figure 5.1 compares the average scores from each quartile on each of the assessments.

**Figure 5.1 Homogenous group average assessment scores**



The first homogeneous quartile, Table A (n=18, Table 5.5), scored the highest average, median, and mode on the MBST (by design). The quartile also recorded the highest lab average and median exam scores when compared to the heterogeneous, self-select, and other homogeneous quartile groups.

**Table 5.5 Homogeneous (Table A) descriptive statistics**

	MBST	Lab	Quiz	Exam	Total
Average	93.10	95.09	87.84	83.97	89.45
Median	96.55	95.80	90.56	89.00	92.16
Mode	96.55	93.86	91.67	93.00	93.63
St. Dev.	5.67	2.53	9.88	10.25	6.29

The second homogeneous quartile, Table B (n=19, Table 5.6), recorded the highest lab median and mode scores, and the highest quiz mode when compared to the when compared to the heterogeneous, self-select, and other homogeneous quartile groups.

**Table 5.6 Homogeneous (Table B) descriptive statistics**

	MBST	Lab	Quiz	Exam	Total
Average	81.99	91.81	83.68	84.22	87.40
Median	81.03	96.14	88.89	84.25	88.53
Mode	79.31	96.14	100.00	94.00	NA
St. Dev.	5.98	11.96	13.48	8.55	8.92

The third homogeneous quartile, Table C (n=16, Table 5.7) recorded the highest average quiz score, the highest average and mode exam score, and the highest average and median total course grade when compared to the heterogeneous, self-select, and other homogeneous quartile groups.

**Table 5.7 Homogeneous (Table C) descriptive statistics**

	MBST	Lab	Quiz	Exam	Total
Average	71.77	93.85	90.17	87.00	90.51
Median	70.69	95.34	93.06	88.38	92.94
Mode	82.76	94.55	98.89	94.00	92.94
St. Dev.	10.48	4.20	9.07	7.60	5.17

Finally, the fourth homogeneous quartile, Table D (n=16, Table 5.8), scored the highest lab mode score when compared to the heterogeneous, self-select, and other homogeneous quartile groups.

**Table 5.8 Homogeneous (Table D) descriptive statistics**

	MBST	Lab	Quiz	Exam	Total
Average	56.74	91.26	77.60	79.52	84.25
Median	58.62	94.09	75.28	79.75	83.63
Mode	58.62	96.14	NA	93.50	NA
St. Dev.	10.15	8.12	13.24	12.65	8.88

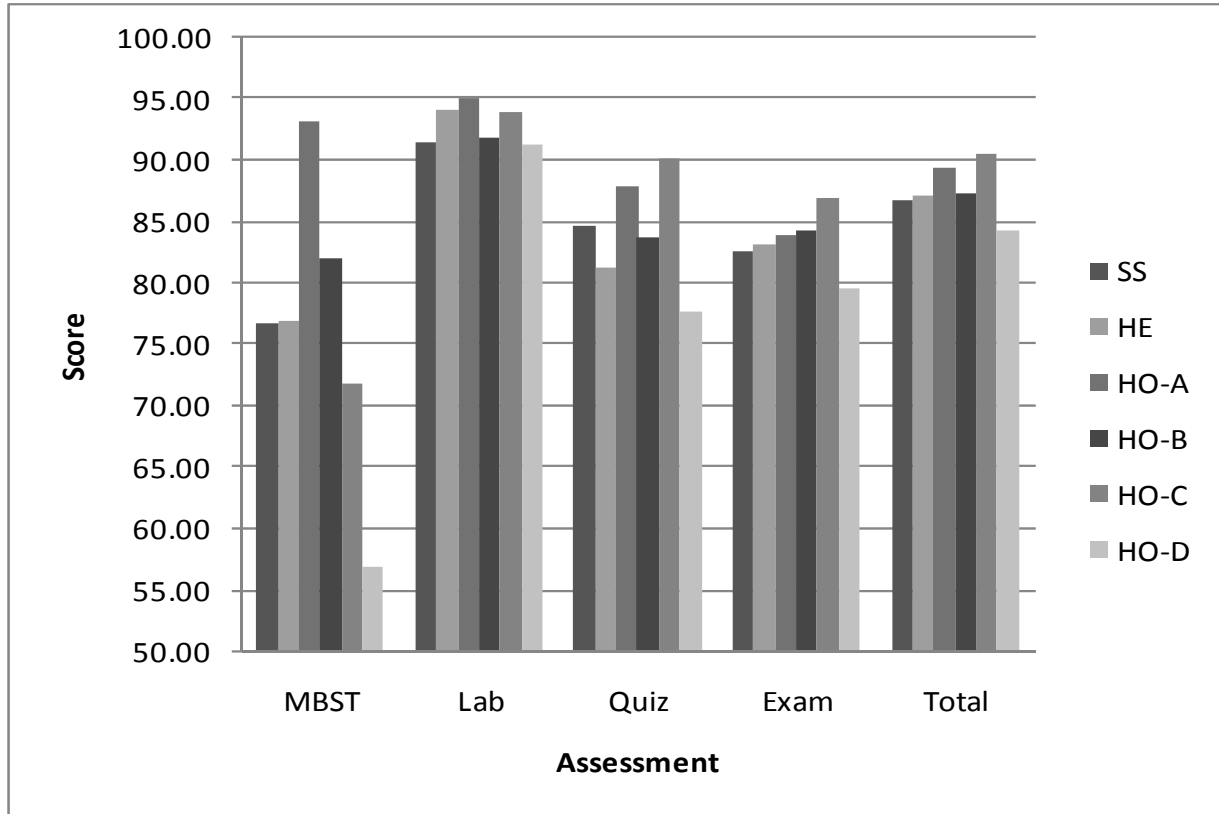
Table 5.9 lists the descriptive statistics of all assessments across all ability group types. The three self-select sections and the three heterogeneous sections are combined into one. The three homogeneous first quartile sections are combined (HO-A), as are the three second quartile sections (HO-B), etc. The highest average, median, and mode for each assessment are highlighted in gray; the HO-B and HO-D quartiles have the same mode score on the lab.

**Table 5.9 Scores across all ability groups**

		MBST	Lab	Quiz	Exam	Total
SS	Average	76.72	91.53	84.60	82.60	86.81
	Median	79.31	93.18	86.67	84.63	87.70
	Mode	82.76	93.18	92.22	85.00	94.31
	St. Dev.	15.19	5.33	10.07	9.08	5.94
HE	Average	76.97	94.14	81.34	83.16	87.18
	Median	81.03	83.50	95.23	87.78	88.24
	Mode	82.76	95.23	94.44	85.00	94.71
	St. Dev.	13.73	10.89	4.14	12.88	6.77
HO-A	Average	93.10	95.09	87.84	83.97	89.45
	Median	96.55	95.80	90.56	89.00	92.16
	Mode	96.55	93.86	91.67	93.00	93.63
	St. Dev.	5.67	2.53	9.88	10.25	6.29
HO-B	Average	81.99	91.81	83.68	84.22	87.40
	Median	81.03	96.14	88.89	84.25	88.53
	Mode	79.31	96.14	100.00	94.00	NA
	St. Dev.	5.98	11.96	13.48	8.55	8.92
HO-C	Average	71.77	93.85	90.17	87.00	90.51
	Median	70.69	95.34	93.06	88.38	92.94
	Mode	82.76	94.55	98.89	94.00	92.94
	St. Dev.	10.48	4.20	9.07	7.60	5.17
HO-D	Average	56.74	91.26	77.60	79.52	84.25
	Median	58.62	94.09	75.28	79.75	83.63
	Mode	58.62	96.14	NA	93.50	NA
	St. Dev.	10.15	8.12	13.24	12.65	8.88

Figure 5.2 illustrates the average scores for each assessment across all ability groups. The total average score for each assessment type, across all ability groups is as follows: MBST, 77.41%; lab, 92.92%; quiz, 84.21%; exam, 82.56%; and total course average, 87.32%.

**Figure 5.2 Average scores across all ability groups**



### Comparing group types and assessments

There were four areas of significance in the lab averages across the groups (Table 5.10). The first homogeneous quartile (HO-A, 95.09%) compared with the last homogeneous quartile (HO-D, 91.26%) has a p-value of 0.0332. The HO-A quartile is also significantly different from the self-selected sections (SS, 91.53%), with a p-value of 0.0038, which is then different from the heterogeneous grouped sections (HE, 94.14%) with a p-value of 0.0011. The heterogeneous sections are also significantly different from the HO-D quartile, with a p-value of 0.0233.

Additionally, when comparing the homogeneous HO-A quartile with the comparable self-select top quartile (91.72%), the p-value was still significant (0.0310). The difference

between the homogeneous HO-D quartile and the comparable bottom heterogeneous quartile (94.26%) was also significant ( $p = 0.0124$ ).

**Table 5.10 Statistical significance in average lab scores**

Group (Average)		p-value
HO-A (95.09)	HO-D (91.26)	0.0332
HO-A (95.09)	SS (91.53)	0.0038
HE (94.14)	SS (91.53)	0.0011
HE (94.14)	HO-D (91.26)	0.0233

These results show that grouping based on math ability did, in fact, make a significant difference on the lab scores. The HO-A group not surprisingly earned a higher average on labs than the HO-D group and the self-select control group. On this assessment, the argument found in the literature that homogeneous grouping does a disservice to lower ability students seems to hold true, as the heterogeneously grouped sections also had higher scores than the HO-D group. In addition, the heterogeneously grouped sections earned a higher lab average than the self-select sections. Grouping students into heterogeneous groups improves lab scores compared to letting them randomly sit where they want.

Five areas of significance were found in comparing quiz averages (Table 5.11). The HO-A quartile averaged 87.84% on the quizzes, the heterogeneously grouped students scored an 81.34% average, and the HO-D quartile earned an average of 77.60%. The differences between the HO-D quartile and the HO-A quartile ( $p = 0.0061$ ) and the HO-D quartile with the self-select sections ( $p = 0.0113$ ) are both significant. The third homogeneous quartile, with an average of 90.17%, was significantly higher than the heterogeneous sections (81.34%,  $p = 0.0215$ ), the self-select sections (84.60%,  $p = 0.0236$ ), and the HO-D quartile (77.60%,  $p = 0.0019$ ).

Additionally, when comparing a homogeneous quartile to the comparable self-select and heterogeneous quartile, two of the three significances still held true. The third homogeneous quartile (HO-C) was statistically higher than the third heterogeneous quartile (80.65%) with a p-value of 0.0164 and also statistically higher than the third self-select quartile (81.08%) with a p-value of 0.0037. However, when comparing the HO-D quartile with the fourth self-select quartile (80.80%), the p-value was a not significant 0.2298.

**Table 5.11 Statistical significance in average quiz scores**

Group (Average)		p-value
HO-A (87.84)	HO-D (77.60)	0.0061
SS (84.60)	HO-D (77.60)	0.0113
HO-C (90.17)	HE (81.34)	0.0215
HO-C (90.17)	SS (84.60)	0.0236
HO-C (90.17)	HO-D (77.60)	0.0019

As expected, the HO-A and HO-C quartiles performed higher than the HO-D quartile. Again, the literature appears to hold true, as the self-selected sections earned a higher score on the quizzes than the HO-D quartile. However, the quizzes cover material that the students are required to read before the start of class. The students have not worked with each other on the concepts to be assessed on the quiz. Differences in scores on the quiz are more likely to be a result of the students' preparation, rather than the groups in which they were placed, and the seemingly odd placement of the third quartile over the heterogeneous and self-select groups is likely a result of this.

Three areas of significance were found in comparing exam scores (Table 5.12). The third homogeneous quartile (HO-C, 87.00) scored higher than the heterogeneous sections (83.16%,  $p = 0.0265$ ), the self-selected sections (82.60%,  $p = 0.0390$ ), and the HO-D quartile (79.52%,  $p = 0.0257$ ).

Again, when comparing the HO-C quartile with each of the comparable heterogeneous (80.34%) and self-select (82.61%) quartiles, both are also statistically significant with p-values of 0.0197 and 0.0491 respectively.

**Table 5.12 Statistical significance in average exam scores**

Group (Average)		p-value
HO-C (87.00)	HE (83.16)	0.0265
HO-C (87.00)	SS (82.60)	0.0390
HO-C (87.00)	HO-D (79.52)	0.0257

The strength of the third homogeneous quartile on the exams is a strong argument for homogeneous grouping. It is not surprising that they scored higher than the fourth homogeneous

quartile, but it is surprising that they performed better than the heterogeneous and self-selected sections.

### **Demographics**

There were no significant differences found between grouping type and gender ( $p = 0.2025$ ), grouping type and race/ethnicity ( $p = 0.8110$ ), grouping type and class year ( $p = 0.0663$ ), grouping type and major ( $p = 0.3910$ ), grouping type and mother’s education ( $p = 0.6108$ ), or grouping type and father’s education ( $p = 0.5683$ ).

However, there were a few areas of significance comparing class years (Table 5.13): freshmen and juniors ( $p = 0.0001$ ), freshmen and seniors ( $p = 0.0455$ ), and sophomores and juniors ( $p = 0.0013$ ). Another significant difference (Table 5.14) is found between the Caucasian students ( $n = 156$ ) and those of non-Caucasian decent ( $n = 26$ ), with a  $p$ -value of 0.0003.

**Table 5.13 Statistical significance between class years**

Class year		p-value
Freshmen	Juniors	<0.0001
Freshmen	Seniors	0.0455
Sophomores	Juniors	0.0013

**Table 5.14 Statistical significance in student race**

Race		p-value
Caucasian	Non-caucasian	0.0003

Although there were no statistical differences between male and female performance on the MBST, there were some expected results in the make-up of the sections that resulted from students’ performance on the assessment (Table 5.15). Males are known to perform well in math and science (Spelke, 2005). 42.31% of the males assigned to homogeneous sections scored well enough on the MBST to be placed in the highest quartile; if distributed evenly, this value would be only 25%. Gender differences are expanded in Table 5.16, comparing gender, ability grouping type, and average scores on each assessment category. The highest average in each category is highlighted in gray.

**Table 5.15 Gender breakdown of grouping types**

	Female		Male	
	n = 121	% of total	n = 64	% of total
SS	39	21.08%	22	11.89%
HE	45	24.32%	16	8.65%
HO	37	20.00%	26	14.05%
	n = 37	% of HO	n = 26	% of HO
HO-A	7	18.92%	11	42.31%
HO-B	13	35.14%	5	19.23%
HO-C	8	21.62%	8	30.77%
HO-D	9	24.32%	2	7.69%

**Table 5.16 Gender breakdown of grouping types by assessment category**

Group	Gender	MBST	Lab	Quiz	Exam	Total
All	F	77.37	93.22	84.29	83.02	87.65
	M	78.45	92.54	84.94	83.09	87.49
SS	F	78.69	92.06	86.47	84.16	87.97
	M	73.98	90.92	81.64	80.55	85.21
HE	F	78.08	94.31	83.40	82.08	87.59
	M	78.02	94.60	83.78	82.34	87.89
HO-A	F	92.61	95.39	87.94	84.61	89.85
	M	93.42	94.90	87.78	83.57	89.20
HO-B	F	81.96	93.55	80.94	82.21	86.88
	M	82.07	88.00	88.33	87.60	87.90
HO-C	F	68.10	94.49	87.29	84.31	89.23
	M	75.43	93.21	93.06	89.69	91.80
HO-D	F	57.85	89.49	78.64	81.61	84.49
	M	51.72	89.43	73.89	76.75	81.72

Some of the descriptive statistics appear significantly large, an example is the quiz grades for the HO-B group, a t-test analysis reports very few areas of significance within the 95% confidence level (Table 5.17). Only the quiz and total scores in the self-select section show statistical significance, highlighted in gray.



**Table 5.17 t-test analysis: gender breakdown of grouping types by assessment**

ALL	MBST	Lab	Quiz	Exam	Total
M/F	0.3127	0.2343	0.3601	0.4823	0.4403
SS	MBST	Lab	Quiz	Exam	Total
M/F	0.1244	0.2092	0.0326	0.0606	0.0360
HE	MBST	Lab	Quiz	Exam	Total
M/F	0.4927	0.4025	0.4595	0.4641	0.4357
HOA	MBST	Lab	Quiz	Exam	Total
M/F	0.3893	0.3500	0.4873	0.4206	0.4192
HOB	MBST	Lab	Quiz	Exam	Total
M/F	0.4872	0.2033	0.1566	0.1193	0.4191
HOC	MBST	Lab	Quiz	Exam	Total
M/F	0.0846	0.2804	0.1074	0.0821	0.1681
HOD	MBST	Lab	Quiz	Exam	Total
M/F	0.2346	0.4967	0.3447	0.3348	0.3686

Many small areas of significance were found in comparing assessment scores across class year. Table 5.18 outlines the class year breakdown by ability groups. Students are spread fairly evenly across the grouping types, the highest percentages are highlighted in gray.

**Table 5.18 Class year breakdown of grouping types**

	Fr		So		Jr		Sr	
	n = 44	% of total	n = 75	% of total	n = 41	% of total	n = 24	% of total
SS	15	8.15%	25	13.59%	14	7.61%	7	3.80%
HE	18	9.78%	21	11.41%	14	7.61%	7	3.80%
HO	11	5.98%	29	15.76%	13	7.07%	10	5.43%
	n = 11	% of HO	n = 29	% of HO	n = 13	% of HO	n = 10	% of HO
HO-A	4	36.36%	8	27.59%	5	38.46%	1	10.00%
HO-B	3	27.27%	7	24.14%	4	30.77%	4	40.00%
HO-C	3	27.27%	9	31.03%	2	15.38%	2	20.00%
HO-D	1	9.09%	5	17.24%	2	15.38%	3	30.00%

When comparing assessment average scores across grouping types and class years, many large differences are found (Table 5.19). Freshmen scored the highest average in all categories, and at first glance, it appears that freshmen in the lowest homogeneous quartile earned the highest scores in all other assessments. However, Table 5.18 shows that there is only one student that falls into that category. That person scored only a 58.62% on the MBST, placing the student into the fourth quartile, but obviously performed quite well on the geology assessments.

Freshmen in the second homogenous quartile, n=3, scored the second highest average on the quizzes and exams, highlighted in light gray. Heterogeneously grouped seniors (n=7) scored highest on the labs.

**Table 5.19 Class year breakdown of grouping types by assessment category**

Group	Year	MBST	Lab	Quiz	Exam	Total
All	Freshmen	83.31	93.77	90.92	86.76	90.52
	Sophomores	78.30	93.92	83.31	84.24	88.25
	Juniors	75.02	90.64	80.38	77.44	83.65
	Seniors	71.41	92.54	83.45	82.00	86.80
SS	Freshmen	83.22	92.80	87.63	84.70	88.71
	Sophomores	77.38	92.90	85.78	85.60	88.78
	Juniors	75.62	89.95	82.46	78.64	84.19
	Seniors	65.02	88.08	79.29	77.54	82.39
HE	Freshmen	83.33	93.35	91.48	86.04	90.15
	Sophomores	78.49	94.37	78.17	81.95	86.64
	Juniors	74.14	94.35	80.20	76.64	84.91
	Seniors	74.38	97.08	84.92	83.36	89.55
HO-A	Freshmen	94.83	96.59	91.81	89.69	93.04
	Sophomores	93.53	95.37	85.76	84.16	89.28
	Juniors	93.10	93.68	89.89	83.05	88.84
	Seniors	82.76	93.86	78.33	64.25	79.51
HO-B	Freshmen	82.76	96.59	96.30	91.00	94.35
	Sophomores	84.24	97.14	82.70	83.71	89.33
	Juniors	76.72	76.65	71.67	77.69	76.18
	Seniors	82.76	94.94	84.86	84.25	88.97
HO-C	Freshmen	77.01	92.88	94.44	90.17	92.09
	Sophomores	74.71	94.14	89.57	87.33	90.66
	Juniors	58.62	91.25	80.56	78.25	84.26
	Seniors	63.79	96.59	96.11	89.50	93.73
HO-D	Freshmen	58.62	98.86	100.00	96.00	97.94
	Sophomores	55.86	89.82	78.22	82.40	84.86
	Juniors	44.83	89.20	60.56	59.25	72.40
	Seniors	65.52	85.98	81.11	87.17	85.59

Again, it is difficult to see where areas of significance can be found. A t-test analysis (Tables 5.20 and 5.21) clarifies. In Table 5.21, combinations notated by NA are a result of categories with only one student and a t-test could not be run.

As mentioned earlier, there were overall significant differences (Table 5.13) between freshmen and juniors, freshmen and seniors, and sophomores and juniors. Overall, freshmen performed better than seniors regardless of the group that they are in. Because there was not one

group or quartile with a high concentration of freshmen, there is little chance of skew in the results.

**Table 5.20 t-test analyses: class year breakdown of grouping types by assessment (SS/HE)**

<b>SS</b>	<b>MBST</b>	<b>Lab</b>	<b>Quiz</b>	<b>Exam</b>	<b>Total</b>
Fr/So	0.0854	0.4656	0.2344	0.3658	0.4821
Fr/Jr	0.0557	0.0916	0.0942	0.0342	0.0170
Fr/Sr	0.0090	0.0334	0.0422	0.0298	0.0100
So/Jr	0.3564	0.0392	0.1516	0.0093	0.0062
So/Sr	0.0444	0.0085	0.0533	0.0121	0.0037
Jr/Sr	0.1074	0.2927	0.2984	0.3940	0.2783
<b>HE</b>	<b>MBST</b>	<b>Lab</b>	<b>Quiz</b>	<b>Exam</b>	<b>Total</b>
Fr/So	0.0794	0.2272	0.0002	0.0532	0.0187
Fr/Jr	0.0252	0.2588	0.0043	0.0075	0.0094
Fr/Sr	0.0596	0.0291	0.1035	0.2729	0.4124
So/Jr	0.1436	0.4934	0.3223	0.0531	0.2049
So/Sr	0.2032	0.0446	0.1226	0.3557	0.1439
Jr/Sr	0.4855	0.0483	0.2450	0.1260	0.1000

Interestingly, the self-select and heterogeneous sections show many more significant differences between class years than the homogeneous sections. These groups are much larger, so one would think that particularly high or low scores would cancel each other out, reducing the chance for overall significance. However, that is not the case. No statistical differences were found between class years for the first homogeneous quartile (HO-A, n=18). This group performed the best on the MBST and earned the highest average scores on the labs and the second highest average on the total course grade. As shown in Table 5.9, the students in the third homogeneous quartile (HO-C) scored the highest in quiz, exam, and total course grade scores as a whole. It is not surprising that these two quartiles exhibit only a few areas of significance between the class years. All most all of the students did extremely well, as seen by the high averages and low standard deviations (Table 5.5 and Table 5.7). The other two quartiles, HO-B and HO-D had more variations between student performances in all assessments.

**Table 5.21 t-test analyses: class year breakdown of grouping types by assessment (HO)**

<b>HO-A</b>	MBST	Lab	Quiz	Exam	Total
Fr/So	0.3438	0.1344	0.2093	0.1881	0.1771
Fr/Jr	0.3235	0.0926	0.3079	0.0943	0.0961
Fr/Sr	NA (1)	NA (1)	NA (1)	NA (1)	NA (1)
So/Jr	0.4507	0.1563	0.2619	0.4295	0.4564
So/Sr	NA (1)	NA (1)	NA (1)	NA (1)	NA (1)
Jr/Sr	NA (1)	NA (1)	NA (1)	NA (1)	NA (1)
<b>HO-B</b>	MBST	Lab	Quiz	Exam	Total
Fr/So	0.3736	0.3168	0.0748	0.1221	0.1056
Fr/Jr	0.0894	0.0816	0.0238	0.0082	0.0262
Fr/Sr	0.5000	0.2453	0.0154	0.1439	0.0566
So/Jr	0.0366	0.0116	0.1297	0.1422	0.0184
So/Sr	0.3529	0.0986	0.3898	0.4648	0.4609
Jr/Sr	0.0570	0.0654	0.0817	0.1362	0.0473
<b>HO-C</b>	MBST	Lab	Quiz	Exam	Total
Fr/So	0.3490	0.3377	0.2288	0.2958	0.3503
Fr/Jr	0.0776	0.4051	0.0294	0.0954	0.1069
Fr/Sr	0.0793	0.2659	0.3764	0.4548	0.3810
So/Jr	0.0305	0.1799	0.1313	0.0881	0.0609
So/Sr	0.0702	0.1776	0.2048	0.3578	0.2166
Jr/Sr	0.3492	0.1759	0.0243	0.1098	0.0048
<b>HO-D</b>	MBST	Lab	Quiz	Exam	Total
Fr/So	NA (2)	NA (2)	NA (2)	NA (2)	NA (2)
Fr/Jr	NA (2)	NA (2)	NA (2)	NA (2)	NA (2)
Fr/Sr	NA (2)	NA (2)	NA (2)	NA (2)	NA (2)
So/Jr	0.0528	0.4527	0.0377	0.0111	0.0345
So/Sr	0.1006	0.3197	0.3493	0.2520	0.4554
Jr/Sr	0.0514	0.4052	0.1211	0.0171	0.1295

(1) Only one HO-A senior

(2) Only one HO-D freshman

The following tables list the final course averages across each of the demographic groups compiled in Chapter 3:

**Table 5.22 Course average: gender**

Male	n=64	87.65
Female	n=121	87.49

**Table 5.23 Course average: age**

18-21 years	n=148	88.13
22-26 years	n=27	84.77
27-22 years	n=4	86.42
34-40 years	n=27	84.26
>40 years	n=3	89.54

**Table 5.24 Course average: race**

Caucasian	n=156	88.33
Non-Caucasian	n=26	83.36

**Table 5.25 Course average: class year**

Freshman	n=44	90.82
Sophomore	n=75	88.13
Junior	n=41	83.61
Senior	n=24	86.64

**Table 5.26 Course average: major**

Arts, Humanities, Social Sciences	n=79	87.08
Education	n=48	88.13
Business Administration	n=41	87.20
Science/Math	n=11	89.30
Engineering	n=5	89.50

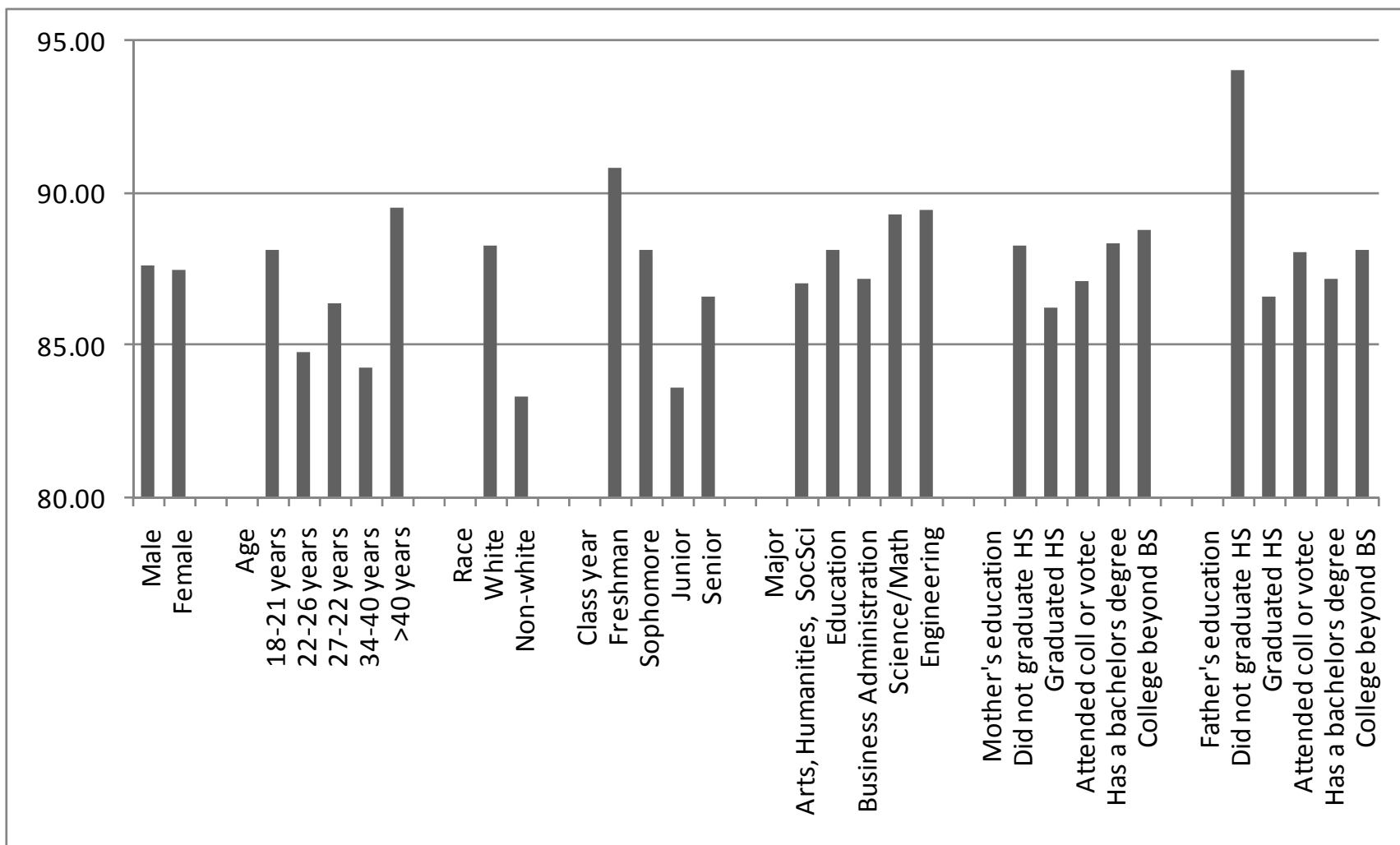
**Table 5.27 Course average: mother's education**

Did not graduate high school	n=3	88.33
Graduated high school	n=41	86.26
Attended some college or vocational school	n=59	87.13
Has a bachelors degree	n=50	88.38
Attended college beyond a bachelors level	n=31	88.80

**Table 5.28 Course average: father's education**

Did not graduate high school	n=3	94.02
Graduated high school	n=30	86.61
Attended some college or vocational school	n=57	88.11
Has a bachelors degree	n=48	87.18
Attended college beyond a bachelors level	n=43	88.14

**Figure 5.3 Course averages across all demographic groups**



## **MBST validation**

For the MBST to be a valid instrument for the purposes of this study, students who scored well should also have earned high grades in the course. Students who tested poorly on the MBST should also have earned low grades in the course. This is indeed the case. The students who scored in the top 25% on the MBST had a significantly higher course average ( $p = 0.0001$ ), earning an average of 90.68% compared to an 86.24% earned by the bottom 75%. The students who scored in the bottom 25% on the MBST had a significantly lower course average ( $p = 0.0464$ ), earning an average of 85.59% compared to an 87.86% earned by the top 75%.

Additionally, there were no statistical differences in performance on the MBST between males and females. This result predicts a similar response for the other assessments in the study, and in fact, no gender differences were found in lab, quiz, or exam scores.

## **CHAPTER 6 - Implications**

The purpose of this study was to answer the question: does ability grouping, organizing classrooms to combine those of similar ability, have an impact on student performance in the GEOL 103 labs? This research found the answer to be yes.

### **Ability grouping**

The students in all three grouping types, homogenous, heterogeneous, and self-select, scored higher averages on the group assessments (laboratories) than on the individual assessments (quizzes and exams), as seen in Figure 5.2. This result was expected, as groups of six are more likely to come up with the correct response to a question than any one person alone.

The top 50% of students, whether grouped homogeneously or heterogeneously, performed the same. The top two quartiles showed no significant difference between the homogenous groups and the heterogeneous groups on the labs, exams, and quizzes. This finding implies that the upper half of students are not positively or negatively affected by purposeful grouping.

### ***Homogeneous grouping***

Although there was no global increase in scores with any of the homogeneous groups, one area of note was the third quartile (HO-C). The students in that quartile scored significantly higher than the heterogeneous and self-selected sections, and also on the HO-A and HO-B quartiles, on two of the three assessment types, quizzes and exams. While this could be a strong argument for the benefits of homogeneous grouping, gains in one fourth of a group of students does not mean the grouping method should be adopted for all students. As the fourth homogenous quartile earned significantly lower scores on the labs, quizzes, exams, and therefore total grade, it is clear that this grouping method does not benefit all students and should not be used in this course.



### ***Self-select grouping***

Self-selected groups scored significantly better than another group in only one area; they scored higher on quizzes than the fourth homogeneous quartile. As mentioned earlier, quiz scores do not reflect students working together, as quizzes covered material not yet discussed in class. Even so, one would expect a mixed ability group of students to perform better than the lowest 25<sup>th</sup> percentile on any type of assessment. Therefore, this significance can be ignored. In contrast, both heterogeneous and homogeneous groups performed better than the self-selected groups on the labs and exams. Additionally, in self-select sections, students with friends in the class are likely to sit with those friends. This can be very distracting and would likely impact their performance in the class. Clearly, allowing students to choose their own seats is not benefitting all students.

### ***Heterogeneous grouping***

Heterogeneously grouped students earned significantly higher scores than the self-selected students on the labs, and did not fall behind either of the other grouping methods in any of the other assessments. Only heterogeneous grouping resulted in gains for *all* students; therefore, it is better to group the students heterogeneously than to allow them to sit wherever they wish.

## **Demographics**

There was not a large difference in performance between genders. Although traditionally males score higher than females in science subjects (Spelke, 2005), the GEOL 103 course is an introductory level laboratory that does not delve deeply into the science of geology. Concepts are covered in a broad level, designed to incorporate student experiences as much as possible with the geologic topics.

Similarly, no trend was found in students' age or in the education level of students' parents. One spike is found with students whose fathers did not graduate from high school, but only three students recorded that response and thus the sample size is too small to be of significance.

Lower-level class years, freshmen and sophomores, scored much higher than juniors and slightly better than seniors. This may be due to the shorter time between high school geology courses and students' enrollment in GEOL 103. Seniors may be working harder to increase their GPA before graduation. Juniors are neither close to graduation nor have taken high school geology classes recently. Alternatively, there could be completely different factors influencing their poor results.

Not surprisingly, students majoring in science, math, and engineering showed the highest performance in overall course grades. These students have an interest in science and therefore likely a higher aptitude as well. Business administration, arts and humanities, and social science majors do not have much in common with the natural and physical sciences, and their lower course grades match this.

### **Sources of data error**

Student performance on the MBST was not a factor in the overall semester grade for the course. Because of this, students did not have an incentive to perform at their best on the test. Upon compiling overall student responses on the individual questions on the MBST, some of the easier concepts resulted in higher incorrect responses than expected. For example, thirty students did not record the correct response to a question that asked students to divide a number by ten. Fifty-two students recorded an incorrect response for a simple addition problem. Thirty students missed a question requiring students to average three two-digit numbers. Twelve missed a question asking students to average 2 and 4.

The implication for this finding is profound for this study. If students did not perform to their actual ability on the MBST, then the placement of those students in the homogeneous and heterogeneous groupings may not have aligned appropriately for accurate results.

In order to reduce grouping error due to students' lack of effort on the MBST, is there a method of encouraging students to perform to their true ability? Similar studies at the university level have given extrinsic rewards, not counting toward their grade in the course. Students could be given candy or preferred seating in the classroom. Perhaps they might earn a chance to submit an assignment for extra credit or being allowed to drop a homework grade – rewards that will indirectly influence their grade and discourage student apathy.

Another source of data error may be due to the four sections that showed statistical similarity on the MBST scores. While the nine sections as a whole did not show significant similarity, four sections did. Two of the four were assigned to homogeneous groups which may have skewed those results. This is likely to be a much smaller source of error than student apathy on the MBST itself, but nevertheless, it is a possible factor.

## **Conclusions**

Some of the areas of significance are in demographic categories that are beyond the Geology department's control during registration. Obviously, course decisions can not be made due to race ( $p = 0.0003$ ). However, other differences can be controlled for, with minor additions to the registration line schedule. Because of the significant variations between class years, students may benefit from enrollment of students into sections designated only for freshmen or seniors, etc.

Overall both homogeneous and heterogeneous groupings performed better than the control self-selected sections. One homogeneous quartile showed significant improvement in performance compared to the heterogeneously grouped students, but another homogeneous quartile showed a significant decline in scores. Gains in one subset of student should not come as a detriment to another subset of students, so homogeneous grouping is not recommended. Only heterogeneous grouping showed significant increases in scores without harm to other students, and for this reason, this study recommends using a heterogeneous method of grouping students in future GEOL 103 classes.

## **Questions for further study**

Why did we find so little significance between grouping methods? Is it because GEOL 103 students only meet once per week, for less than two hours? Lou et al. (1996) found that classes that meet only once per week may not have enough face-to-face time in order for grouping to have an effect. Homogeneous and heterogeneous groups that meet more than once per week show greater gains.

Is it a problem with how we grouped the students? Does math ability relate strongly enough to geology for the MBST groupings to be valid? Do students in science or math classes show improvement with the establishment of ability groups? Research shows that reading and English composition classes report much higher benefit from ability grouping over math and science classes (Lou et al, 1996). The ability groups in this study were established using students' mathematical knowledge; in contrast, a study by Gustin and Corazza (1994) found that grouping by verbal reasoning may be more valid as a predictor of scientific performance.

Differentiated instruction, when done correctly, has shown to bring very significant gains in small groups of almost any type (Kulik and Kulik, 1987; Esposito, 1973; Ireson, 2002a). Perhaps grouping students by ability and adapting the teaching methods for each particular group could result in the overall gains in performance that this study failed to find.

Data on student self-efficacy in laboratory groups was collected during this study. Further research could concentrate on influences on students' preferences within laboratory ability groups.

## References

- Abrami, P.C., Chambers, B., Poulsen, C., De Simone, C., d'Apollonia, S., and Howden, J., 1995, Classroom connections: Understanding and using cooperative learning: Toronto, Ontario, Canada, Harcourt-Brace, p. 221.
- Allan, S.D., 1991, Ability-grouping research reviews: What do they say about grouping and the gifted?: Educational Leadership, v. 48, p. 60-65.
- Benbow, C.P., and Minor, L.L., 1986, Mathematically talented males and females and achievement in the high school sciences: American Educational Research Journal, v. 23, p. 425-436.
- Boyd, B., 2007, To set or not to set; Is that the question?: Improving Schools, v. 10, p. 283-294.
- Britton, S., New, P.B., Sharma, M.D., and Yardley, D., 2005, A case study of the transfer of mathematics skills by university students: International Journal of Mathematical Education in Science and Technology, v. 36, p. 1-13.
- Burris, C.C., Heubert, J.P., and Levin, H.M., 2006, Accelerating mathematics achievement using heterogeneous grouping: American Educational Research Journal, v. 41, p. 105-136.
- Burris, C.C., Wiley, E., Welner, K.G., and Murphy, J., 2008, Accountability, rigor, and detracking: Achievement effects of embracing a challenging curriculum as a universal good for all students: Teachers College Record, v. 110, p. 571-607.
- Davenport, L.R., 1993, The effects of homogeneous groupings in mathematics: ERIC Clearinghouse for Science, Mathematics, and Environmental Education ED 359 065, Report EDO-SE-93-6.
- Esposito, D., 1973, Homogeneous and heterogeneous ability grouping: Principal findings and implications for evaluating and designing more effective educational environments: Review of Educational Research, v. 43, p. 163-179.
- Fiedler, E.D., Lange, R.E., and Winebrenner, S., 2002, In search of reality: Unraveling the myths about tracking, ability grouping, and the gifted: Roeper Review, v. 24, p. 108-111.
- Gamoran, A., 1992, Is ability grouping equitable?: Educational Leadership, v. 50, p. 11-17.
- Gamoran, A., 1986, Instructional and institutional effects of ability grouping: Sociology of Education, v. 59, p. 185.

Good, T.L., and Marshall, S., 1984, Do students learn more in heterogeneous or homogeneous groups? *in* Peterson, P., Wilkinson, L.C. and Hallinan, M., eds., *The social context of instruction: Group organization and group processes*: Orlando, FL, Academic Press, p. 15-38.

Gustin, W.C., and Corazza, L., 1994, Mathematical and verbal reasoning as predictors of science achievement: *Roeper Review*, v. 16, p. 160-162.

Hallam, S., and Ireson, J., 2006, Secondary school pupils' preferences for different types of structured grouping practices: *British Educational Research Journal*, v. 32, p. 583-599.

Hanushek, E.A., and ößmann, L.W., 2006, Does educational tracking affect performance and inequality?: *The Economic Journal*, v. 116, p. C63-C76.

Hoffer, T.B., 1992, Middle school ability grouping and student achievement in science and mathematics: *Educational Evaluation and Policy Analysis*, v. 14, p. 205-227.

Ireson, J., Hallam, S., Hack, S., Clark, H., and Plewis, I., 2002a, Ability grouping in English secondary schools: Effects on attainment in English, mathematics, and science: *Educational Research and Evaluation*, v. 8, p. 299-318.

Ireson, J., Clark, H., and Hallam, S., 2002b, Constructing ability groups in the secondary school: Issues in practice: *School Leadership & Management*, v. 22, p. 163-176.

Kansas State University, 2008, About K-State: v. 2009, <http://www.k-state.edu/welcome/>.

Kansas State University Registrar's Office, 2009, Enrollment statistics: v. 2009, <http://www.k-state.edu/registrar/statistics/>.

Kulik, C.L.C., and Kulik, J.A., 1982, Effects of ability grouping on secondary school students: A meta-analysis of evaluation findings: *American Educational Research Journal*, v. 19, p. 415-428.

Kulik, J.A., and Kulik, C.L.C., 1987, Effects of ability grouping on student achievement: *Equity and Excellence*, v. 23, p. 22-30.

Lou, Y., Abrami, P.C., Spence, J.C., Poulsen, C., Chambers, B., and d'Apollonia, S., 1996, Within-class grouping: A meta-analysis: *Review of Educational Research*, v. 66, p. 423-458.

Mullen, B., and Copper, C., 1994, The relationship between group cohesiveness and performance: An integration: *Psychological Bulletin*, v. 115, p. 210-227.

Noddings, N., 1989, Theoretical and practical concerns about small groups in mathematics: *Elementary School Journal*, v. 89, p. 607-623.

Oakes, J., 1990, *Multiplying inequalities: The effects of race, social class, and tracking on opportunities to learn mathematics and sciences*: Santa Monica, CA, Rand Corporation, p. 132.

- Oakes, J., 2005, *Keeping track: How schools structure inequality*: New Haven, CT, Yale University Press, p. 352.
- Petty, M.C., 1954, *Intraclass grouping in the elementary school*: Austin, TX, University of Texas Press, p. 189.
- Piaget, J., 1954, *The construction of reality in the child*: New York, Ballantine Books, p. 386.
- Rogers, K.B., 2002, Grouping the gifted and talented: *Roeper Review*, v. 24, p. 103-107.
- Rosenbaum, J.E., 1976, *Making inequality: The hidden curriculum of high school tracking*: New York, Wiley, p. 256.
- Saleh, M., Lazonder, A.W., and DeJong, T., 2005, Effects of within-class ability grouping on social interaction, achievement, and motivation: *Instructional Science*, v. 22, p. 105-119.
- Shields, C.M., 2002, A comparison study of student attitudes and perceptions in homogeneous and heterogeneous classrooms: *Roeper Review*, v. 24, p. 115-119.
- Slavin, R.E., 1990, Achievement effects of ability grouping in secondary schools: A best-evidence synthesis: *Review of Educational Research*, v. 60, p. 471-499.
- Spelke, E.S., 2005, Sex differences in intrinsic aptitude for mathematics and science?: *American Psychologist*, v. 60, p. 950-958.
- Terwel, J., 2005, Curriculum differentiation: Multiple perspectives and developments in education: *Journal of Curriculum Studies*, v. 37, p. 653-670.
- Tieso, C.L., 2003, Ability grouping is not just tracking anymore: *Roeper Review*, v. 26, p. 29-36.
- Vygotsky, L.S., 1978, *Mind in society: The development of higher mental processes*: Cambridge, MA, Harvard University Press, p. 159.
- Webb, N.M., 1989, Peer interaction and learning in small groups: *Journal of Educational Research*, v. 13, p. 21-39.
- Wilkinson, L.C., 1986, June, Grouping low-achieving students for instruction, *in* *Designs for Compensatory Education Conference*, Washington, D.C. (ERIC Document Reproduction Service No. ED 293 915).
- William, D. and Bartholomew, H., 2004, It's not which school but which set you're in that matters: the influence of ability grouping practices on student progress in mathematics: *British Educational Research Journal*, v. 30, p. 279-293.

# Appendix A - Mathematics Proficiency Basic Skills Test

Name \_\_\_\_\_ (record as directed on your scan sheet) Date: \_\_\_\_\_ (record as directed on your scan sheet)

What is the course and section number of this class? \_\_\_\_\_ (record as directed on your scan sheet)

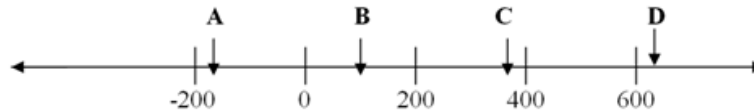
## Mathematics Proficiency Basic Skills Test

You all come to this class with different levels of proficiency in science and mathematics. To enable me in making better instructional decisions, please complete the following math proficiency skills test. Your score on this test will not be counted in computation of your course grade.

**Instructions:** For each of the following questions, select the single best answer and mark the corresponding letter on your answer sheet. You are **not** allowed to use a calculator on this test.

### Number Scale:

Using the number line below, determine the nearest approximate value denoted by each of the given letters. Select the corresponding correct answer from among the set of options, and mark it on your answer sheet.



1) What number is represented by the letter "A" above?

- a) -175
- b) .75
- c) -1.75
- d)  $1\frac{3}{4}$
- e) 200

2) What number is represented by the letter "B" above?

- a) -50
- b) 100
- c)  $1\frac{1}{2}$
- d) 100
- e) .5

3) What number is represented by the letter "C" above?

- a) -275
- b) 200.75
- c) 375
- d)  $200\frac{3}{4}$
- e) 300

4) What number is represented by the letter "D" above?

- a) -600
- b) 625
- c) 6.20
- d)  $600\frac{3}{4}$
- e) -575



**Addition:**

Calculate the sum for the following columns of numbers. Select the corresponding correct answer from among the set of options, and mark it on your answer sheet.

5)

316	
1056	
258	a) 6875
78	b) 6943
698	c) 7201
2589	d) 6843
478	e) 6945
851	
472	
<u>147</u>	

6)

548	
3698	
471	a) 19070
258	b) 20070
569	c) 19170
4518	d) 19080
985	e) 19071
125	
7882	
<u>16</u>	

7)

584	
354	
9851	a) 12876
87	b) 12860
875	c) 12961
69	d) 12775
214	e) 11860
368	
<u>458</u>	

**Fractions:**

8) The number above the line in a fraction is called the \_\_\_\_\_.

- a) Quotient
- b) Denominator
- c) Decimal
- d) Numerator
- e) Improper fraction

9) The number below the line of a fraction is called the \_\_\_\_\_.

- a) Quotient
- b) Denominator
- c) Decimal
- d) Numerator
- e) Improper fraction

Calculate the numerical equivalence for each of the following fractions. Select the corresponding correct answer from among the set of options, and mark it on your answer sheet.

10)  $1/2 =$

- a) 2.1
- b) .5
- c)  $3/2$
- d) 1.2
- e) 1.5

11)  $1/8 =$

- a) 8.1
- b) 1.25
- c) 1.8
- d) .125
- e)  $8/2$

12)  $13/22 =$

- a) 22.13
- b)  $1.3/2.2$
- c) .59
- d) 1.59
- e) 13.22

13)  $225/10 =$

- a) 225.10
- b) 22.5
- c)  $5/2$
- d) 10.225
- e) .225

14)  $36/6 =$

- a) 6.36
- b) .60
- c)  $3/6$
- d) 36.6
- e) 6

**Means:**

Calculate the arithmetic mean (average) for each of the following sets of numbers. Select the corresponding correct answer from among the set of options, and mark it on your answer sheet.

15) 2, 4

- a) 2.5
- b) 6
- c)  $2/4$
- d) 3
- e)  $3\frac{1}{2}$

16) 35, 54, 16, 85, 36

- a) 45.2
- b) 226
- c)  $109/121$
- d) 36
- e)  $224/5$

17) 29, 14, 74

- a) 40.3
- b) 39
- c)  $74/29$
- d) 29
- e)  $3/2$

18) 25, 684, 65, 34, 98

- a) 181.2
- b) 179
- c)  $659/5$
- d) 65
- e)  $5/2$

19) 404, 89, 106, 61

- a) 152.5
- b) 75
- c)  $671/4$
- d) 165
- e)  $4/3$

**Powers:**

20) In the number  $6^4$ , the "4" is called the \_\_\_\_\_.

- a) Square
- b) Subscript
- c) Exponent
- d) Decimal
- e) Integer

Calculate the numerical equivalence for each of the following powers. Select the corresponding correct answer from among the set of options, and mark it on your answer sheet.

21)  $4^4 =$

- a) 16
- b) 256
- c) 4.4
- d)  $\frac{1}{4}$
- e) 64

22)  $256,487,451,575^0 =$

- a) 256,487,451,575
- b) 0
- c)  $256.487451575 \times 10^9$
- d)  $1/256$
- e) 1

23)  $5.654 * 10^3 =$

- a) 5,654
- b) 16
- c) .005654
- d)  $5.654/3$
- e) 56,540

24)  $7.43 * 10^1 =$

- a) 743
- b) 74,310
- c) 74.3
- d)  $1/7.43$
- e) 7,430

25)  $1^{54} * 2^2 =$

- a) 216
- b) 4
- c) 2.254
- d)  $54/4$
- e) 54

**Logs:**

Calculate the numerical equivalence for each of the following logs. Select the corresponding correct answer from among the set of options, and mark it on your answer sheet.

26)  $\log_{10} 10 =$

- a) 0
- b) 1
- c) 10
- d) 100
- e) -10

27)  $\log_{10} 100 =$

- a) 1
- b) 2
- c) 3
- d) 4
- e) 10

28)  $\log_{10} 1000 =$

- a) 10
- b) 1
- c) 2
- d) 3
- e) 100

29)  $\log_{10} 10000 =$

- a) 100
- b) 2
- c) 3
- d) 4
- e) 1000

**Instructions:** The following sets of questions are related to your interest, skills, and background. Select the single best answer and mark the corresponding letter on your answer sheet.

**Laboratory Preferences and Skills:**

30) Assuming that all lab group members are responsible for every aspect of lab activities, if given an opportunity, my preferred primary contribution in a lab group would be in the role of the:

- a) Person who gathers, cleans, and returns materials and supplies
- b) Person who records and documents data
- c) Person who “does” the mechanics of the activity
- d) Person who analyzes and interprets the data
- e) Person who writes the final lab report

Determine your extent of agreement with each of the following and mark your answer sheet according to the scale provided below:

A = Strongly Disagree	B = Disagree	C = Neither Agree nor Disagree	D = Agree	E = Strongly Agree
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**In a science lab activity, I can:**

- 31) Be the leader of the lab group.
- 32) Write the introduction and procedures of a lab report.
- 33) Direct the activities of the lab session.
- 34) Gather the materials and supplies needed for a particular lab activity.
- 35) Monitor and encourage safe practice in the lab.
- 36) Return all lab equipment in proper working order.
- 37) Clean the workspace during and after a lab activity.
- 38) Form hypotheses and questions.
- 39) Plan the procedures for the lab session.
- 40) Follow detailed instructions provided in a lab activity.
- 41) Take measurements.
- 42) Record observations in a narrative (i.e., text) form.
- 43) Record observations numerically.
- 44) Sketch observations.
- 45) Create visual representations of the data.
- 46) Create graphs and tables of the data.
- 47) Analyze the data.
- 48) Make interpretations of analyses of the data.
- 49) Draw conclusions from the analyses of the data.
- 50) Write the analysis and results section of a lab report.
- 51) Form follow-up questions.
- 52) Write the recommendations for further research of a lab report.

**Background Questions:**

Complete the following statements by selecting the most appropriate response, and record the letter on your answer sheet.

53) I am a: (A) Freshman (B) Sophomore (C) Junior (D) Senior (E) Graduate Student

54) I am a: (A) Male (B) Female

55) My ethnicity is: (A) African-American  
(B) Asian  
(C) Caucasian (white)  
(D) Hispanic  
(E) None of the above (other options on item 56)

56) My ethnicity is: (A) Native-American  
(B) Pacific Islander  
(C) Multiple ethnicities  
(D) Other  
(E) None of the above (mark this if you responded to item 55 with A-D)

57) My primary academic interest is: (A) Science or Mathematics  
(B) Engineering  
(C) Business  
(D) Education: K – 12, Science or Non-Science  
(E) Arts, Humanities, or Social Science

58) My age is: (A) 18-21 (B) 22-26 (C) 27-33 (D) 34-40 (E) > 40

59) My mother (or female guardian): (A) Did not graduate from high school  
(B) Graduated from high school (but no further schooling/training)  
(C) Attended some college or vocational school  
(D) Has a bachelor's degree  
(E) Attended college beyond a bachelor's degree

60) My father (or male guardian): (A) Did not graduate from high school  
(B) Graduated from high school (but no further schooling/training)  
(C) Attended some college or vocational school  
(D) Has a bachelor's degree  
(E) Attended college beyond a bachelor's degree