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Using active learning strategies to investigate student learning and attitudes in a large enrollment, introductory geology course

Stacy Jane Berry
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USING ACTIVE LEARNING STRATEGIES TO INVESTIGATE STUDENT LEARNING AND ATTITUDES ABOUT GEOLOGY IN A LARGE ENROLLMENT, INTRODUCTORY GEOLOGY COURSE.

Stacy Jane Berry

Dissertation submitted to the Eberly College of Arts and Sciences of West Virginia University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Geology

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Department of Geology and Geography

Morgantown, West Virginia 2013

Keywords: higher education, curriculum development, geoscience education, active learning strategies, online homework
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USING ACTIVE LEARNING STRATEGIES TO INVESTIGATE STUDENT LEARNING AND ATTITUDES ABOUT GEOLOGY IN A LARGE ENROLLMENT, INTRODUCTORY GEOLOGY COURSE.

ABSTRACT

Stacy Jane Berry

There has been an increased emphasis for college instruction to incorporate more active and collaborative involvement of students in the learning process. These views have been asserted by The Association of American Colleges (AAC), the National Science Foundation (NSF), and The National Research Counsel (NRC), which are advocating for the modification of traditional instructional techniques to allow students the opportunity to be more cooperative (Task Group on General Education, 1988). This has guided educators and facilitators into shifting teaching paradigms from a teacher centered to a more student-centered curriculum. The present study investigated achievement outcomes and attitudes of learners in a large enrollment (n ~ 200), introductory geology course using a student centered learning cycle format of instruction versus another similar section that used a traditional lecture format. Although the course is a recruiting class for majors, over 95% of the students that enroll are non-majors.

Measurements of academic evaluation were through four unit exams, classroom communication systems, weekly web-based homework, in-class activities, and a thematic collaborative poster/paper project and presentation. The qualitative methods to investigate the effectiveness of the teaching design included: direct observation, self-reporting about learning, and open-ended interviews. By disaggregating emerging data, we tried to concentrate on patterns and causal relationships between achievement performance and attitudes regarding learning geology. Statistical analyses revealed positive relationships between student engagement in supplemental activities and achievement mean scores within and between the two sections. Completing weekly online homework had the most robust relationship with overall achievement performance. Contrary to expectations, a thematic group project only led to modest gains in achievement performance, although the social and professional gains could be considered as significant as the academic merit. The qualitative data substantiated the achievement success and revealed a positive relationship between a student centered learning environment and attitudes regarding learning geology. Our findings indicated a positive trend favoring active learning instructional practices, particularly methods that emphasize independent and active thinking, and analyzing of data. Of particular interest was the correlation between the amount of student ownership in an activity and students’ attitude toward authenticity and application in learning. Students’ perceptions and attitudes provided depth in program evaluation and helped in identifying which components used in teaching methodologies were the most effective towards learning. Although the exigencies of high enrollment introductory courses set limits for this study, the outcomes support the positive influence that active learning has on achievement performance in a high enrollment, introductory Geology course.
The research for this study was completed and then presented and written as two in-depth papers in relation to the dissertation topic. The first chapter describes the overall outcomes of implementing several student centered teaching strategies in a large lecture introductory physical geology course. The second chapter is dedicated to the results found in implementing online homework, one of the components of the overall study. Both chapters in this study will be condensed so they may be submitted for publication in a higher education peer reviewed journal. As research involving instructional methods with students requires Internal Review Board (IRB) oversight, the requirements and regulations necessary for IRB compliance are included as an independent Appendix.
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I would like to thank all of my committee members. Without them, I could not have accomplished my research goals. I would like to thank my advisor and mentor, Dr. Jack Renton. Thank you for believing in me and letting me work with you on my research. It has been a lifetime experience to work under your tutelage and guidance. Thanks to A.B. Billings, for guiding me through my statistical analyses. I can never repay you for the countless hours spent over many months ensuring my analyses were thorough and accurate. Thank you Dr. Richards-Babb for your help with my writing. Your countless corrections and suggestions helped me improve the presentation of my own research. I am sure you wore out a pen on my behalf! Thank you Dr. Hemler for your commitment to ensure that my research and writing were pedagogically sound. Your guidance and contributions helped to shape the research format. Thanks Dr. Obenauf for steering the WVU curriculum courses and I.R.B. approval. Thanks to Dr. Behling, for supporting geoscience education in the Geology Department.

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1.0 Using Achievement Performance to Evaluate For Grade Supplemental Learning Activities in a Large Enrollment, Introductory Geology Course

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1.1 ABSTRACT

Interest in active learning at the college level is growing rapidly. Recent research in higher education indicates that active learning enhances student learning and attitudes about science. This study investigated achievement performance and attitudes of learners during a student centered learning cycle format of instruction versus a traditional lecture format as measured by data collected through classroom personal response systems, online homework, a thematic collaborative group poster/paper project, in class activities, and four achievement exams. Attitudinal data regarding the active learning format were obtained through classroom administered monthly survey questions and semester end interviews. Statistical analyses revealed positive relationships between student engagement in supplemental activities and achievement mean scores within and between the two sections. Completing weekly online homework had the most significant relationship with overall achievement performance. Contrary to expectations, a thematic group project only led to modest gains in achievement performance. Monthly surveys and interviews showed student interest and enthusiasm for the use of an interactive classroom communication system (clickers), homework, and the peer interaction that occurs in an active learning setting. Although the exigencies of high enrollment introductory courses set limits for this study, the results support the positive influence that active learning has on achievement performance in a high enrollment, introductory Geology course.
1.2 INTRODUCTION

There is mounting evidence that a course with opportunities for different types of learning activities can result in better understanding, learning, and attitudes about science. In recent years, many college science instructors have encouraged in-class learning by utilizing teaching methods that promote collaborative, active learning during the lecture period (Macdonald and Korinek, 1995; Bykerk-Kauffman, 1995; Mazur, 1997; Reynolds and Peacock, 1998; Murck, 1999). Adapting these pedagogical approaches requires the re-examination of the central course content, with additional development of exercises that encourage inquiry and build student interest and confidence (Riggs and Kimbrough, 2002). This shift in instruction is away from a traditional lecture approach to one that puts students central in the process of teaching and learning. Learning environments that support sustained inquiry, for example, those rich in real and tangible experiences show great promise for improving student achievement (Abraham, 1997; National Research Council, 1996, AACU, 2007).

Students learn science best by doing science, rather than a didactic approach. This implies the need for more active, inquiry-directed science teaching at all levels of instruction (NSF, 1996; NRC, 1997) It is recommended that inquiry opportunities be incorporated into instruction to facilitate students’ learning and ability to transfer their knowledge to new situations (Driver et al, 1995, AACU, 2007). While there are varying degrees and types of active learning activities that fall under the moniker of inquiry, similarities in framework center on strategies that involve experience, interpretation, and elaboration (Duckworth, 1987; Angelo and Cross, 1992; Fisher, 1998; Keys and Bryon, 2001; Sunal et al, 2004; AACU, 2007; Minner et al, 2009). The inquiry framework articulated and characterized in the National Science Education Standards is: (1) the presence of science content, (2) student interaction with science content,
and (3) student responsibility in learning, active thinking, or motivation with design, communication, data, and conclusions in scientific endeavors (NSF, 1996).

Key debates in science education reform are centered on research evidence that suggests active learning assessments, as an ongoing practice by engaging in-classroom and out-of-classroom learning activities, enhance learning (NSF, 1996, NSTA, 2000; AACU, 2007). Active learning opportunities are ways that faculty of large enrollment general science courses can demonstrate a direct relationship about student learning in an ongoing manner (i.e. formative assessment) rather than a direct demonstration of student learning accomplished through achievement testing (i.e. summative assessment) (Tobias, 1992; Elkwood, 2002; Allen, 2004). These assessment methods range from daily feedback, project-based learning, in-class activities, out of class homework, and student feedback. As greater emphasis is placed on assessment of student learning in higher education, institutions increasingly find themselves needing to offer quantitative evidence of continuous improvements in student learning.

The physical restrictions and time constraints of large-enrollment ($200 \leq n \leq 350$ students), undergraduate, introductory geology courses made it cumbersome for our department to develop in and out of class learning opportunities. As a result of a recent relocation of the Geology Department, introductory section enrollments increased from a maximum of 280 students to a maximum of 350 students. Computer formatting of tests replaced paper testing for most of the introductory sections. The face of the introductory population has changed and increased as well, as state requirements for post-secondary graduation include non-science majors taking a natural science course. This was validated by an increase in the spring introductory geology enrollments from 844 to 1152 (27%) between 2002-2007 and a fall enrollment increase from 1076 to 1266 (15%) for the same time period. Although the general,
introductory geology course is a recruiting class for geology majors, over 95% of the students that enroll are non-majors. The course objectives are to provide students with a broad examination of geological phenomena and the processes that influence and impact their daily relationship on and with Earth’s geologic structures and resources.

For many students, undergraduate, introductory science courses serve as their last exposure to the natural sciences. Improved attitudes and views of learning and teaching are regarded as one of the goals of education, as perceptions developed in the classroom can determine learning strategies and commitments for ongoing learning (Trigwell and Prossner, 1991; NSF. 1996; AACU, 2007). Many studies have shown that students that have a positive attitude toward science participate more and learn more, and that attitudes of women and minorities are often improved when learning is coupled with active learning strategies (Cavallo and Laubach, 2001; Richards Babb et al, 2011). These studies led us to investigate how active learning methods would influence students’ learning strategies, achievement outcomes, and attitudes developed about the learning of geology in a large enrollment introductory course.

For purposes of the study, we chose two similarly attended introductory geology sections historically taught by the same instructor, who authored the textbook used by both sections. One section maintained a traditional lecture format and in the other section, simultaneous, student-centered, in-class and out-of-class learning activities were developed and implemented in the course. Departmental records from 2002-2007 showed similar semester achievement mean averages between both sections, with a mean achievement range between 65%-68%. Following a move in fall of 2007 to a larger lecture hall and change to computerized testing, both sections’ semester mean averages declined by 5%-6%. As a result, a goal within the department was to implement diverse student centered teaching strategies in an attempt to improve achievement
performance outcomes and attitudes about the learning of geology in large enrollment, introductory geology classes.

This goal led to the research questions:

1. Does providing student centered in-class and out-of-class learning opportunities enhance student achievement performance in introductory geology coursework? In particular, (a) which of the student centered activities showed statistical correlation with achievement outcomes, and (b) to what extent, and (c) how do these activities influence overall success rates in geology coursework?

2. Do students value the student-centered activities as a high priority and attempt to successfully complete the assigned coursework?

3. How do students view the student-centered activities used in the course? Did these activities (a) contribute to overall learning, (b) extend learning beyond the classroom, and (c) have a positive influence on attitudes regarding the learning of geology?

Background for the Study

For large enrollment, general geoscience instructors, implementation of inquiry-based learning activities involves (1) a shift in pedagogical approach in classroom instruction, (2) a choice of activities to include/exclude when designing inquiry approaches (Apedoe et al, 2006), and (3) developing the background skill necessary to utilize technology as a teaching tool to convey 21st century learning goals (AACU, 2007). In spite of these challenges, some undergraduate geoscience instructors are utilizing at least one type of inquiry activity per semester in an attempt to engage students and increase performance outcomes (Macdonald et al,
2005). These include media demonstrations (Reynolds and Peacock, 1998), Concept-test type questions following instruction (McConnell et al, 2003), in-class group activities (Arthurs and Templeton, 2009), and supplemental web based activities (Grove, 2002; Nelson et al, 2010). All of these active learning strategies have been correlated with improved learning in entry-level geology courses.

To improve the introductory geology course, our department looked for methods to promote student participation in the general, introductory geology course that would engage the students while not increasing the instructor’s work load, encourage peer interaction and instruction, and increase student time on task. Furthermore, it was felt that by attaching a small percentage of grade to the activities, the students would be motivated to complete the activities. Integrating supplemental, graded learning activities would shift the emphasis from high stakes achievement testing at the end of a period of learning to a practice that would describe student’s best performance across time and using a variety of methods to capture evidence of typical performance (Elkwood, 2002). In the spring of 2009 the department implemented the use of Concept-test type questions, in-class student-centered activities, weekly web-based homework, and a unit based group project in an attempt to improve learning of geology. Providing a range of activities was expected to create a more level playing field for the diversity of population enrolled in the course.

Extensive literature exists in physics and chemistry research supporting the use of personal response systems (clickers) to deliver concept test type questions following instruction (Mazur, 1997; Elliot, 2003; Nicol and Boyle, 2003; Beatty, 2004) to improve learning and exam scores. Research indicates that the use of concept test questions improves conceptual understanding of difficult concepts (Crouch and Mazur, 2001; Nicole and Boyle, 2003), fosters
more active participation (Mazur, 1997), and stimulates interest and enjoyment in the class (Elliott, 2003). In student interviews, Nicol and Boyle found that peer discussion with Concept test questioning following lecture was supported by 92% of the students as helpful to understand general physics material better. In peer instruction, more knowledgeable students help those less advanced to achieve higher levels of conceptual acquisition (Nicol and Boyle, 2003; Elliott, 2003). Other findings about the utilization of P.R.S. include: more active involvement in learning, time to think and reflect while learning, the positive effects of receiving immediate feedback, and peer interaction (Crouch and Mazur, 2001, Elliott, 2003).

Assigning homework has widely been recognized as a way for teachers to foster out of class learning. Large enrollment classes may prevent instructors from implementing homework because of the difficult task of how or if to grade the homework. Recent research shows a statistical correlation between spending time on homework or exercises (with and without grade attachment) that supplement learning in undergraduate geoscience courses (Durbin, 2002; Grove, 2002; Polsani, 2003; Cramer, 2007; Arthurs and Templeton, 2009) and higher achievement scores and better attitudes about learning. Grove’s virtual oceanography homework, which was required to be completed prior to attending class and accounted for 20% final grade, increased students’ time on task, and improved achievement scores. Students ranked the online exercises as the most beneficial tool in the course for learning and improved attitudes about learning science. Arthurs and Templeton coupled five collaborative in-class activities with follow up homework in an introductory Environmental Geology course attended by 51 students. In a pre-test to post-test comparison, students showed significant learning gains in targeted learning outcomes. Other literature discussed herein addresses the use of specific science domain web based programs for homework, which by their nature offer merits worthy of use in a large enrollment science course.
Online homework or supplemental exercises affords greater teacher flexibility (LaRose, 2010; Arisasingham et al, 2011), increases students’ time on task (Bembenutty, 2009; Cooper et al, 2006), and provide timely and immediate feedback to students on their work (Smith, 2007).

Although many textbooks offer homework delivery systems complimentary or for free trial use with their textbook, the authors designed and built the on-line homework used in this study. It was labor intensive to build, but could be tailored to the course to present specific geologic processes through multiple perspectives, such as visualization, simulations, laboratories, or real time exercises, from multiple open source or educational sites. Some examples of site sources are listed in Appendix B. It was felt that having a small percentage of final grade associated with homework would motivate the students to successfully complete it. In other natural science courses, there is evidence that attaching a grade to the homework increases students’ attention to the assignment resulting in having a better understanding of the material (Cheng et al, 2004; LaRose, 2010; Richards-Babb et al, 2011). By replacing weekly quizzes with graded online homework, Richards-Babb et al (2011) found significant improvement in success rates in second-term general chemistry despite increasing enrollments in the course. Furthermore, over 80% of the class viewed the homework favorably and recommended that it be continued in the course. When implementing graded/not graded homework in a second semester calculus course, LaRose found the students in the graded homework group spent more time on and completed more homework than students in the not graded homework group, suggesting that the graded homework students had a better understanding of what they were learning (LaRose, 2010).

Numerous studies support the benefits of science laboratories and other inquiry-based or project-based learning at the primary and secondary education levels (Bybee, 2011; Akinoglu, 2008; Minner et al, 2009). Akinoglu interviewed 100 middle school students that completed
inquiry exercises throughout an entire school year, and found that inquiry activities increased students’ interest towards science and improved exam grades (Akinoglu, 2008). Minner’s synthesis of 138 different K-12 studies found that teaching strategies that actively engage students in scientific investigations are more likely to increase K-12 students’ understanding of the material than are strategies that rely on passive techniques (Minner et al, 2009). Laboratories are also central in teaching geosciences, although quantitative research examining them in association with large enrollment lecture and enhanced learning at university level appears lacking (Macdonald et al, 2005; Nelson et al, 2010). A recent On the Cutting Edge Survey of near 1,000 introductory geoscience instructors indicated that only 25% of current introductory geoscience courses utilize more than one in-class laboratory per term (Macdonald et al, 2005). Therefore, in this study, a laboratory-based activity that related to the instructional material was completed twice monthly following lecture in the active learning section. It was felt that encouraging in-class peer interaction and learning through active engagement would have a positive effect on the understanding of geologic concepts and overall achievement performance.

Geoscience educational research suggests that the use of in-class laboratory type activities following lecture can provide benefits to achievement scores and conceptual understanding, especially with teacher-guided hypothesis testing that is followed up by scientific discourse (Hannula, 2003; Apedoe et al, 2006). Apedoe found that lab based activities that were designed to actively engage cognitive thinking with scientific inquiry had a positive correlation with student learning in a small size, general, undergraduate geoscience course (Apedoe et al, 2006). His results did not come without some resistance from students who were not accustomed to this form of inquiry instruction. Hannula (2003) found that introductory geology students’ perceptions about what they thought they knew regarding the scientific method differed from
what assessment outcomes stated. But repeated exposure over time improved students’ performance success (Hannula, 2003). In an investigation to understand teaching and learning, Roth studied high school (grade 12) Physics students of varying achievement levels to characterize factors that mediate what and how students learn from demonstrations (Roth et al, 1996). The resultant feedback point to the complexity of influences that students bring to a laboratory based activity: including not knowing what to focus on, frame of reference interfering with new learning, lack of discourse following a demonstration, or giving the activity a low priority.

It was expected that a collaborative group project would address a wider array of student learning than that captured by a traditional exam. There is research about the use of group projects in primary and secondary science education, but there is little quantitative research about group projects in undergraduate geoscience courses. Papers and presentations are used more extensively in courses for majors rather than large enrollment introductory courses (Harris, 2002; Macdonald et al, 2005). This is the first time that a graded collaborative group poster/paper project in an introductory geoscience setting is reported. Group projects have been shown to provide engagement and encouragement, as well as a mixture of group and individual accountability. In geoscience literature, Harris (2002) reported that creative group poster work was successful towards learning in an advanced geology course in a mid western university. Students excelled when given the opportunity to demonstrate specific skills and knowledge they acquired in the development of their own research and presentation. As well, working as a group to complete a technical paper and poster supported our objective to give students responsibility in scientific endeavors (NSF, 1996) by utilizing 21st century skills to complete the project (AACU, 2007).
Research Claim

The potential and anticipated influence that instructional methodologies have on achievement outcomes regarding the learning of geology led us to question whether there would be positive changes in achievement performance and attitudes based on the use of different instructional styles and assessment strategies in two similar introductory geology sections. As well, which of the study design methods were the most useful towards conceptual understanding and achievement performance? This study offers comparative analysis of multiple ongoing, graded assessments used simultaneously in a large-enrollment, introductory geology course populated mostly by non-majors compared to a similar section that maintained a traditional lecture format. Interactive systems such as media demonstrations, concept test questions, in-class laboratories, and web based homework provided the context to build learner participation and student-centered teaching/learning. This allowed assessment to be embedded directly into class using exercises that challenged existing student conceptions and that required students to apply newly acquired knowledge to solve problems in and out of the classroom (Fosnot, 1989; Driver et al, 1995). Of particular interest and unique to this type of setting was the incorporation of a one-time group-collaborative poster/paper project used as a means to evaluate learning. With the belief that group work builds shared communities in learning and applies learning beyond the classroom, it was considered that a cooperative project would benefit learning and conceptual understanding, especially for non-majors.

To assess students’ views of these methods, attitudinal data were obtained through monthly student self-assessment reporting and post interview questioning of students at the end of the semester. The attitudinal results informed our research, helped to evaluate our program, and continue to guide us in future curriculum development.
Research Agenda

Achievement test comparisons were made between the sections in spring semester 2009 to see if students in the active learning section had higher achievement test averages than the students in the traditional lecture format section. As well, comparisons were made within the active learning class to ascertain if students who completed weekly homework and/or did a group project had a higher achievement test average than their peers. Further comparisons were made to see if participation in the in-class laboratory based activities over the semester influenced semester achievement performance outcomes. The final distribution of points by ten-percentile rank order (i.e., 90-100%, 80-89%, 70-79%, etc.) were compared between the active learning and traditional sections to investigate differences in point dispersal and success rates in the course.

A Student Self-Assessment of Learning Survey was created and given monthly to students in the active learning section for student self assessment of their own learning strategies and to inform instructional practices. Administered at the start of class near the end of each unit of instruction, the questions were categorically divided into: 1) the use of introductory engagements or questions at the beginning of instruction, 2) concept-test questions used at the close of daily instruction, 3) weekly on-line based homework, and 4) bi-weekly in-class activities done at two week intervals through the course of the semester. The surveys were delivered through a classroom communication system, which counted the number of students to respond to each answer choice. Questions addressed use and applicability of the teaching strategies used in the course. The choice of answers were detailed around learner’s prior conceptions or knowledge of a geologic concept at the start of learning, student self-awareness and responsibility while learning, and how the methods used in the active learning class related to learning in the classroom. The questions and choices of answers are listed in the results section.
Last, eleven open-ended interview questions (Appendix D) were developed to probe personal attitudes and views about geology and views about the teaching methodologies used in this study. Tape-recorded interviews, 45-60 minute in length, with eleven students in the active learning section were transcribed into hard copy for content analysis. Content analysis generated and connected raw data to codes, codes to categories, and categories to themes (Patton, 2001). This process allowed data reduction and organization of a volume of qualitative interview material in an attempt to identify core consistencies and meaning. In this way, we could substantiate and validate our quantitative findings through student responses to the open ended questions.

We maintain that because of the dynamic nature of student populations, continued investigations about learning outcomes and student attitudes about learning science are needed. As the impetus of science education reform is more authentic learning, students’ performance and attitudes are valuable in evaluating the effectiveness of existing programs and subsequent modifications to the program. This study contributes more specifically to research on undergraduate science teaching and learning and the use of different learning and assessment strategies in a large-enrollment, introductory geoscience course.

Definition of Terms

**Active Learning**

As defined in this study, is the engagement in activities and/or collaborative class projects through which students take responsibility for their learning; the activities offer students opportunities to talk, read, write, listen, and reflect.
Blackboard Learning System

The Blackboard Learning System is a virtual learning (platform) environment and course management program, developed by Blackboard, Incorporated. It is a Web-based server software that offers course management, customizable internal architecture, and integration with student information systems.

Concept Tests

Developed by Dr. Edwin Mazur for use with the Galileo Project at Harvard University (1993), Concept Tests are usually multiple choice questions imbedded into power point presentations utilized throughout an instructional phase to gauge comprehension of a concept and to encourage dialogue between student to student and student to instructor. Students use “clickers” (PRS) to answer concept-type questions, where the responses are aggregated and scored through computer software. Resultant scores to questions are displayed on histograms on the projector.

Learning Objects

For purpose of this study, any multimedia delivery system that provides a resource for supplemental material is considered a learning object. Compendiums of web-based educational sources are available through national, federal, and private institutions and agencies. These sites provide interactive labs, demonstrations, and exercises that apply specifically to geoscience and geologic learning.
The Learning Cycle

The Learning Cycle is an inquiry-based teaching model in science education and consistent with contemporary theories about how individuals learn. The three sequential phases in this model are: Exploration, Instruction, and Application. This approach can be traced to the Science Curriculum Improvement Study (SCIS).

Personal Response Systems (P.R.S.)

The Personal Response System (P.R.S.) is a hand held radio frequency transmitter that allows students to input responses by sending infrared (IR) signals to receptors located within the classroom. Used in conjunction with concept-test questions, computer software then aggregates the responses, where students can see the results on a displayed histogram on the projector.

Traditional (Lecture) Instruction

As defined in this study, it is a method of teaching that uses lecture as a format and has no supplemental activities, alternative assessments, or student to student interaction.
1.3 METHODOLOGY

1. Institutional Review Board (IRB) Protocols Approval

Approval was received for the administration of monthly student surveys and exit interviews with students from the university’s Institutional Review Board (protocol # H-21354). I.R.B. protocols and processes are included in Appendix G.

2. Class Demographics

The initial sample consisted of regularly enrolled students in two sections of Geology 101 in the spring of 2009 (Section 001, n = 330; Section 006, n = 198). Section 001 was scheduled mid morning and maintained a traditional lecture format. Section 006 was scheduled later in the morning and utilized an active learning approach. Demographic information for the two sections was obtained from the institutional Information for Decision Enabling and Analysis System (IDEAS), to give gender, average age, minimum/maximum and average current university G.P.A., as well as past high school scholastic achievement performance records as shown in Table 1.1.

Table 1.1  Background Demographic Information of Sample Population

<table>
<thead>
<tr>
<th>Instructional Style</th>
<th>Section</th>
<th>Count</th>
<th>Male: Count and %</th>
<th>Female: Count and %</th>
<th>AVG Age</th>
<th>AVG COLLEGE G.P.A.</th>
<th>AVG ACT Scores</th>
<th>AVG SAT Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Lecture</td>
<td>001</td>
<td>330</td>
<td>184 (56%)</td>
<td>146 (44%)</td>
<td>21</td>
<td>2.60</td>
<td>17</td>
<td>1170</td>
</tr>
<tr>
<td>Active Learning</td>
<td>006</td>
<td>198</td>
<td>129 (65%)</td>
<td>69 (35%)</td>
<td>21</td>
<td>2.52</td>
<td>22</td>
<td>987.5</td>
</tr>
</tbody>
</table>
The records demonstrate a scope of factors that are not considered in the study, such as gender difference, major, and high school achievement test scores, which would be worthy of further investigation in understanding performance. The differences in ACT and SAT scores of both groups could violate the assumption that the two groups are similar, prior to instruction. However, the average college G.P.A. of the two groups is approximately the same. Thus, there is little or no difference with regard to academic success in college. Therefore, we are not concerned about differences in previous scholastic predictors (ACT & SAT).

Both sections met three days per week: Monday, Wednesday, and Friday, for 50 minutes per day in a 350 seat, large lecture hall. Both sections used the same test bank for test questions and gave four sequential exams (etests) through the semester. The semester course sequencing, outline, and exam information is listed in Appendix A. The 3-hour introductory course has an accompanying 1-hour laboratory course, of which grades are derived independent of the lecture. Most students take the laboratory the same semester that they are taking the introductory course, although it is not required that they be taken at the same time. The laboratory course deviates from the introductory textbooks used in the department, conveying broad scope geologic constructs that relate to such issues as geologic events and hazards, economy, resources, and development.

The distribution of points used in both sections is displayed in Table 1.2. All tests in Section 006 (active learning section) were transformed to 99 points for sake of statistical analysis to allow comparisons to Section 001 (traditional lecture section). After determining there was equality of variance in the distribution of each test score with an F test, a one-sided t-test at a 5% significance level (p = 0.05) was performed on the test scores between the sections to see if the mean for the active learning section was greater than the mean for the lecture section. A one-
sided t-test was used as we expected that doing the activities would have a positive effect on achievement performance. Each test in the active learning section was worth 18% of the total grade, together equaling 288 points, or 72% of the final grade of 400 points possible. Each test in the lecture-based section was worth 25% of final grade.

Table 1.2
Distribution of Points for Section 001 and Section 006 used in this study; Spring, 2009

<table>
<thead>
<tr>
<th>Section</th>
<th>Distribution of Points</th>
<th>% Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>4 Tests @ 99 points each = 396 points</td>
<td>25% each =</td>
</tr>
<tr>
<td>006</td>
<td>4 Tests @ 72 points each = 288 points</td>
<td>18% each =</td>
</tr>
<tr>
<td></td>
<td>12 On-line HW @ 4 points = 48 points</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>1 Group Poster/Paper Project = 48 points</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>8 In-class Labs @ 2 points = 16 points</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>Total 400 points</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

3. Teaching Methodology

The pedagogical sequence we followed in the active learning section was a learning cycle, consisting of three phases: concept exploration, concept introduction, and concept application (Abraham, 1997, Grove, 2002). An example of the Learning Cycle is given in Appendix F. The exploratory phase involved introducing students to the daily topic through visualization, questions, and inquiry based activities. This was followed by an introduction and instruction of the terms of the concepts, through lecture and power point slides. Following daily lecture, students answered a total of 12-15 timed concept-test type questions either independently or after a brief time consulting with a peer. The timed questions duration ranged from 30 seconds to 1.5 minutes dependent on the difficulty of the question. Although there was no grade assigned to concept-type answers, it was expected that daily assessment would check for conceptual
understanding immediately following instruction and inform student’s progress in learning and instructor’s teaching. The final phase of the learning cycle involved application, extension, and generalization of learning through for grade in-class activities, homework, and a group project.

The twelve mandatory weekly online homework assignments were part of the scheduled course outline. Each homework assignment was worth 4 points, totaling 48 points, or 12% of the cumulative 400 points possible. Each homework assignment contained 18-24 questions with different formats, such as multiple choice, matching, true/false, and text entry. Students were given one attempt to answer each question. Homework was managed through Blackboard Academic Suite®, a web-based Learning Management System (LMS) widely used in secondary and tertiary educational settings. Homework was available from Friday, at 5:00 PM through the following Tuesday, at 5:00 PM, and overlapped with the class content studied. Students had the flexibility to submit homework anytime within the assigned time period. The homework remained open and was accessible beyond the due date for student use in test preparation. The majority use of multiple choice type answers in the homework format led us to establish a lower threshold level of <25% of total homework score for exclusion as participators in statistical analysis. A one sided t-test at a 5% significance level (p = 0.05) was performed in the active learning section to investigate if there was a significantly higher test achievement mean for those students that did homework versus those students that viewed it as a low priority and earned <25% points or did not do the homework. A one-sided t-test was used as we expected that doing the homework would have a positive effect on achievement performance.

The eight in-class activities related to topics covered in class and were done at approximate two-week intervals or two activities per unit test coverage. The inquiry-based laboratory type activities were more “structured and guided” tasks (Banchi and Bell, 2008)
because students were given the question to pursue, and the data from which to formulate their explanations. The activities consisted generally of graphs and data of geologic phenomena in which students were asked to analyze, discuss, and communicate findings. Completed in the last 20-25 minutes of class, students were encouraged to work as groups in completing the activity, with minimal guidance from the instructor. Each laboratory type activity was worth 2 points, totaling 16 points, or 4% of the cumulative grade out of 400 points. These were hand graded by the instructor and returned to students the next day of instruction. Semester mean achievement scores were compared between the students that did the in-class activities versus the students that did not successfully complete the semester activities (<25% total activity point value) to see if there was a significantly higher semester achievement mean for the students that did the in-class activities. A one sided t-test at a 5% significance level (p = 0.05) was performed. A one-sided t-test was used as we expected that doing the in-class activities would have a positive effect on achievement performance.

The group project was worth 48 points, or 12% of cumulative grade, out of 400 points available (Appendix C). The project grade was independent of test achievement performance and was a one-time assignment per student. Students were given the first two weeks of the course to sign up for a project. The assignment entailed researching any topic or theme covered in Unit 1, 2, 3, or 4 as a group (4-5 members) and presenting a professional poster and research paper at or after the close of the unit of instruction. All project titles except for Unit One participants needed approval within four weeks of due date.

Project due dates corresponded with the close of the unit of instruction, at which time groups displayed their posters on easels in the large hallway outside of the lecture hall. For the first 20 minutes of class, the groups were asked to stand with their work to explain and defend
their research to their peers and other departmental faculty and students invited to view the group project displays. Each group was graded by a rubric (Appendix C.2) and was required to submit three signatures from individuals with whom they discussed their project at presentation time. Student accountability in project participation included weekly postings to a discussion board during the four-week time period of project preparation and group member performance evaluations (Appendix C.3) submitted upon project completion. Examples of students work can be found in Appendix C.4-5. In order to manage group work with 198 students, each unit of instruction was capped at 12 project groups. This evenly distributed the number of students per unit of instruction (approximately 50 students per unit). Students were assigned to groups if they failed to sign up. A one sided t-test at a 5% significance level (p = 0.05) was performed on each achievement test to compare if there was a significantly higher mean achievement score for those students that did a poster/paper project in a particular unit compared to those students that did not do a project for the same unit. A one-sided t-test was used as we expected that doing the group work would have a positive effect on achievement performance.

4. Study Design

This study used test achievement performance to investigate if active learning teaching strategies enhanced learning and improved attitudes about geology. A triangulated mixed methods design was used that integrated quantitative and attitudinal data so that each dataset carried equal weight, priority, and consideration. Data was obtained from three sources: mean achievement scores, monthly student self-assessment surveys, and semester end interviews.
Data Collection

1. Achievement Records

Both sections used the same four multiple choice content tests administered at approximate one month intervals through the fifteen week semester (Section 001, n= 33 questions per test; Section 006, n= 36 questions per test) with questions randomly selected from the same test bank. All tests bore equal weight and were not cumulative in nature. In the student-centered section, weekly online homework was scored via computer software upon submission each week. The eight in-class activities were hand graded by the instructor and returned to students the next day of instruction. The group project was evaluated through a rubric, which gave a clear understanding of performance expectations (Harris, 2002; McConnell et al, 2003; Allen, 2004), discussion posts, and peer evaluation. Students were able to monitor all grades by accessing the online class management site.

2. Monthly Student Self-Assessment Surveys

Four times through the semester in the active learning section, students responded to questions regarding teaching methods in the course and priority to learning strategies used through self-assessment reporting in a P.R.S. managed Student Self-Assessment of Learning Survey. The narrow range of responses from which the students were able to choose constricted the lens from which student views towards methodologies may be regarded, but offered a snapshot of student changing views of the methodologies used through time.

3. Student Open ended Interviews

Interviews were conducted with eleven students from the student-centered section within ten days prior to the close of the semester to get students’ feedback on the features of the teaching design. Interview questions are listed in Appendix D. As the individual characteristics
that make up the student population are so vast and complex, it was expected that interview responses would vary based on the individual student interviewed. Emergent themes were used to develop a matrix to better link program processes and program outcomes. (Appendix E) This matrix enabled cross-referencing of items such as attitude regarding the social context of the teaching design, personal attitudes about the teaching format, and achievement outcomes of this course with the processes used in the study.

In this way, a combination of sampling methods that produced data from multiple sources best represented the complexity of the teaching instructions to give a holistic view of the participants.

1.4 RESULTS

1. Achievement Performance between Sections

A one-sided t-test revealed a statistically significantly higher mean score (p< 0.05) in achievement scores in the active learning section for all four-achievement tests administered through the semester as seen in Table 1.3.
Table 1.3  Lecture (Section 001) and Active Learning (Section 006)  
Comparison of Test Averages between Sections

<table>
<thead>
<tr>
<th>Unit Test</th>
<th>Class Average: Section 001</th>
<th>STDEV Section 001</th>
<th>Class Average: Section 006</th>
<th>STDEV Section 006</th>
<th>t-ratio</th>
<th>Prob &lt; t Critical</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>61.44</td>
<td>15.90</td>
<td>64.59</td>
<td>13.28</td>
<td>2.21</td>
<td>0.0139</td>
</tr>
<tr>
<td>2</td>
<td>56.78</td>
<td>16.15</td>
<td>62.74</td>
<td>15.56</td>
<td>3.92</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>3</td>
<td>54.65</td>
<td>16.06</td>
<td>63.95</td>
<td>14.79</td>
<td>6.12</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>4</td>
<td>64.47</td>
<td>15.65</td>
<td>69.47</td>
<td>16.46</td>
<td>3.12</td>
<td>&lt;0.0009</td>
</tr>
</tbody>
</table>

In the active learning section, Unit One test showed modestly better results in test performance than the lecture based section (p = 0.0139). Differences in mean scores became statistically stronger (p<0.001) in the student-centered class for the remaining 2\textsuperscript{nd}, 3\textsuperscript{rd}, and 4\textsuperscript{th} test. The highest achievement gain was seen at test 3, where there is greater than a 9-point (9.10%) increase in average achievement score in the active learning section. Both section averages were lower on the second test compared to Test One, possibly because there were five chapters of material covered, whereas the other units covered four chapters. Graphical representation is shown in Figure 1.1.
2. Achievement Performance in the Active Learning Section

A. Weekly Homework Results

In the active learning section, the achievement test scores were further divided into subsets of students that did homework and those that did not do homework. (Table 1.4) A strong statistical relation was found between doing homework and mean achievement performance, with achievement scores at least 10 points (10.00%) higher for students that did homework on all four tests. For the 2\textsuperscript{nd} and 3\textsuperscript{rd} test, students that did homework outperformed peers by greater than 12 points (12.12%) at a 1% significance (p < 0.001) level. Further, students that did homework scored higher than the overall student centered section average as well as the overall class average of the lecture based section. The subset of students that did not do homework in the student centered class scored slightly lower than the test averages in the lecture-based class on the 1\textsuperscript{st}, 2\textsuperscript{nd}, and 4\textsuperscript{th} test.
Table 1.4
Test Average Comparison of students that did Homework and students that did not do Homework for each corresponding achievement test.

<table>
<thead>
<tr>
<th>Unit Test</th>
<th>Test Average: No HW</th>
<th>STDEV No HW</th>
<th>Test Average: HW</th>
<th>STDEV HW</th>
<th>t-Ratio</th>
<th>p-value</th>
<th>Ratio and % to complete HW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>54.52</td>
<td>14.59</td>
<td>65.66</td>
<td>12.71</td>
<td>3.388</td>
<td>&lt;0.0004</td>
<td>159/176 (90%)</td>
</tr>
<tr>
<td>2</td>
<td>52.05</td>
<td>15.31</td>
<td>64.71</td>
<td>14.83</td>
<td>4.057</td>
<td>&lt;0.0001</td>
<td>146/174 (84%)</td>
</tr>
<tr>
<td>3</td>
<td>55.43</td>
<td>13.56</td>
<td>67.98</td>
<td>13.65</td>
<td>5.576</td>
<td>&lt;0.0001</td>
<td>114/168 (68%)</td>
</tr>
<tr>
<td>4</td>
<td>60.59</td>
<td>17.77</td>
<td>71.29</td>
<td>15.49</td>
<td>3.323</td>
<td>&lt;0.0006</td>
<td>133/163 (82%)</td>
</tr>
</tbody>
</table>

The ratios and percentages used in the table are based on the number of students that took the corresponding Unit Test.

As shown in Table 1.4, most students gave homework a high priority as can be seen by the overall percentage of students to participate. Although we anticipated that there might be some difficulty in completing this portion of the course because of lack of computer access, this did not appear to be the case. The number of students to participate in homework submission was highest in the first half of the semester during unit 1 (n = 159) and unit 2 (n = 146) instructional time periods, respectively. Following midterm, student participation in homework declined by 22% compared to the start of the semester, (n = 114) during the third unit of instruction. During the last quarter of the semester, the number of students to do homework increased by 14% compared to the third unit (n = 133), but was still lower than the first half of the semester.

B. Group Poster/Paper Project

Students in the active learning section (Section 006) were categorized into two groups: students that completed the one time thematic group project and those that did not complete a project within each unit. (Table 1.5) There was no significant difference in test average between those students that participated in a Poster/Paper Project to those that did not do a project for any given specific unit test. However, students that completed the project in Units 1, 3, and 4 did
have higher achievement performance averages than those students that did not do the project for that specific unit, although not of statistical significance. An unanticipated result was students that did a project for unit 2 performed less well on the corresponding achievement test than their classmates that did not do a project, although their scores were still higher than the class average and that of the lecture section. This outcome could be influenced by the fact that project topics were chosen by the students and did not necessarily reflect the same content covered from the book.

Table 1.5

<table>
<thead>
<tr>
<th>Unit Test</th>
<th>Test Average: No Project</th>
<th>STDEV No Project</th>
<th>Test Average: Project</th>
<th>STDEV Project</th>
<th>t-Ratio</th>
<th>p-value</th>
<th>Ratio and % to complete Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64.41</td>
<td>13.55</td>
<td>65.38</td>
<td>12.05</td>
<td>0.367</td>
<td>0.357</td>
<td>31/176 (18%)</td>
</tr>
<tr>
<td>2</td>
<td>63.43</td>
<td>15.85</td>
<td>59.93</td>
<td>14.42</td>
<td>-1.176</td>
<td>0.879</td>
<td>34/173 (20%)</td>
</tr>
<tr>
<td>3</td>
<td>63.01</td>
<td>14.57</td>
<td>67.16</td>
<td>15.29</td>
<td>1.527</td>
<td>0.064</td>
<td>38/165 (23%)</td>
</tr>
<tr>
<td>4</td>
<td>68.83</td>
<td>17.26</td>
<td>70.81</td>
<td>14.16</td>
<td>0.680</td>
<td>0.249</td>
<td>44/163 (27%)</td>
</tr>
</tbody>
</table>

The ratios and percentages used in the table are based on the number of students that took the corresponding Unit Test.

Outside of this finding, project participants’ scored very similarly to those that successfully completed the homework. We had hoped for a more significant relation between doing the thematic project and achievement performance, but this was not the case. However, students did perceive the group work as an important aspect of the course. One hundred forty seven students out of 181 students to complete the course completed the project, or 81% of the class. Of the remaining 19%, or 34 students that did not do the project, 17 of those dropped the course, meaning that 90% of the students who fulfilled the course objectives gave the project a high priority and completed it.
Further, we looked at test averages including those to do homework/not do homework, the project/no project, and doing both homework and the project in all units of instruction through the semester (Table 1.6). Although doing weekly homework showed the strongest positive relationship to achievement performance, students that did homework and the thematic project in both Unit 1 and Unit 3 slightly outperformed those students that only did homework. These referenced scores were significantly higher than the students that did not do homework.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Section 001</th>
<th>Section 006</th>
<th>Section 006</th>
<th>Section 006</th>
<th>Section 006</th>
<th>Section 006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>Class Test Average</td>
<td>Class Test Average</td>
<td>Test Average of subset of students who did not do homework</td>
<td>Test Average of subset of students who did project</td>
<td>Test Average of subset of students who did HW &amp; project</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>61.44</td>
<td>64.59</td>
<td>65.66</td>
<td>90%</td>
<td>54.52</td>
<td>10%</td>
</tr>
<tr>
<td>2</td>
<td>56.78</td>
<td>62.74</td>
<td>64.71</td>
<td>84%</td>
<td>52.05</td>
<td>15%</td>
</tr>
<tr>
<td>3</td>
<td>54.65</td>
<td>63.95</td>
<td>67.98</td>
<td>68%</td>
<td>55.43</td>
<td>32%</td>
</tr>
<tr>
<td>4</td>
<td>64.47</td>
<td>69.47</td>
<td>71.29</td>
<td>82%</td>
<td>60.59</td>
<td>18%</td>
</tr>
</tbody>
</table>

A t-test could not be performed because of the overlap that existed between group members.

C. In-Class Activities

Semester achievement averages were compared between students that did the in-class activities and those that did not successfully complete them over the semester (Table 1.7). The students that did not successfully complete the in-class activities were students that, in essence, did not view coming to class as a high priority and/or did not successfully complete the course. Of the 22 students that earned <25% in-class activity points, 4 dropped the course and the
remaining 18 students did not successfully complete the course. The semester mean average for students that did the activities was 64.76 versus a semester mean average of 43.42 for those students that did not do the in-class activities. However, doing activities was not necessarily associated with improved achievement scores. In consideration of these facts, the results cannot be considered indicative of a relationship between doing/not doing in-class activities and overall achievement. Students that came to class succeeded with in-class activities, meaning they made it a high priority to be in class and participate, suggesting a relationship between students attending class and overall success in the course.

Table 1.7

<table>
<thead>
<tr>
<th>Section 006</th>
<th>Semester test average comparison of students that did in-class activities and students that did not do in-class activities.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spring 2009</strong></td>
<td><strong>Students to earn &lt;25% activity points</strong></td>
</tr>
<tr>
<td>Semester Average</td>
<td>43.42</td>
</tr>
</tbody>
</table>

3. Overall Grade Distribution of both Sections

This research informed how the use of active learning strategies was reflected in final letter grade distribution in the course. As both instructors used different calculations for final letter grade, for purposes of comparison, the total points accumulated were distributed by ten-percentile ranking (i.e.: 90-99%, 80-89%, 70-79%, etc.), as displayed in Figure 1.2.
Overall, there were a higher percentage of students to successfully complete the course in the active learning section than in the lecture-based section of the course. Although there is little difference in the earning of 90-99% of total points (1% vs. 3%), the greatest difference in successful completion of the course can be seen with the students to earn 80-89% and 70-79% of total points available; 7% vs. 18%, and 13% vs. 27%, respectively. This means that in the student-centered section, there were over twice as many students to earn B’s and C’s using a 10-percentile ranking than in the traditional, lecture section. Only 21% of the students in the lecture based section earned a successful A, B, or C ranking in this distribution, whereas 48% of the students in the student-centered section were able to achieve this success. The student-centered sections’ distribution overall reflects a mound-shaped distribution with positive skewing towards a higher value range. The lecture-based section reflects a Bell distribution. There was a consistently larger percentile for Section 006 (active learning) in the “passing grade” deciles.
4. Attitudinal Results

The Student Monthly Self-Assessment surveys and interview responses provide a descriptive summary of students’ views and attitudes regarding some of the teaching methodologies used in the study. The surveys were administered in class and students were not required to answer all questions; therefore the number of student responses to any given question cannot be assumed to be equal. The average number of students to participate in the surveys was approximately 50% of the class enrollment. As a result of these limits, only percentages of respondents to particular questions are presented. The fourth survey was attached to test four; therefore there was a large increase in number of students to complete the survey.

Through self-selection, students in the student-centered section voluntarily signed up for interviews at the end of the semester. All of the students interviewed were taking Geology 101 to fulfill a general science elective requirement. None were Geology or science majors. Seven were female and 4 were male. Student’s ages ranged from early 20’s to early 30’s. The letter grade range earned in the course for the interviewees were B and C.

As can be seen in Table 1.8, survey results show that the exploratory (introductory) questions used at the beginning of a new class engaged 50% of the students in recalling prior knowledge of a particular geologic phenomenon at the start of the semester and increased to 76% near the end of the semester. All 11 interviewed students responded that they found the opening activities to be an effective way to “get your attention” and bring focus to the class.

The percentage of students that did not feel comfortable with being asked to provide a conceptual response to a geologic construct before formal instruction was small through the semester, varying from 12% to 21%. As the semester progressed, the percentage of students not
engaged at the beginning of a topic decreased to a minimum level. Introductory questions proved to be a good tool for focusing and preparing for the day’s instruction.

Table 1.8  
Student Monthly Self Assessment Survey
Exploratory Question Results

<table>
<thead>
<tr>
<th>Question 1 (Exploratory Questions)</th>
<th>Survey 1 $80 \leq n \leq 90$</th>
<th>Survey 2 $75 \leq n \leq 85$</th>
<th>Survey 3 $92 \leq n \leq 106$</th>
<th>Survey 4 $155 \leq n \leq 165$</th>
</tr>
</thead>
<tbody>
<tr>
<td>When we start a new chapter</td>
<td>% response</td>
<td>% response</td>
<td>% response</td>
<td>% response</td>
</tr>
<tr>
<td>a. I like having previous knowledge called upon with questions about the topic.</td>
<td>51</td>
<td>65</td>
<td>64</td>
<td>76</td>
</tr>
<tr>
<td>b. I am uncomfortable with being asked about my prior knowledge on a subject.</td>
<td>21</td>
<td>14</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>c. I am not engaged when we start a new topic.</td>
<td>28</td>
<td>22</td>
<td>22</td>
<td>4</td>
</tr>
</tbody>
</table>

Footnote: n is given in range because not all students responded to all question items on the questionnaire.

Table 1.9 shows an increase of 34 percentage points in appreciation of the use of Concept-test question: a) to help see strengths and weaknesses in understanding material by the end of the term compared to the beginning of the semester (44% to 78%). Also, four of the 11 students interviewed (36%) said they favored the use of the P.R.S. as a delivery tool for introductory exploratory questions or Concept test questions as the most valuable tool in the course. This type of formative assessment engages students in their own learning, retention of knowledge content, understanding, and gives feedback to the teacher on student mastery of the instruction (Seymour, 1998; Crouch and Mazur, 2001).

Students felt more comfortable with the pace of the Concept-test questions with a greater than 50% reduction in the negative survey response choice: (b.) Concept-test questions go so quickly that I cannot retain the material on the question (46% to 20%). Through the course, student feedback led the instructor to adjust the time and formatting of question presentation,
which could be responsible for this positive change. Only a small percentage of students felt inadequate if they did not have the correct answer, which could be attributed to having anonymity when responding and lack of grade attachment. Nine of the 11 students (82%) interviewed liked that points were not associated with instructional use of P.R.S.

<table>
<thead>
<tr>
<th>Concept-Test Questions</th>
<th>% response Survey 1 80 ≤ n ≤ 90</th>
<th>% response Survey 2 75 ≤ n ≤ 85</th>
<th>% response Survey 3 92 ≤ n ≤ 106</th>
<th>% response Survey 4 155 ≤ n ≤ 165</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. …help me see my strengths and weaknesses in understanding material.</td>
<td>44</td>
<td>55</td>
<td>75</td>
<td>78</td>
</tr>
<tr>
<td>b. …go so quickly that I cannot retain the material on the question.</td>
<td>46</td>
<td>41</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>c. …make me feel inadequate if I do not know the answer.</td>
<td>10</td>
<td>4</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Footnote: n is given in range because not all students responded to all question items on the questionnaire.

The interviewed students commented that the use of the PRS for introductory questions or Concept Test questions was engaging, brought focus, and/or was socially dynamic.

Representative interview responses to the use of Exploratory and/or Concept-Test questions included:

- “Yeah, the introductory picture or question really got your attention. If you weren’t engaged, you were then.”
- “The problem solving helps me to expand my knowledge.”
- “It let me know whether I knew the material or whether I needed to go back and review [sic] it.”
- “It’s kind of like [a] review of what the test might be like.”
- “They are good in class and good outside study tools as well.”

Other interview responses regarding the use of the P.R.S. included gaining understanding in learning, recalling past knowledge when answering an introductory question, and peer
instruction and learning with Concept-tests. Two students (18%) responded negatively towards P.R.S. usage as distracting or stressful, with the statements:

- “My clicker would fall asleep and when the question started, by the time I got it [my clicker] awake, I didn’t have enough time to read and answer the question.”
- “People drop their clickers or have to go get them and it’s distracting.”

Student views and value of the online homework are expressed in the Student Monthly Self Assessment results in Table 1.10. Portions of homework sets paralleled and/or were extensions of the concepts covered in the textbook, as a section of the homework was presented in laboratory, simulation, or real-time exercises. We found it encouraging that twice as many students used homework to assist them for test preparation (44-57%) compared to students that found homework to only reinforce classroom learning (19-35%) but did not utilize it as a study tool. Six interviewees (54%) made a direct reference to homework as reinforcing to learning geology concepts and as a study tool for test preparation. This is in agreement with the student monthly self-assessment survey response (b)…” that homework helps reinforce what I have learned in class and helps me to prepare for a test”.

To check for internal validity in our survey, negative responses were included regarding homework, as well. As the semester progressed, fewer students found homework to not relate to learning (25-10%) as can be seen in answer (c ) …”is not related to how much and what I learn.” These findings support the increase that was seen in homework usefulness. Through the entire semester, there was a small percent (3-7%) of students that did not think homework related to the material covered in class. This is typical in a large enrollment (~200+ student) course.
Table 1.10
Student Monthly Self Assessment Survey
Weekly Homework Question Results

<table>
<thead>
<tr>
<th>Question 3</th>
<th>Survey 1 80 ≤ n ≤ 90</th>
<th>Survey 2 75 ≤ n ≤ 85</th>
<th>Survey 3 92 ≤ n ≤ 106</th>
<th>Survey 4 155 ≤ n ≤ 165</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekly Homework</td>
<td>% response</td>
<td>% response</td>
<td>% response</td>
<td>% response</td>
</tr>
<tr>
<td>a. …helps to reinforce what I have learned in class.</td>
<td>24</td>
<td>19</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>b. …helps reinforce what I have learned in class and helps me to prepare for a test.</td>
<td>44</td>
<td>56</td>
<td>57</td>
<td>48</td>
</tr>
<tr>
<td>c. …is not related to how much and what I learn.</td>
<td>25</td>
<td>21</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>d. …does not relate to the material covered in class.</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

Footnote: n is given in range because not all students responded to all question items on the questionnaire.

In interviews, students indicated that the homework was interactive and hands on or a useful tool for studying. The interviewed students recognized benefits of doing homework that extended beyond learning in the classroom, such as providing connections to real world geological events, learning from another perspective, and taking some pressure off of achievement testing. Representative responses from the interviews regarding homework included:

• “I found [sic] the most efficient way of learning of the entire class was those homework(s).”
• “There would be times when I was doing a homework and all of a sudden the news that night would have to do with what we were learning. It makes you feel that your work is relevant.”
• “…you would have different studies from other universities that you would go on there and ask questions…I thought that was super helpful and it did help me with my tests…”
• “The homework took some other pressure off.”

All interviewed students thought that the percentage of points for homework (12% of grade) was appropriate for the work involved. All 11 responded, as well, that having graded homework for a
portion of their overall grade gave them a self-awareness about the amount of homework they did as well as a more positive view towards the homework. Similar to the findings of La Rose (2010) and Richards-Babb et al (2011), we found that including homework in the course grade had a positive effect on time on task and giving attention to the homework.

Of particular interest is the diversity of views held regarding the use of in-class activities as listed in Table 1.11. We found that activities, like homework, were held in higher view for being both helpful with classroom instruction and test preparation (17 to 52%) compared to students that found the activities to tie geologic concepts together with classroom learning (10 to 24%), but did not use them as a study tool. Both of these positive remarks increased through the semester. Percentages of students agreeing with negative response statements of: (c) …”are only helpful because of the points associated with them” and (d) …”are of no value to me” decreased through the semester. Grade as a motivator reduced by over 50% through the semester (57% to 25%). This could possibly be attributed to both student and instructor change over time in becoming more familiar and clear with expectation and instruction. As the semester progressed, there was a reduction in the percentage of students that felt that the activities were of little or no value towards learning (16% to 10%).
### Table 1.11

#### Student Monthly Self Assessment Survey

<table>
<thead>
<tr>
<th>Question 4</th>
<th>Survey 1 ($80 \leq n &lt; 90$)</th>
<th>Survey 2 ($75 \leq n &lt; 85$)</th>
<th>Survey 3 ($92 \leq n \leq 106$)</th>
<th>Survey 4 ($155 \leq n \leq 165$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In class activities</td>
<td>% response</td>
<td>% response</td>
<td>% response</td>
<td>% response</td>
</tr>
<tr>
<td>a. …help to clarify and tie together the concept.</td>
<td>10</td>
<td>13</td>
<td>13</td>
<td>24</td>
</tr>
<tr>
<td>b. …help clarify and tie together the concept and prepare me for the test.</td>
<td>17</td>
<td>22</td>
<td>52</td>
<td>40</td>
</tr>
<tr>
<td>c. …are only helpful because of the points associated with them.</td>
<td>57</td>
<td>51</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>d. …are of no value to me.</td>
<td>16</td>
<td>14</td>
<td>12</td>
<td>10</td>
</tr>
</tbody>
</table>

Footnote: n is given in range because not all students responded to all question items on the questionnaire.

The in-class activities were of such low point value (4%) towards total grade that a t-test on doing activities/not-doing activities could only be constructed on the semester accumulated activity points (16 points). Students that did not do the activities were students that, in essence, did not give coming to class a high priority. Therefore, the results of a semester t-test on semester mean achievement scores did not reflect an association of achievement success with the activities, but was skewed to reflect outcomes of students that did not come to class and/or did not successfully complete the course. However, doing the activities was not necessarily associated with improved achievement scores.

Interview responses allude to inherent problems that can occur when implementing group activities in class. In interview, 4 of the 11 (36%) students commented that they felt inadequate in completing the hands-on activity or that instruction was not clear. As well, those students suggested more time be given to complete activities, as they often felt rushed. These remarks are corroborated by the percentage of students that responded negatively in the Student Self
Assessment survey results regarding in-class activities. Representative negative responses include:

- “…cause they were always the last thing we did and I didn’t always understand the instruction, I didn’t think I would ever get them done.”
- “Like some of the things I felt were kind of difficult just because I just honestly find this material difficult…”
- “If I kind of like was having a really hard time with a certain chapter, then the activity didn’t necessarily make anything clearer to me.”
- “I think I would have understood them more if we could take them home and do them, then discuss them in class before we turned them in.”

Roth et al (1996) and Richard et al (2006) point out the significance of students’ understanding the important aspects of the hands-on activity and how critical follow up is in response to activities for improving student learning from the activity. The omission of follow up on the in-class activities could have contributed to the overall negative findings. Five (45%) of the interviewed students found the in-class activities served as a tool to reinforce learning and for test preparation. This is in agreement with the self reported survey response percentages.

Representative remarks include:

- “It was helpful that they seemed to close up any topic that we discussed.”
- “…they help to [like] see if you understood what we did that day.”
- “If I could answer the questions well, …then I would feel more comfortable going into the exam.”

All interviewed students stated one positive comment about the activities; for example, for the social aspects of group work, breaking up the monotony of class, points, or further understanding of the material. The use of drawings and graphs in activities were favored by six (55%) of the interviewed students.
Although the project was not included in the students self reported monthly surveys, it was discussed in interview. Interview responses were focused on social, professional, and technical skills needed to accomplish the project as much as towards the learning of geology. Eight students (73%) interviewed viewed this group work as similar to real work situations they will be facing in the future, whether they were comfortable with it or not. Representative responses include:

- “…we go through all the technical skills of putting posters together, printing them out, writing technical reports.”
- “I think that that type of work is helpful at this point in our life and this state of education. I think it’s important to work with others.”
- “Especially useful for when you graduate and you’re out in the real world and no matter what career you have, you know you’re going to be working with a couple of people.”

Nine out of 11 students (82%) interviewed indicated a deeper learning with the geologic concept or phenomena researched for their group’s project. Projects were limited in their usefulness for test preparation as each group chose their own topic to research within the unit theme being studied, but they were useful if test questions surrounded the topic of research of the project. Possibly the projects would have had a more positive influence on achievement performance if topics were restricted to those covered in class. Five of the 11 students interviewed (45%) found a practical side to learning through broadening professional and technological skills. As with Harris’s (2002) findings using poster presentations in a geoscience course, we found students more engaged, confident, and critical in evaluating their own work when the course material was aligned with actual field practice. Three of the 11 students (27%) expressed displeasure with other group members’ low priority or ethics surrounding completion of the project.
Student interview remarks surrounding the use of a student-centered approach to classroom instruction were positive. All of the interviewees indicated that the diversity in activities set an atmosphere for the class and provided motivation to come to class. Further, the distribution of points through on-line graded homework, the graded in-class activities, and the graded project gave them more confidence by controlling a portion of their grade and taking some of the pressure off of high stakes testing. Mostly though, students indicated that through these activities, their learning was enhanced and extended beyond the classroom into real world applications. Some representative remarks regarding the student-centered platform include:

- “I know that if I can explain something to someone, then I learn [sic] it well.”
- “I like teaching it to someone else because it is like kind of a learning tool for the student, too.”
- “…like it helped out because when everybody started talking, we’d put feedback in. It’s good to hear other people’s opinions and their descriptions. We each defended our own side before we reached an answer.”
- “…it’s easier to learn from another person, especially with group work.”
- “I will not forget what I teach to someone else…when I was able to help another student, I knew it better because I went through it with him.”

1.5 Discussion

The purpose of the study was to see if providing diverse learning opportunities would result in higher achievement performance, letter grade distribution, and improved attitudes in a large enrollment, introductory geology course. By disaggregating emerging data, we concentrated on patterns and causal relationships between achievement success as well as strengths and weaknesses encountered with our methodology. We realize students come to large
enrollment settings from a myriad of educational backgrounds and experiences. Thus adaptation to an active student learning style, let alone a large lecture hall setting, may be a difficult transition. Promoting a sense of community among students through interactive strategies and peer instruction early in the course showed results that were generally positive, while a few strategies failed or yielded mixed results. We found that the effect of peer interaction on learning typically was positive, although student views regarding peer interaction were not always in a positive direction. Willingness of individuals to accept the views of a peer may have a positive or negative affect on the outcomes commonly associated with peer interactions (Macdonald et al, 1995). We found students approached different activities with different strategies or purposes, as well (i.e. conceptual learning, studying, or points) but that overall, students considered these activities a high priority as can be seen by the high percentage of students to complete them.

There were modest to significant gains in achievement performance in all four academic tests in the student-centered section (See Table 1.3). We found this to be evident in all cases for students that spent time to successfully complete the homework. Our results showed the greatest achievement success was in Unit 1 and Unit 3 tests for those students who did both the homework and the unit project during those units of instruction. It can be reasoned that increased time studying has a positive relationship with achievement performance.

Weekly web-based graded homework appeared to have the most significant relationship on achievement performance in the student-centered class. The students in the active learning class that successfully completed this portion of the course modestly to significantly outperformed their peers in achievement testing at a significance level of 0.05 for hypotheses tests. This corroborates other geoscience research findings that including homework has a positive effect on student learning and outcomes (Grove, 2004; MacDonald, 2010). Furthermore,
attaching a grade appeared to provide motivation to complete homework as could be seen by the percentages of students to complete it (68% to 90%). Not surprising, homework contribution at the end of the semester increased to near beginning semester homework contributors as students attempted to improve their semester point earnings. Monthly survey results indicated that web based homework increased in favorability and usefulness through the semester; with near 50% of the population stating it reinforced what was learned in class and was helpful for test preparation. Students valued the opportunity to be exposed to other sources of information for learning and real time scientific endeavors provided in some site based activities within the homework. In interview responses, attitudes were generally positive with students saying they appreciated this method of assessment not only as a means to control a portion of their grade, but as a means to improve learning and retention of knowledge.

Students indicated that the distribution of homework points took some of the pressures off of ‘high stakes’ achievement tests. The increased time on task to complete homework, as well utilizing homework sites for additional review for test preparation positively influenced the relationship that was found in the study. As is supported by other similar research regarding the use of active learning strategies, increased time on task by doing such activities as homework results in students having a better understanding of what they are doing (Guillaume et al, 2011; Richards-Babb et al, 2011). In the changing introductory classroom, we felt homework was a very useful tool of our study design, resulting in gains in achievement scores as well as better attitudes towards learning.

The use of in-class activities in the study yielded positive, mixed, and sometimes negative results. Monthly self-assessment survey results indicated an increase in the activities’ usefulness to tie together geologic concepts and for test preparation (17% to 40%) as the
semester progressed; which coincided with a decrease in the percentage of students valuing them for point retrieval only (57% to 25%). The limitations in our statistical analysis on in-class activities left the department with more questions than answers on the association of the use of such activities and achievement success. We encountered some of the pitfalls common with hands-on activities in a large enrollment, higher education setting, while also engaging part of the population. Thirty-six percent of interviewed students did not feel they had the knowledge or time to successfully complete an activity and did not abandon superficial strategies such as copying another student’s work to complete the assignment. Student feedback may have been more positive by including further engagement of students in talking about and representing phenomena and the engagement of students in discussion about scientific inquiry and the construction of the variables. Similar to other research findings, certain factors stand in the way of students learning from demonstrations (Roth et al, 1996). As well, some student’s felt that follow up discussion was lacking; a pitfall discussed in literature. Larger knowledge gains might have been made if we had reduced some of the content covered in the course and balanced it with richer in-depth content and activities with time for follow up discussion (Roth et al, 1996; Minner et al, 2009).

Most students enjoyed the social context of peer discussion that occurred when learning new concepts, especially with no stakes Concept tests, which have been successfully adopted by faculty in several disciplines (e.g., chemistry, biology, astronomy, physics) (Crouch and Mazur, 2001). Five of the eleven interviewed students deemed this type of activity as highly motivational to attending class and brought diversity to the learning environment. Survey results indicate that a high percentage (78%) of students perceived Concept-type questions as useful in gauging their own understanding and learning of the material. As well, interview statements
indicated that being able to gauge one’s own performance relative to others increased confidence in the course, as similarly found in Elliott (2003) with use of a P.R.S. in an undergraduate economics course. This view did not necessarily transfer to some students that were not comfortable with being uncertain in peer discussion and/or chose to do independent work rather than work with a classmate. Some research suggests that students accustomed to memorization strategies may experience anxiety when learning through active engagement (Fosnot, 1998; Apedoe et al, 2006). Personal attitudes about the difficulty of understanding science may stymie some non-majors or those that feel inadequately prepared for the rigors and demands of higher education classes. Interviews revealed that several of the non-science majors students did however, value explanation of terms and learning from students they viewed as more knowledgeable than themselves. We would suggest that students who are familiar with prescriptive didactic teaching might need further initial acculturation into an active student learning setting to foster a sense of a shared community and confidence in scientific discourse in peer discussion.

The thematic group poster/paper assignment was time consuming and sometimes difficult to manage, but was met with great enthusiasm and professionalism by the students. The skills that the students developed and displayed for this portion of the course impressed the instructor and other departmental faculty, in attendance. Students excelled when given the opportunity to propose their own research theme, write a technical paper, design a poster for, and communicate findings to their peers. A significant portion of students that were interviewed (73%) indicated that this portion of the grade put them on a level academic field with those they felt were more scientifically proficient and that in the group work, every student was able to contribute a different strength into the project formation. The management methods that were established
ensured that all students participated and learned skills associated with group work, which is always a concern when implementing cooperative work. Although personal and social gains could have outweighed the slight academic gains in achievement performance, it was thought that the benefits derived made the project worth the effort. Student interviews revealed support of the format used and compared the guidelines to criteria or habits necessary to function in a work environment. Students held themselves and their group members accountable. Taken as a whole, these strategies led to improvements in achievement performance and attitudes about learning.

1.6 Conclusions

Significant agreement exists between what some prominent scholars such as Dewey, Bloom, Piaget, and Vygotsky have said are the recommended pedagogical frameworks for improving student achievement and the teaching and learning exercised in many science classrooms. We found that an active learning format may not only have impacted students’ perceptions of effective teaching strategies, but also had an influence on their views of the learning process (Abraham, 1997; National Research Council, 1996, AACU, 2007). Overall, the relations between graded supplemental learning activities were positively mild to strong when comparing achievement score means to a section that used a traditional lecture/test approach to teaching. The student-centered section experienced an improvement in overall semester achievement average (Section 001 = 59.33%, Section 006 = 65.19%), and an overall improvement in semester test average since the change from paper to computer testing. This provided further validation that providing a student centered course with opportunities for different types of learning resulted in higher achievement scores despite steady increases in the
introductory enrollments and expanding diversification in the introductory population. Our data support student improvement in learning with for grade homework (LaRose, 2010; Cheng et al, 2004; Richards Babb et al, 2011), group work (Macdonald and Korinek, 1995; Murk, 1999; Reynolds and Peacock, 1998), and peer instruction (Bykerk-Kauffman, 1995; Mazur, 1997), in particular, as supportive ways to improve achievement outcomes and attitudes about geology. Of particular interest was the relationship that existed between the amount of student ownership in a learning activity and evaluation technique and their own attitudes towards learning. In keeping with other current literature findings, it was found that students set a high value on learning as well as a higher standard on self-expectation of performance in the peer-managed group work (Harris, 2002). This attitude is supported in the slight positive relationship we found between group work and achievement performance. When students work together to complete an assignment, they bring different perspectives to learning, as well as develop the ability to communicate scientific findings to their peers. The shared responsibility that developed within the learning communities of the class promoted peer interaction and instruction as well as reduced the sense of disengagement and/or isolation that is often felt in large lecture classes.

Overall, our findings support current science education reform strategies towards improved learning in higher education, introductory science courses. Questions remain regarding student attitudes from collaborative learning methods of instruction and which students favor a more traditional lecture format typically used in many college classrooms. Of course, reducing class sizes and providing opportunities for increased student-student and student-faculty interaction could find improvements.
Limitations: The exigencies of higher education limit control or selection of participants. Students self-selected the sections into which they were enrolled, but were probably representative of the population of students who enroll in introductory geology courses. There is a confounding effect in the study as the author was one of the instructors used in the study. As well, forced-choice or multiple-choice answers in the prepared surveys renders a narrow range of responses identified in methodologies used and therefore limits interpretations made about student attitudes and opinions in this study. Also, results are limited by not being able to match survey results with performance for each student. With any large population, there are those that give low priority to work beyond the minimal expectation, as can be seen by the percentage of students’ that chose to not do the homework or the thematic poster/paper project in the student-centered section. As well, other influences that characterize and influence student performance and teacher bias are not taken into account in this study.
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2.1 ABSTRACT

Homework has long been considered an effective way to engage students and enhance student performance. This report is part of a larger study that investigated the incorporation of mandatory, graded supplemental learning activities in a large enrollment, introductory geology course. Homework was a large component of the study and is further analyzed in this report. This part of the study investigated how implementing graded weekly online homework to the course syllabus would influence exam performance in a large-enrollment physical geology course. Results indicated a positive, statistically significant difference in exam scores between students that completed the assigned homework and those that did not submit the required work. Students that maintained higher averages on homework scores tended to have higher achievement success on all exams, albeit, not to the same extent. The specific impact of homework on achievement varied from student to student, dependent on scholastic ability, how much homework the student completed, and the level of priority a student gave to the required assignments. In addition to improving overall success in the course, the use of homework appeared to contribute towards lessening the differing preparedness levels coming into the course by 1) providing students with out of class mandatory assignments to increase time on task with the course material, 2) providing an opportunity for point accrual outside of academic exams, and 3) improving students’ achievement scores.
2.2 Introduction

It is widely accepted that encouraging active in-class learning (Mazur, 1997; Macdonald et al, 2005) and out-of-class learning such as homework (National Assessment of Educational Progress, (N.A.E.P.) 1997; Cooper et al, 2006; Alleman et al, 2010) enhances learning and improves attitudes about learning. Active teaching methods support modifications in pedagogical approaches to curriculum and instruction as set forth by the National Science Foundation’s Shaping the Future: New Expectations for Undergraduate Education in Science, Mathematics, Engineering and Technology (1997), the Directorate for Geosciences (NSF, 1997), and Blueprints for Reform (AAAS, 1998). Research syntheses in cognitive and educational psychology, as well as neurosciences support active learning by promoting intentional time on task (e.g. homework) that is grounded in natural learning and active processing (Fisher, 1998; Cotton, 1991; Caine and Caine, 2007), with the educational goal of real world competence (NSF, 1996). Caine and Caine posit “that it is simply not possible to adequately teach for real world performance without adequately calling upon the real world in learning, teaching and assessment” (Caine and Caine, 2007, p. 7) To increase active learning in introductory geology, a variety of in-class methods, such as visualization (Reynolds and Peacock, 1998), peer-instruction (Bykerk-Kauffman, 1995; Macdonald and Korinek, 1995), and interactive communication systems (McConnell et al, 2003) have been used to improve learning. Further, out-of-class methods, such as exercises or homework that supplement learning (Durbin, 2002; Smith, 2007) led to improved achievement performance and improved attitudes about learning. Following this thinking, if students are actively engaged and spend more time-on-task, it is more likely they will succeed at learning (Guillaume and Khachikian, 2011). In addition, students who have active involvement in learning strategies have more positive attitudes about science, as summarized in
Osborne’s (2003) review of 20 years of literature about student attitudes towards science.

Attitudes about science are of increasing importance when research shows that students are alienated by science even though it has significance in contemporary life, both at a personal and societal level (Osborne, 2003). His findings suggest that activities that are of 1) interest, 2) importance, and 3) utility might make a significant contribution to how students feel about science.

The quality of student population (i.e. background preparation) in introductory science courses has increased in quantity, as well as diversified in population over the last decade. Many higher education institutions have expanded their core curriculum elective requirements for non-science majors to include some natural science instruction (AAAS, 1998). As a result, courses that were intended as recruiting classes for majors often serve as the non-science majors last exposure to the study of scientific process and natural phenomena (Hannula, 2003). This appears to be validated at our post secondary institution with institutional records indicating significant enrollment increases in the introductory geology section enrollments over the last decade. Records from 2002-2011 reveal a 12% increase in fall enrollment, from 1076 students to 1216 students, and a 29% increase in spring enrollment, from 844 students to 1196 students. Moreover, many introductory science courses have large-class settings and content-driven lectures that can have a negative impact on student attitudes and learning about science, even among majors (Allard & Barman, 1994). Along with these challenges and changes, many institutions have seen a decline in success rates and retention in the undergraduate population (National Center for Higher Education Management System, 2010). Our institution reported 77.8% retention from Fall 2010 to Fall 2011, slightly lower than the national average of 78.4%, and higher than the state average of 69.9%. Therefore, in an attempt to improve the introductory
science service course and respond to calls for reform in science education practices, our department sought teaching methods that would engage the introductory population and increase their time on task without increasing instructor burden.

One difficulty in implementing and effectively managing active and intentional student engagement is the time and/or physical constraints that higher enrollment \((n \geq 200)\) courses impose. These classes are often delivered in an auditorium style setting with fixed seating arrangements. Time and size constraints limit instructor-student individualized attention and feedback. Homework is a method that addresses these limitations and engages students actively. In smaller courses this appears fairly uncomplicated and simple, but for large enrollment courses, the burden of homework collection and grading is burdensome. The amount of time invested in hand grading, limitation in availability of graders, and inability to provide timely feedback do not make it conducive for instructors to adopt homework/grading policies. If homework is adopted, instructors may not collect or grade it (Allain and Williams, 2006), or only partially grade it (Radhadkisham et al, 2008), thus removing some of the motivation for a student to complete it (Dihoff et al, 2004). Further, the amount of homework that students complete has been found to be associated with grade incentive versus no grade incentive.

One option is an online homework program designed for specific domain use. The literature in a number of science disciplines has shown that commercially packaged homework systems offer tools that fit them for instruction and practice rather than merely informing, provide timely feedback (Dihoff et al, 2004), and offer teacher and student flexibility (LaRose, 2010; Arisasingham et al, 2011). Several academic publishers offer online homework packages for use with their textbook. The ease of use of these online homework systems has met with success in many large enrollment science courses. For our department, we were guided to create
our own internal online homework for use because: 1) it could be tailored to include a variety of natural learning processes by linking homework readings to specific real world and/or interactive educational web sites and 2) it could be tailored to use with a specific textbook that was already in use in the department. This afforded the opportunity to present specific geologic processes through multiple perspectives, such as visualization, simulations, laboratories, or real time exercises, as obtained from multiple open source or educational sites. The textbook in use was authored by a seasoned instructor in the department and had been in use for several years. The 3rd Edition of the textbook was the one used in the study.

The motivation to create our own online homework was compelling. Literature shows that Internet learning objects linked to web-based Learning Management System (LMS) have been used successfully to develop online homework or exercises to supplement learning in K-12 and post secondary education (Polsani, 2003; Cramer, 2007, Sun et al, 2007). Learning objects are Internet-based reusable instructional materials that illustrate, support, and perform some subset or function to supplement and enhance learning. It was expected that the use of Internet learning objects (i.e. multimedia, animation, movies, traditional photographs and diagrams) would enhance ideas, and illustrate complicated geologic concepts covered in the course material.

This paper discusses the implementation of online homework in a large enrollment, introductory geology course in an attempt to enhance student learning and improve course success as measured through student achievement exam outcomes and student surveys. Foremost were research questions such as:

1. Does online homework have a positive effect on student learning as measured through achievement performance in a general, introductory geology course? Specifically, a) is there a
statistical relationship between doing homework and achievement performance as seen in achievement grade and number of students to do homework, and b) to what extent does homework grade relate to exam grade?

2. Does one scholastic subgroup of the population benefit from homework more than another?

3. Do students feel that the online homework benefits their learning of geology?

Background for the study

Homework has long been considered to have a positive relationship on achievement performance and learning retention. Educational research on the relationship between homework (out of class assignments) and achievement performance has found that the amount of time given to studying and achievement success only strengthen as a student progresses further through his/her education from primary to middle to secondary school (National Assessment for Educational Progress, (N.A.E.P) 1997; Cooper et al, 2006; Bybee and McCrae, 2011). This is significant in view of data indicating that approximately one out of every four freshmen who begin their studies at four-year colleges and universities does not return for the sophomore year (National Center for Higher Education Management Systems (NCHEMS), 2010).

Implementation of homework has been found to help bridge the academic gap that inherently exists in large enrollment, introductory courses that are populated by diversity of majors and with students at different levels of preparedness (Arasasingham et al, 2011). The findings of that research indicate that all students have a comparable opportunity to engage themselves with the task, (i.e. the homework), and to learn from it, thereby allowing for a more level playing field for students with different preparedness. Other research has found that encouraging and assigning homework in higher education courses has a positive influence on students’ beliefs about
learning, which in turn leads students to take more responsibility for their academic outcomes (Bembenutty, 2009; Kitsantas, 2009).

A student’s view of his/her own ability to perform at a designated achievement level is associated with time on task and the amount of effort that is put into the tasks necessary towards accomplishing that goal (Bembenutty, 2011). In a technical field such as geology where many of the underlying principles are conceptual in nature, students’ time on task is paramount to their overall success in the course. In Arasasingham, Martorell, and McIntire’s (2011) six-semester study with 3,800 physics students, the amount of time that students spent on homework and their success in physics significantly improved exam performance. They further found that online homework use substantially influenced exam performance in spite of different levels of academic preparedness coming into the course. Similar results were found in Guillaume’s (2011) study conducted over a three year time period with 231 engineering students. He studied the effect of time on task on student grades and grade expectation, finding that regardless of a student’s previous overall grade point average standing, most students go into a new course with a good attitude and expectations for success. He found students’ predictions of their grades to be closely aligned with the amount of time they put into studying and homework and their overall success in the course. Other research has found that the most positive student attitudes are associated with high levels of involvement and the use of a variety of teaching strategies and unusual learning activities (Tobias, 1990; Osborne, 2003). Bembenutty’s (2011) review on homework practices found support for the notion that homework assignments can enhance the development of how students’ view their own learning and be instrumental in facilitating academic achievement and performance.
There are many benefits ascribed to the practice of homework. According to Alleman and her colleagues (2010), meaningful homework assignments are the ones “that enrich the in-school curriculum by challenging students to think deeply about important questions, apply their knowledge and skills toward solving genuine problems, and creating authentic products that will be used in meaningful ways” (Alleman et al, 2010: pp.3-4). To proponents of homework, it makes logical sense that assigning homework increases the amount of time that students spend on academic tasks because it extends learning beyond classroom instruction (Bembenutty, 2011). Other education research shows a positive trend linking study habits, time on task with homework, and achievement performance (N.A.E.P, 1997; Durbin, 2002; Guillaume and Khachikian, 2011). In a N.A.E.P. (1997) survey of study habits given to K-12 students, it was found that as time given to studying increases, so does achievement performance. Conversely, as time given to studying declines, so does performance. In other natural sciences where problem solving is a major focus, homework is considered a main venue for practicing and increasing time on task. Extensive literature exists about the benefits of homework as it relates to achievement performance in several fields of science, including physics (Bonham et al, 2003; Cheng et al, 2004), general chemistry courses (Arasasingham et al, 2011; LaRose, 2010; Richards-Babb et al, 2011), and the social sciences (Ryan and Hemmes, 2005; Radhadkishnan et al, 2006; Rehfelt et al, 2010).

The homework was very time consuming to create, but in doing so, a mixture of natural learning experiences could be incorporated into the assignments. An abundance of Internet-based open source and educational sites exist, which are accessible for instructors to design interactive student exercises. These repositories provide links to a myriad of educational instructional material, (i.e. learning objects, which can be easily attached to class learning files.) The
significance of learning objects and educational resource sites on the Internet is not undervalued.

A Google search on the term “learning object” in December 2008 returned 45 million hits. Some significant K-12 portals or repositories that have been developed include:

Gateway to Education Materials, 2007, [http://www.thegateway.org](http://www.thegateway.org)
HotChalk Lesson Plan, [http://www.lessonplanspage.com](http://www.lessonplanspage.com)

These open source sites maintain high standards of excellence in the development and distribution of educational resource material for instructor’s use. The above K-12 portals have been accessed as recently as September 2013.

Research literature in higher education shows that learning objects have been used successfully in developing online homework and exercises that supplement classroom learning in undergraduate geoscience courses (Durbin, 2002; Grove, 2002; Arthurs and Templeton, 2009). This use resulted in higher achievement scores and better attitudes about learning. Over a seven-semester study in a large enrollment ($100 \leq n \leq 300$) Earth System’s course, Durbin found that increased exposure to course content through Internet learning objects increased exam scores and knowledge of Earth Science in sections that used supplemental computer work relative to sections that did not use the Internet. Final exam scores improved an average of 11%, with a range of 5% to 16% (Durbin, 2002). Grove (2002) used Internet homework as preparatory assignments in an oceanography course. The use of informational images and text, along with real world data improved students learning as seen in exam scores and attitudinal survey findings. Arthurs and Templeton (2009) found that when students in an Environmental Geology course were able to couple in-class science instruction with follow up homework involving real-world problems using simulations, computer-based laboratories and videos, targeted student learning outcomes improved.
Attaching a grade to homework has been seen as a motivational tool in encouraging students to complete their homework, (i.e., out-of-class practice (Radhakrishnan, 2008).) There is evidence that including the homework in the course grade appears to increase students’ homework completion, which results in a better understanding and improved benefit due to its completion (Cheng et al. 2004; Ryan and Hemmes, 2005; LaRose, 2010; Rehfel et al, 2010; Richards-Babb et al, 2011). In an undergraduate psychology course, Ryan and Hemmes (2005) studied the effects of how grade contingency for submission of homework influenced the probability of assignment submission and the improvement of quiz grades. They found that the group mean percentage of homework assignments submitted and quiz grades were higher when there was a for grade contingency. Rehfel, Walker, Garcia, Lovett, and Filipiak (2010) set out to duplicate Ryan and Hemme’s study in a psychology course. They found the same results, demonstrating that homework submission was not maintained when the only consequences were instructor feedback and an expectation of improved quiz performance. In a general chemistry course at a postsecondary university, Richards-Babb, Drelick, Henry, and Robertson-Honecker (2011) replaced weekly quizzes with mandatory weekly online homework for grade and found the use of online homework to be associated with improved study-habits, achievement scores, and retention rates. Further analysis of these results showed that female students held a more positive view about the online homework than male students, even though the performance gains were larger for male students (Richards-Babb and Jackson, 2011).

The positive relationship between student time on task and performance outcomes led us to question whether the use of online, graded homework would have a positive effect on student achievement performance as seen in exam scores in a large enrollment, introductory geology course. As well, does homework performance relate with achievement performance on academic
tests administered? Further, are there some academic groups of students that benefits more than others from doing homework? This study offers statistical comparisons of different aspects of homework performance in relationship to exam performance (e.g. homework grade, student contribution, achievement grade change over time) in an attempt to improve learning outcomes in an introductory geology service course. Additional attitudinal data were obtained through monthly student self-assessment reporting done in class. The findings contribute to the general research area of implementing homework in higher education and more specifically towards how homework can be successfully implemented in large enrollment introductory geology courses.

2.3 Methods

In the spring of 2009 semester, internal online homework created by the authors of this study was included in one of five sections of the introductory physical geology. Inclusion was expected to increase time on task and to improve learning as measured through achievement outcomes on exams. Prior to the introduction of homework, final grades for this section were calculated through the averaging of four achievement exam scores. The exams were not cumulative in nature. Weekly online homework was added to the spring course outline, beginning at week two and continuing through week fourteen of the 15-week semester. Each week, the required homework corresponded with chapter material covered in class and was worth 4 points, or 1% of final grade. Together, the homework grade contributed 48 points, or 12% towards the student’s total points available for the course. Each homework assignment contained 18-24 questions with different answer formats, such as multiple choice, matching, true/false, and text entry. Homework was managed through Blackboard Academic Suite®, the web-based Learning Management System (LMS) used at the post secondary institution where
this research was conducted. Students were given 5 days to complete an assignment and one attempt to answer each question. An example of the assigned homework is presented in Appendix A. Homework sites remained open even after the due date so that students could use them for exam preparation. Examples of Internet sites used to build the homework in the study are listed in Appendix B. To see if the online homework had a positive effect on performance outcomes, achievement exam averages were compared between students that completed homework and the students that did not successfully complete it and therefore did not view it as a high priority. The students that did homework were further grouped by level of homework success, (i.e., A, B, C, D, and F) to see how homework performance related to achievement performance.

**Class Demographics**

The Physical Geology 101 course taught at this PhD granting, comprehensive land grant institution is a typical, introductory-level course designed in part to fulfill a state-mandated core-distribution requirement for all undergraduates. The course objectives are to provide students with a broad examination of geologic phenomena and processes that influence and impact their daily relationship on and with Earth’s geologic structures and resources. Large enrollments of approximately ~200 < n < 330 students are maintained in the four to five sections offered each semester. The initial sample consisted of regularly enrolled students in one section of Geology 101 in the spring of 2009 (n = 198). Sixty-five percent of the enrollment was male (129/198) and 35% of the enrollment was female (69/198). At the time of this study, approximately 95% of the students were taking the course to fulfill an institutional-based required general elective science
credit. The section met three days per week: Monday, Wednesday, and Friday, for 50 minutes per day.

Data Collection

1. Homework Collections and Analysis

This was the first attempt within our department to use online homework for grade as part of the introductory course outline. The key element of the homework assignments was online delivery via the university’s course management software with programming structure that allowed flexibility for students and time frame control for the instructor. Linked to the class files through Blackboard Learning Suite®, students submitted homework through an assessment page on their individual course home page. Online homework was scored immediately upon submission via computer software, providing immediate feedback to students. Once posted, the homework scores were visible and accessible to students through their course home page. Although each assignment was time sensitive for grading purposes, they remained open following the weekly submission deadline so students could use them for exam preparation. For purposes of this study, it was decided that successful achievement on homework included scores of 70% or above on the homework. Exam scores were compared between students that did homework and students that did not do homework. Because the majority of homework questions had a multiple-choice type answer format, it was decided that students earning <25% homework points were considered as “not having done homework.”

2. Exam Collections and Analysis

The section used four computerized multiple choice content exams (n= 36 questions per test) given at approximate one month intervals through the fifteen week semester with questions
randomly selected from an established test bank. All exams bore equal weight and were not cumulative in nature. Exams were worth 72 points each and transformed (scaled) to 99 points for ease in statistical analysis. This was because another portion of the research compared exam scores with a more traditional section that used a 99-point scale for exams. A one tailed t-test was performed on all achievement exam averages to ascertain if there was a significantly higher achievement mean for the students that did homework than for the students that did not do homework. A Chi Square Test was performed to further investigate the strength of the relationship between homework score and achievement score on an exam. Also, a distribution table of homework scores and exam scores was built to compare a range of factors such as 1) student homework score as it related to exam score, 2) the ratio and percentage of homework grades and changes to those ratios and percentages over time, 3) changes in distribution of achievement scores over time, and 4) average homework grade relative to exam grade.

3. Survey Analysis

A monthly student self-assessment survey was given in class to obtain feedback on the use of homework and other teaching strategies used in the section. Only the question choices that pertain to homework are included in this report. The monthly surveys were delivered through an interactive classroom communication system, the Personal Response System (P.R.S.), at the end of each of the 4 units of instruction. Answers were kept anonymous and approximately 50% of the class responded. Students were not required to answer any survey question, therefore the range of students responding as well as the percentage within that range to respond to each question are reported. The response rate increased significantly for survey four because it was attached to the last computerized content achievement exam. In this way, we could substantiate and validate our quantitative findings through students’ attitudinal responses.
2.4 Results

For the course, three sources of data were examined: (a) online homework scores, (b) content achievement exam mean scores, and (c) attitudinal data. Statistical analysis identified several significant relationships that exist between student completion of homework and exam performance over time. The impact that homework had on exam scores varied from student to student, dependent on scholastic ability, how much homework they completed, and the level of priority a student gave to the required assignments.

Research question 1: Does online homework have a positive effect on student achievement performance?

a. Impact of online homework on achievement performance

The first analysis looked at the impact of online homework on achievement performance on the four exams. Any student that submitted homework and scored >25% of total homework points available were included in statistical analysis as having done homework. One-tailed t-test results showed a strong positive, statistically significant relationship (p<0.001) between completing homework and achievement performance on all four-achievement exams. (Table 2.1) Students that completed homework scored 10 to 12 points higher on average on the four exams compared to students that did not submit homework. The t-ratio was very similar between Exam 1 (one tailed: p < 0.0004, t = 3.388) and Exam 4 (one tailed: p < 0.0006, t = 3.323), while the t-ratio was stronger in Exam 2 (one tailed: p < 0.0001, t=4.057) and Exam 3 (one tailed: p < 0.0001, t = 5.576). Clearly, the completion of homework had a positive effect on the overall class exam averages obtained.
Table 2.1
T-test results of achievement exams between students that did not do homework to students that did homework for each achievement exam; Spring, 2009.

<table>
<thead>
<tr>
<th>Exam</th>
<th>Class Exam average</th>
<th>Exam average of students that did not do homework</th>
<th>Exam average of students that did homework</th>
<th>t-Ratio</th>
<th>p-value</th>
<th>Ratio and % to complete HW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>64.59</td>
<td>54.52</td>
<td>65.66</td>
<td>3.388</td>
<td>&lt;0.0004</td>
<td>159/176 (90%)</td>
</tr>
<tr>
<td>2</td>
<td>62.74</td>
<td>52.05</td>
<td>64.71</td>
<td>4.057</td>
<td>&lt;0.0001</td>
<td>146/174 (84%)</td>
</tr>
<tr>
<td>3</td>
<td>63.95</td>
<td>55.43</td>
<td>67.98</td>
<td>5.576</td>
<td>&lt;0.0001</td>
<td>114/168 (68%)</td>
</tr>
<tr>
<td>4</td>
<td>69.47</td>
<td>60.59</td>
<td>71.29</td>
<td>3.323</td>
<td>&lt;0.0006</td>
<td>133/163 (82%)</td>
</tr>
</tbody>
</table>

b. Homework average in relationship to exam average

Students’ homework scores were grouped into those that were considered successful (≥ 70%; A, B, or C) on each unit of homework and those that were not as successful (>25% HW score and < 70%; D or F) on each unit of homework to see how success in homework related to exam score. (Table 2.2) On all four-achievement exams, the students that scored ≥ 70% on homework averaged a higher exam mean score than the students that scored < 70% on homework and the students that did not do homework. The difference in achievement is noticed most at Exam 1, 2, and 3 for students who earned ≥ 70% of homework, averaging 4.52 points, 8.8 points, and 5.84 points higher, respectively, in exam performance compared to students with lower homework scores. Homework score appeared to have the least impact on exam average at the end of the semester with an average gain of 2.23 points for the students who earned ≥70% of homework points. Additional time on task doing homework, irrespective of homework success, had a positive influence on student’s achievement performance. It can therefore be suggested that there is a positive relationship between time on task with the course material and exam performance.
Table 2.2
Exam average of students’ that did not do homework to students’ that scored <70% on homework and students’ that scored >70% on homework.

<table>
<thead>
<tr>
<th>Exam</th>
<th>Exam average of students that did not do homework or earned &lt;25% homework points</th>
<th>Exam average of students that earned &gt;25% to &lt;70% homework points</th>
<th>Exam average of all students that did homework</th>
<th>Exam average of students that earned &gt;70% homework points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>54.52</td>
<td>63.91</td>
<td>65.66</td>
<td>68.43</td>
</tr>
<tr>
<td>2</td>
<td>52.05</td>
<td>60.45</td>
<td>64.71</td>
<td>69.25</td>
</tr>
<tr>
<td>3</td>
<td>55.43</td>
<td>61.95</td>
<td>67.98</td>
<td>67.79</td>
</tr>
<tr>
<td>4</td>
<td>60.59</td>
<td>67.09</td>
<td>71.29</td>
<td>69.32</td>
</tr>
</tbody>
</table>

A Chi Square Test (Table 2.3) established to what extent there was a degree of association between the two independent variables: homework score and exam score. The Chi Square Test showed a strong statistical association between homework success and achievement performance at a 5% significance level ($p < 0.05$) for Exams 2, 3, and 4. The relationships are represented in graph in Figure 2.1 and summarized in Table 2.4, as well as discussed below.

Table 2.3
Testing the level of strength between homework grade and exam performance; Spring, 2009

<table>
<thead>
<tr>
<th>Exam</th>
<th>Test</th>
<th>Chi-Square</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Likelihood Ratio</td>
<td>21.09</td>
<td>0.175</td>
</tr>
<tr>
<td>2</td>
<td>Likelihood Ratio</td>
<td>43.46</td>
<td>0.012</td>
</tr>
<tr>
<td>3</td>
<td>Likelihood Ratio</td>
<td>60.55</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>4</td>
<td>Likelihood Ratio</td>
<td>41.37</td>
<td>0.021</td>
</tr>
</tbody>
</table>

The Likelihood correlation ratio is a Chi Square Test that looked at the two variables – homework score and exam score and represents the degree of association between the two variables.

The graphical presentation of homework success and achievement performance depicted in Figure 2.1 supported the above Chi Square Test results. In Figure 2.1A, it is seen that over the semester, as the percentage of successful homework scores increased, so did the percentage of successful exam scores. The association between the two strengthened over the semester, being
the greatest at Exam 3. At the same time, as seen with the students that submitted sub standard of failing homework score (Figure 2.1B), there was a non-trivial percentage of students that did not consider homework a high priority, but were still successful with achievement performance. Likewise, there were a significant percentage of students that were unsuccessful with both homework performance and exam performance. The decline in the percentage of unsuccessful homework to exam scores occurred at the end of the semester as there were fewer students contributing to this portion of the course outline.

Distribution Table 2.4 shows the frequency, ratio, and percentage of homework and exam grades over the semester from which we derived the above analyzes. The table is representative of students that were included in the homework statistical analysis (i.e.: > 25% total homework points.)
Table 2.4
Summary Distribution Table relating homework score to exam score, Spring 2009

<table>
<thead>
<tr>
<th>Exam One</th>
<th>Exam grade: A</th>
<th>Exam grade: B</th>
<th>Exam grade: C</th>
<th>Exam grade: D</th>
<th>Exam grade: F</th>
<th>Ratio and % of HW Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW grade: A</td>
<td>2</td>
<td>3</td>
<td>12</td>
<td>6</td>
<td>5</td>
<td>28/159 (17.6%)</td>
</tr>
<tr>
<td>HW grade: B</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>3</td>
<td>10</td>
<td>29/159 (18.2%)</td>
</tr>
<tr>
<td>HW grade: C</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>7</td>
<td>5</td>
<td>25/159 (15.7%)</td>
</tr>
<tr>
<td>HW grade: D</td>
<td>1</td>
<td>3</td>
<td>8</td>
<td>3</td>
<td>7</td>
<td>22/150 (13.8%)</td>
</tr>
<tr>
<td>HW grade: F</td>
<td>0</td>
<td>4</td>
<td>11</td>
<td>14</td>
<td>26</td>
<td>55/159 (34.6%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exam Two</th>
<th>Exam grade: A</th>
<th>Exam grade: B</th>
<th>Exam grade: C</th>
<th>Exam grade: D</th>
<th>Exam grade: F</th>
<th>Ratio and % of HW Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW grade: A</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>16/146 (10.9%)</td>
</tr>
<tr>
<td>HW grade: B</td>
<td>0</td>
<td>7</td>
<td>12</td>
<td>6</td>
<td>5</td>
<td>30/146 (20.5%)</td>
</tr>
<tr>
<td>HW grade: C</td>
<td>0</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>5</td>
<td>22/146 (15.1%)</td>
</tr>
<tr>
<td>HW grade: D</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>20/146 (13.7%)</td>
</tr>
<tr>
<td>HW grade: F</td>
<td>2</td>
<td>7</td>
<td>11</td>
<td>11</td>
<td>27</td>
<td>58/146 (39.7%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exam Three</th>
<th>Exam grade: A</th>
<th>Exam grade: B</th>
<th>Exam grade: C</th>
<th>Exam grade: D</th>
<th>Exam grade: F</th>
<th>Ratio and % of HW Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW grade: A</td>
<td>1</td>
<td>8</td>
<td>10</td>
<td>2</td>
<td>0</td>
<td>21/114 (18.4%)</td>
</tr>
<tr>
<td>HW grade: B</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>4</td>
<td>5</td>
<td>25/114 (21.9%)</td>
</tr>
<tr>
<td>HW grade: C</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3/114 (2.6%)</td>
</tr>
<tr>
<td>HW grade: D</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4/114 (3.5%)</td>
</tr>
<tr>
<td>HW grade: F</td>
<td>0</td>
<td>16</td>
<td>18</td>
<td>15</td>
<td>12</td>
<td>61/114 (53.5%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exam Four</th>
<th>Exam grade: A</th>
<th>Exam grade: B</th>
<th>Exam grade: C</th>
<th>Exam grade: D</th>
<th>Exam grade: F</th>
<th>Ratio and % of HW Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW grade: A</td>
<td>5</td>
<td>18</td>
<td>15</td>
<td>6</td>
<td>4</td>
<td>48/133 (36.1%)</td>
</tr>
<tr>
<td>HW grade: B</td>
<td>0</td>
<td>3</td>
<td>11</td>
<td>4</td>
<td>4</td>
<td>22/133 (16.5%)</td>
</tr>
<tr>
<td>HW grade: C</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>12/133 (9.0%)</td>
</tr>
<tr>
<td>HW grade: D</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>8/133 (6.0%)</td>
</tr>
<tr>
<td>HW grade: F</td>
<td>6</td>
<td>11</td>
<td>11</td>
<td>5</td>
<td>10</td>
<td>43/133 (32.3%)</td>
</tr>
</tbody>
</table>

Ratio and % of Test Takers

Exam One: 6/159 (3.8%) 17/159 (10.7%) 50/159 (31.4%) 33/159 (20.7%) 53/159 (33.3%)
Exam Two: 4/146 (2.7%) 25/146 (17.1%) 38/146 (26.0%) 30/146 (20.5%) 49/146 (33.6%)
Exam Three: 3/114 (2.6%) 28/114 (24.6%) 39/114 (34.2%) 23/114 (20.2%) 21/114 (18.4%)
Exam Four: 12/133 (9.0%) 35/133 (26.3%) 39/133 (29.3%) 22/133 (16.5%) 25/133 (18.8%)
**Exam One Findings**

Approximately half of the students that did Unit One homework (82/159) had an average of $\geq 70\%$ on homework, although homework grade did not necessarily correlate with exam grade. The Chi Square Test (Table 2.3) supported a mild positive relationship ($p = 0.175$) between homework performance and achievement performance on Exam One, although not of statistical significance. Homework performance did not appear to be a good indicator for exam outcome. This was wide variability with homework performance versus exam performance as seen in the distribution listed in Table 2.4. Within the successful homework submissions ($\geq 70\%$ score), the greater number of these students earned a “C” on the exam. It can be observed that as homework grade declined, academic performance tended to decline.

**Exam Two Findings**

Sixty-eight of one hundred forty six students that did Unit Two homework earned $\geq 70\%$ on the homework, although the distribution within the homework grade rankings changed. There were fewer A’s earned on homework while the number of B homework scores remained approximately the same. The percentage of students to earn a C or D on homework remained approximately the same as in Unit One. The Chi Square Test supported a strong statistical relationship linking homework and achievement performance ($p = 0.0125$) on Exam Two. Similar to Exam One findings, a large percentage of students submitted unsuccessful homework scores, although many of these students performed $\geq C$ test performance level. Some students apparently did not feel they needed to do homework to perform well on the exam or had lowered their own expectation on grade outcome. In general, as homework grades went down, the number of unsuccessful test scores tended to increase.
**Exam Three findings**

The Chi Square Test showed the strongest relationship strength between homework grade and achievement grade at \( p < 0.001 \) in the third unit of instruction. This is seen in the sharp contrast between successful or unsuccessful homework entries submitted for this time period. A large percentage (40.3%) of students that did homework ranked within an A-B (A =18.4% and B =21.9%) homework score range or submitted failing work (F = 53.5%). Only 7 students (6.1%) ranked in a C or D homework range during this unit, indicating that these performers either increased their time on task and improved their homework grade or lost motivation to complete the assigned task. This is reflected by an increase from Unit Two in the percentage of students to rank within an A/B homework score range (34.4% to 40.3%), a significant decrease in the number of students to achieve a C/D in homework score (28.8% to 6.1%), and an increase in F’s by 14% compared with the previous unit, from 39.7% to 53.5%. Interestingly, greater than half of the students (52.3%) that submitted failing homework scores (D/F) were successful with exam score. This seemed to indicate that some students relied more on scholastic ability for exam performance and did not feel like they needed to do the homework for achievement success.

**Exam Four Findings**

The Chi Square Test revealed a strong statistical relationship (\( p = 0.0210 \)) between homework score and achievement success. The number of A’s earned on homework was the highest for the semester (\( n = 48; 36.1\% \)) with 33 (69%) of these students earning B-C on the exam. The number of B’s earned on homework declined slightly (\( n = 22; 16.5\% \)) with the largest amount of these students scoring in a C exam range. This was a greater than 10% increase in the percentage of students to earn within an A-B homework achievement range during this unit compared to the proceeding unit of instruction. Again, there was a sharp contrast between doing well on
homework and failing to give the assignments a high priority during this unit of instruction. A significant portion of the population felt that successful homework completion was not a high priority, with 58.8% of the failing entries (n=51) achieving a C or better on the exam. Again, this seemed to indicate that some students relied more on scholastic ability for exam performance and did not feel like they needed to do the homework for achievement success.

Research Question One Discussion

a. The exam scores suggest that adding graded online homework into the course outline was an effective way to get students more actively engaged with the course material and to increase their time on task outside of the classroom. Students who did homework had significantly higher achievement averages on all four exams than students who did not do homework – albeit, not to the same extent through the semester. Further division of homework scores (Table 2.2) showed that students who scored > 70% in the homework assignments averaged at least 2.23 points higher and up to 8.8 points higher in achievement average than students who scored <70% on the assignments. The findings are similar to Arasasingham et al, (2011). They found that even when taking into account a students’ level of preparedness for the course, online homework substantially influences test performance for 1st year general chemistry students. The Chi Square Test results supported a statistically positive relationship linking homework performance to achievement performance in the 2nd, 3rd, and 4th exams. The results would suggest that homework is one area where students can be on a more level playing field with students who come into the course with more rigorous science backgrounds.

The large number of students to complete this portion of the course grade was encouraging as we were not sure if Internet access would be an issue for students. This did not
appear to be the case. Most students started the semester with high expectations for success with 159 students (90%) completing the homework during the first unit of instruction. One hundred forty six students (84%) of the class completed homework during the second unit of instruction. Unit Three overlapped with spring break, which could explain the lower number and percentage (n = 114, 68%) of students to contribute towards the homework portion of the course grade. In the last unit of instruction, the number of students to submit homework increased to 133 or 82% of Unit Four test takers.

b. There was a lot of variability in homework performance in how it related to achievement performance. Until mid-term, ratios and percentages of students to achieve a homework grade ranking B, C, D, and F remained fairly consistent. Following mid-term, the ratio and percentage values changed significantly as students either increased or decreased efforts towards successful completion of the assignments. From an initial decline following Exam One in the percentage of students who earned A’s on homework (17.6% to 10.9%), the value steadily increased until the end of the semester, up to 18.4% in the 3rd, and 36.1% in the 4th unit. These homework grade percentages were not necessarily mirrored in achievement performance however. It was also evident that some students with strong scholastic backgrounds may not have put a lot of effort in homework because they realized that they did not need to do it to do well on exams. This is especially seen at Exam Four where half of the ‘A’ achievement performers submitted failing homework assignments. The ratio and percentage of B homework achievers fluctuated the least over the semester, from a range of 16.5% to 21.9%. The greatest number of the B homework achievers performed at a C scholastic range on exams. The number of C’s and D’s earned on homework decreased significantly following mid-term (2nd and 3rd unit) from 15.1% to 2.6% and
13.7% to 3.5%, respectively. At the 4th unit of instruction, the number of students to earn a C or D on homework was half the number to earn that score at the start of the semester. These students either improved their homework efforts and score or failed to give the assignment any priority and did not do it. Students seemed to adjust their work efforts over the semester to be more realistically aligned with scholastic abilities. Homework effort alone did not appear to be a good predictor of achievement performance.

**Research question 2: Do different scholastic subgroups utilize homework the same?**

The dynamics of academic performance level and online homework is further seen when we compared students’ exam grade percentile ranking (i.e. A = 90-99%, B = 80-89%, C = 70-79%, D = 60-69%, and F = < 60%) by the percent of students that did homework to achieve each of these test ranking categories over time.
Figure 2.2 graphically presents the academic achievement range of the four exams for students that submitted homework and scored >25% total homework points. A non-trivial proportion of ‘A’ achieving students seemed to think they could get an ‘A’ with minimal effort expended on homework. The data in Table 2.4 show that several of the ‘A’ students did not view homework success as a high priority to their achievement success. The ‘B’ scholastic achievement range of students increased through the semester, from 10.7% at the beginning of the semester to 26.3% at the end of the semester. In the successful exam achievement range, the ‘C’ scholastic achievement students were the largest percentage of students to utilize online homework compared to the other subgroup of students. This finding is similar to research results of Cheng, Thacker, Cardenas, and Crouch (2004), who found that the C grade subgroup of introductory physics students benefited more from the use of online homework than any other achievement level of students.
The percent value and number of students to perform at a D scholastic level slowly declined over the semester, coinciding with fewer students submitting unsuccessful (D/F) homework assignments. The greatest change can be seen with the students that were academically challenged and scored <50% on an exam. It appeared that they started the semester with high expectation, but by mid-term had lost motivation to work towards their original intended goal and chose to submit failed assignments or to no longer do the homework.

Figure 2.3
Average homework score within scholastic achievement rankings on exams; Spring, 2009

We also derived homework averages for each exam achievement ranking (i.e.: A, B, C, D, and F) to see how scholastic ability related to homework scores (Figure 2.3). The figure depicts the varying homework averages earned per exam score ranking. Although there was no statistical analysis done on this portion of data, visual representation shows some relations that exist. It can be seen that as exam achievement scores declined, so did homework average score. Interestingly, within successful exam scores (A, B, and C), the ‘A’ exam achievers showed the
most variability in homework averages obtained over the semester. The B and C exam achievers had comparable homework scores to each other, with a slight decline in homework average from Exam One to Exam Two to Exam Three, and an increase in average for both groups at the end of the semester. It can be seen that the D and F exam achievers homework performance scores declined slightly over the semester with a significant improvement in homework average score at the end of the semester. There is a decline trend in homework average score in the C, D, and F scholastic achievement rankings with all exams.

**Research Question Two Discussion**

*a.* It appeared that scholastic achievement performance acted as a positive or negative feedback for motivation to continue to spend time on task on homework. The findings of this study are similar to Guillaume and Khackakian’s (2011) 3-year study with 231 engineering students and student time-on-task and grade expectations. Near the end of the semester, ‘A’ students’ increased their efforts to meet their goal. This subgroup of students knows what effort is required to maintain an A and will maintain or change that level of effort to meet their goal. Interestingly, a non-trivial portion of the ‘A’ ability students did not rely on homework to assist them with test performance and relied more on scholastic ability for achievement outcomes. The ‘B’ scholastic achievement range of students stayed motivated to complete homework and devoted time to achieving their originally intended goals. These students appear to be willing to work harder and increase their time on task. The ‘C’ scholastic achievement range of students benefited more from doing the assignments than any other subgroup of students. Pinet’s (1995) geoscience research found that the C scholastic performers ‘flourished’ from active learning activities. Cheng, Thacker, Cardenas, and Crouch’s (2004) earlier referenced work found that for the C
grade subgroup of introductory physics students, time on task with homework correlates with course grade. Although we cannot say that the homework correlated with course grade, the ‘C’ scholastic subgroup maintained the highest level of contribution to this portion of the course. The number of ‘D’s to be achieved within the subgroup of students to submit homework declined over the semester (33 to 22 students) as fewer students within this subgroup stayed motivated to do homework. Given the variability when comparing homework performance to achievement performance, we would suggest that other factors such as overall G.P.A. and scholastic ability (Bonham et al, 2003) are important when studying student performance in a course.

**Research question 3: Students’ attitudes toward online homework use**

The self-reporting of the student monthly self-assessment surveys may offer additional information into students’ views about the use of the online homework. It is important to recognize that the responses to the survey question were self-reported by each student in the section. The responses listed in Table 2.5 show that attitudes toward online homework use were generally positive. Between 19% and 35% of the students responded that they thought homework supported classroom instruction, although they did not spend more time on task than necessary with the assignments. It was encouraging to see that a larger percentage of students (44% to 56%) used homework beyond its’ weekly task value, increasing time on task to use the homework material for further understanding of the material for test preparation.
Table 2.5  Student Monthly Self-Assessment Survey: Homework Question Results

<table>
<thead>
<tr>
<th>Weekly Homework</th>
<th>Survey 1 80 ≤ n ≤ 90</th>
<th>Survey 2 75 ≤ n ≤ 85</th>
<th>Survey 3 92 ≤ n ≤ 106</th>
<th>Survey 4 155 ≤ n ≤ 165</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. …helps to reinforce what I have learned in class.</td>
<td>24% response</td>
<td>19% response</td>
<td>20% response</td>
<td>35% response</td>
</tr>
<tr>
<td>b. …helps reinforce what I have learned in class and helps me to prepare for a test.</td>
<td>44% response</td>
<td>56% response</td>
<td>56% response</td>
<td>48% response</td>
</tr>
<tr>
<td>c. …is not related to how much and what I learn.</td>
<td>25% response</td>
<td>21% response</td>
<td>21% response</td>
<td>10% response</td>
</tr>
<tr>
<td>d. …does not relate to the material covered in class.</td>
<td>6% response</td>
<td>4% response</td>
<td>3% response</td>
<td>7% response</td>
</tr>
</tbody>
</table>

Footnote: n is given in range because students were not required to respond to all question items on the questionnaire. Percentage values within the response rate were therefore used.

Students’ value of the homework was strongest during the 2nd (56%) and 3rd (56%) unit of instruction, which is supported by the strength of the 2nd and 3rd Chi Square Test results. Some students found the homework to be more aligned and relevant to the class material later in the semester, with a reduction in response (c) […]is not related to how much and what I learn] from 25% to 10%. As with any large enrollment course, there is always a small portion of the population that does not feel that assignments relate to the course outline.

**Research Question Three Discussion**

Attitudes toward online homework use were generally positive as indicated in survey response. We could not connect a particular student’s survey response to achievement success (e.g. A, B, C, D, and F) because of anonymity maintained in the surveys. On average, approximately 51% of the students valued homework usage beyond its’ weekly task value and used it to enhance their learning and improve their scores on achievement tests. These attitudes are validated by the improvement in achievement mean scores found in the study. Approximately another 25% of students completed the assignments, but did not use them beyond their weekly utility. This
would seem to indicate that some students were motivated to complete the homework assignments because of grade attachment. We would suggest that students have a more positive view of learning when they are active participants in learning.

2.5 Conclusions

Web-based homework is increasing in use in several natural science fields, supplementing in-class instruction with out-of-class practice, thereby increasing student time on task while minimizing instructor burden of grading but providing timely feedback to students on homework performance. The web-based homework used in this study was not a disadvantage for students and had an overall positive impact on student learning as seen in achievement scores. Adding online homework to the course significantly affected (p < 0.001) success rates in achievement in an introductory geoscience course. This is further verification that increased time on task enhances learning (Bembenutty, 2009; Alleman et al, 2010) and has a positive influence on student learning (Cooper et al, 2006). Similar to Arasasingham et al (2011) research findings, we did not see a significant relationship between students’ academic level of preparation and their online homework success. Thus, homework was one area where students were on a more level playing field with students that were more academically prepared for the course. The use of homework appeared to contribute towards lessening the differing preparedness levels coming into the course by 1) providing students with out of class mandatory assignments to increase time on task with the course material, 2) providing an opportunity for point accrual outside of academic testing, and 3) improving students’ achievement scores. Since homework effort alone did not appear to be a good predictor of achievement performance, it could be put forward that
factors such as scholastic ability and competing time demands (i.e. family and job) are important when trying to understand student achievement.

Advantages of the online technique include the ability to assign homework in large classes without adding significant teacher burden and to increase student time on task with the course material. This does not come without an increased front-end burden in the designing and building an internal homework program. Appropriately designed online homework can give a range of practice and give timely feedback to students. It can present opportunities for self-directed study to learn targeted material, provide learning on a larger scale, and enhance the learning experience. The fact that the homework had ‘task value’ (e.g. interest, enjoyment, and applicability) might have made a positive contribution towards student motivation in completing it (Osborne, 2003). In this case, students appeared to give graded homework a high priority as evidenced by the number of students (133 to 157 out of 176) that completed the assignments. The 12% contribution towards final grade from homework points appeared to be significant enough to not be overlooked when students planned their own goals in learning. For this reason, we suggest that large enrollment introductory courses consider or explore the use of graded online homework in their course outline. However, teachers should be aware of how students change their use of homework over time and who appears to benefit the most from it.

Most students appeared to start the semester with high expectations for success in the course, seen with 90% of the class doing homework at the beginning of the semester. Students adjusted their efforts (time on task) to match what they desired in grade outcomes, as evidenced in the change in distribution of achievement scores and homework scores over the course of the semester. Near the end of the semester, some students appeared to increase their efforts with homework, while other students relied on scholastic ability for achievement performance. The B
scholastic students were willing to work harder over the semester to meet their goals, while the C scholastic group of students was the largest subgroup that utilized homework. This is in keeping with the findings of other researchers (Guillaume and Khackakian, 2011; Cheng et al, 2004). The findings of this study suggest that while all students had the opportunity to benefit from doing homework, the impact varied from student to student, dependent on scholastic abilities, and the ongoing commitment to completing the assignments.

Students and the instructor generally responded positively to using online homework. Students acknowledged in survey that homework assisted them to improve their understanding of the material as well as being useful towards test preparation. Students said the length of time to complete the homework was realistic for the point value of the work. Overall, students appreciated online homework most when it was easy to use, carefully planned, and integrated with the course materials. From an instructor’s viewpoint, web based homework offered a way to move beyond classroom instruction by providing exercises that were of broader pedagogical value, increase student time on task, and improve learning outcomes. Our findings would suggest that, overall; students utilize graded homework to maximize achievement outcomes in a large enrollment, introductory geoscience course.

In terms of expanding online homework to a department level, the shared nature of an introductory course can have a positive effect in the development process. When one instructor tries implementation of homework in a general introductory course, especially when met with success, other faculty are at least made aware of the results. The use of self-created online homework comes with an initial cost of time, however, as well as ongoing maintenance because of changing parameters that can occur outside of designer control. Issues such as URL address changes and site modifications or program termination can naturally occur with independently
obtained, interactive courseware. As a result of these issues, caution should be used in site selections for development of homework. It was felt that the academic and attitudinal gains would outweigh the initial burden to provide online homework that engaged students with real time data or events, hands on laboratories, visualizations, and scientific research.

Limitations: The exigencies of higher education limit control or selection of participants. Students self-selected the sections into which they were enrolled, but were probably representative of the population of students who enroll in introductory geology courses. There is a confounding effect in the study as the author was one of the instructors used in the study. As well, forced-choice or multiple-choice answers in the prepared surveys renders a narrow range of circumstances identified in methodologies used and therefore limits interpretations made about student attitudes and opinions in this study. Also, results are limited by not being able to match survey results with performance for each student. With any large population, there are those that give low priority to work beyond the minimal expectation, as can be seen by the percentage of students’ that chose to not do the homework or the thematic poster/paper project in the student-centered section. As well, other influences that characterize and influence student performance and teacher bias are not taken into account in this study.
2.6 References Cited


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Summary

There is little doubt that the research on learning and the resonating recommendations towards active learning and best classroom practices have impacted instruction in geoscience classrooms. This study investigated the use of a three-phase learning cycle format of instruction to explore if a more active instructional design would demonstrate an increase in knowledge gained as measured through exam scores. Interactive systems such as media, classroom communication systems, and on-line engagement provided the opportunity for the instructor to build learner participation directly into classes. The supplemental activities provided ongoing assessment, thinking and problem solving skills, and interpersonal and self-directed skills. The methods put forth were established, as well, to promote a sense of community, enlist students as active collaborators in their education, and have a positive impact on attitudes regarding the learning of geology.

Overall, the effects between for grade activities and achievement exam scores were positively mild to strong when comparing achievement exam means and semester averages to a section that used a traditional lecture/exam approach to teaching. The active learning section showed statistically significant higher achievement mean scores on the four-achievement exams administered through the semester as well as an overall semester average of 6 points higher than the lecture section. These findings validated the hypothesis that providing engagement for students in their learning would positively affect achievement scores despite increases in introductory enrollments and expanding diversification in the introductory population.

The quantitative data became more articulated when comparing achievement means within the active learning section. In particular, the data supported student improvement in learning with for grade homework (LaRose, 2010; Cheng et al, 2004; Richards Babb et al, 2011),
group work (Macdonald and Korinek, 1995; Murk, 1999; Reynolds and Peacock, 1998), and peer instruction (Bykerk-Kauffman, 1995; Mazur, 1997) as supportive ways to improve achievement outcomes and attitudes about geology.

Within the active learning section, students that did homework had statistically higher achievement exam mean scores on the four exams than students that scored <25% on homework or did not submit homework. Further, as exam scores declined, so did the average homework score. We did not see a robust relationship between students’ academic level of preparation and their online homework scores. In the range of successful exam scores (i.e.: A, B, and C), we found that the B scholastic group of students increased in percentage and the largest percentage of students that utilized homework performed at a C scholastic achievement range. Thus, online homework helped diminish achievement gaps that may have existed by providing the opportunity for students to increase time on task with the course material and improve students’ achievement scores. Our findings would suggest that overall students utilized graded homework to maximize achievement outcomes in a large enrollment, introductory geoscience course.

The students’ own perceptions of learning through group work and peer instruction were remarkably aligned with current research findings. Of particular interest was the relationship that existed between the amount of student ownership in a learning activity and evaluation technique and their own attitudes towards learning. The thematic group poster/paper assignment was time consuming and sometimes difficult to manage, but similar to Harris’s (2002) findings using poster presentations in a geoscience course, we found students more engaged, confident, and critical in evaluating their own work when the course material was aligned with actual field practice. Students stated that this portion of the course grade provided criteria or habits necessary
to function in a work environment. This attitude was supported in the slight positive relationship we found between the group work and achievement performance.

We found that the effect of peer interaction on learning typically was positive, although not always in that direction (Macdonald et al, 1995). We found students approached different in-class activities with different strategies or purposes, as well (i.e. conceptual learning, studying, or points) but that overall, students considered these activities a high priority. In interview, the students commented that the use of PRS in class was engaging, brought focus, and/or was socially dynamic. A high percentage (78%) of students in the active learning class perceived the Concept-type questions as helpful in gauging their own learning of the material relative to others, whereby increasing their own confidence in the course (Elliott 2003).

We discovered some flaws and shortcomings in the implementation of the study design that should be noted. The anonymity maintained in student record keeping in the study restricted any interpretation of our results to specific events. Being able to track specific individuals and achievement performance to homework, group work, and in-class activity performance over time would have helped to better illuminate how different scholastic subgroups align/realign their efforts over the semester. Also, we were not able to reasonably analyze the contribution that in-class activities made per exam period because of the low point value associated with each bi-monthly activity. This error in the study design created a gap in our research goals and precluded us from finding relations between this type of activity and achievement. We also experienced some of the common pitfalls experienced when implementing these types of activities in class and would advise careful planning when incorporating in-class activities into the course curriculum.
Taken as a whole, these strategies led to improvements in achievement performance and attitudes about learning. The survey data and semester end interview findings substantiated our quantitative results. Students supported active learning practices as methods that engaged them in their own learning. Further research and development into active learning strategies are warranted, although instructors should be encouraged to utilize these types of activities in large lecture introductory geoscience courses. Supplemental in and out of class teaching exercises can enhance student learning as well as make the learning of geology more enjoyable.
Appendices

**Appendix A**
Introductory Geology Course Outline: Section 001 and Section 006; Spring, 2009

<table>
<thead>
<tr>
<th>Unit One</th>
<th>The Dynamic Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ch. 1</td>
<td>Introduction to the formation of Earth</td>
</tr>
<tr>
<td>Ch. 2</td>
<td>The mechanics of Earth: Plate Tectonics</td>
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<tr>
<td>Ch. 3</td>
<td>Minerals</td>
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<td>Ch. 4</td>
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<table>
<thead>
<tr>
<th>Unit Two</th>
<th>The Rock Cycle: Rocks, weathering, and transportation</th>
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<tr>
<td>Ch. 5</td>
<td>Igneous Rocks</td>
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<td>Ch. 6</td>
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<td>Ch. 7</td>
<td>Soils</td>
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<td>Ch. 8</td>
<td>Mass Wasting</td>
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<td>Ch. 9</td>
<td>Rivers and Streams</td>
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</table>

<table>
<thead>
<tr>
<th>Unit Three</th>
<th>Processes that shape our landscape</th>
</tr>
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<tbody>
<tr>
<td>Ch. 10</td>
<td>Glaciers</td>
</tr>
<tr>
<td>Ch. 11</td>
<td>Deserts</td>
</tr>
<tr>
<td>Ch. 12</td>
<td>Oceans and Shorelines</td>
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</table>

<table>
<thead>
<tr>
<th>Unit Four</th>
<th>Resources and the Environment</th>
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<tbody>
<tr>
<td>Ch. 13</td>
<td>Sedimentary Rocks</td>
</tr>
<tr>
<td>Ch. 14</td>
<td>Groundwater</td>
</tr>
<tr>
<td>Ch. 16</td>
<td>Earthquakes</td>
</tr>
<tr>
<td>Ch. 18</td>
<td>Energy and Resources</td>
</tr>
</tbody>
</table>
Appendix A.1  

General Course and Exam Information

This Geology 101 course is student centered, allowing you the opportunity to derive your total grade from several sources of assessment. It is my goal that you have maximum opportunities to contribute to your overall grade. Points will be accumulated from activities such as: collaborative poster project, homework, and in-class activities. This allows you to be in control of over 25% of your cumulative grade. Grades will be distributed out of a 400 possible points to be earned.

Exam Information: 72% of cumulative grade = 288/400 points

1. Four exams are scheduled. Each exam will consist of 36 multiple-choice questions with a value of 2 points per question, totaling 72 points. Four exams at 72 points each equals 288 points possible.

2. Three of the tests are scheduled during the semester with the 4th exam scheduled for the day appointed by the university for the 1:30 MWF final exams. See the Syllabus for the dates of the exams.

3. All exams are administered by computer in the departmental computer labs, Rms 416 and 419 Brooks Hall.

4. A picture ID and verification of your 70ID# are required for entry into the computer labs.

5. During the semester, tests may be taken over a period of two days. On the two days scheduled for exams #1, 2, and 3, the computer labs will be open from 1 PM to 9 PM Thursday and 1 PM to 5 PM on Friday. Tests may be taken on any of the two days during the times allotted. **Note however, because the computer will terminate the period during which exams may be taken at 9 PM on Thursdays and 5 PM on Fridays, exams MUST be started at least by 8:30 PM on Thursdays and 4:30 PM on Fridays in order to allow sufficient time to complete the exam. Because there are four other large (300+) students) classes assigned to use the rooms during the same time intervals, some delay may be experienced before entry to the computer labs is gained.

6. The 4th exam will be administered between 3:00 PM – 5:00 PM, Monday, May 5, 2009. Four computer labs will be available on that day to expedite the passage of the entire class during the allotted 2 hours. If you fail to take the final, you will receive an incomplete in the course and will have to take the final the first week of the fall semester.

Class Project: 12% of cumulative grade = 48/400 points

Each student will participate in a collaborative group poster presentation that is worth 12% of cumulative grade. Posters and papers will be graded with a rubric that will be distributed along with the poster guidelines and information. See project description sheet for guidelines and schedules of due dated.
Homework: 12% of cumulative grade = 48/400 points

Every Wednesday starting January 21, there will be on-line homework due that corresponds with the material that has been covered in the corresponding chapter. The homework serves as a method to help you review and practice the concepts that have been introduced for that week. The homework is accessible through the home page of Geology 101 on ecampus. Each homework is time sensitive with its’ due date and will be available from Sunday, 9:00 PM until Wednesday 5:00 PM of each week. After 5:00 PM on Wednesday of each week, ecampus will no longer give points to the assignment. A few of the assignments will be distributed and completed in class (usually on a Wednesday). Twelve homework assignments will be given through the semester. Each homework is worth 4 points x 12 wks. homework = 48/400 points.

In-class Activities: 4% of cumulative grade = 16/400 points

There will be eight (8) in-class activities through the course of the semester. Each activity is valued at 2 points for a total of 16 points. These will not be announced.
**Appendix B**

Some open source on-line resources used for homework development. The sites offer comprehensive educational, and often interactive software for use in instruction.

<table>
<thead>
<tr>
<th>Resource</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Earthquake Hazards Program</td>
<td></td>
</tr>
<tr>
<td>Schlumberger Excellence in Educational Development</td>
<td><a href="http://www.planetseed.com/teachercenter/resourcest/3802">http://www.planetseed.com/teachercenter/resourcest/3802</a></td>
</tr>
<tr>
<td>The Dynamic Earth: The Story of Plate Tectonics</td>
<td></td>
</tr>
<tr>
<td>Earth from Space</td>
<td></td>
</tr>
<tr>
<td>National Science Foundation</td>
<td><a href="http://www.classzone.com/books/earth_science/terc/navigation/investigation.cfm">http://www.classzone.com/books/earth_science/terc/navigation/investigation.cfm</a></td>
</tr>
<tr>
<td>Exploring Earth: Investigation</td>
<td></td>
</tr>
<tr>
<td>National Science Foundation</td>
<td><a href="http://www.dlese.org/library/">http://www.dlese.org/library/</a></td>
</tr>
<tr>
<td>Digital Library for Earth System Education</td>
<td></td>
</tr>
<tr>
<td>Science Education Resource Center</td>
<td><a href="http://serc.carleton.edu/index.html">http://serc.carleton.edu/index.html</a></td>
</tr>
<tr>
<td>Teach the Earth</td>
<td></td>
</tr>
<tr>
<td>Teachers Domain, supported by multiple Agencies</td>
<td><a href="http://www.teachersdomain.org/sci/ess/earthsys/index.html">http://www.teachersdomain.org/sci/ess/earthsys/index.html</a></td>
</tr>
<tr>
<td>Earth System, Structure, and Processes</td>
<td></td>
</tr>
<tr>
<td>Smithsonian Institution</td>
<td><a href="http://www.smithsonianeducation.org/educators/lesson_plans/minerals/index.html">http://www.smithsonianeducation.org/educators/lesson_plans/minerals/index.html</a></td>
</tr>
<tr>
<td>Park Geology Tour, Geologic Features</td>
<td><a href="http://www.nature.nps.gov/geo/">http://www.nature.nps.gov/geo/</a></td>
</tr>
<tr>
<td>National Park Service</td>
<td></td>
</tr>
<tr>
<td>Science Course Ware: Virtual EQ, Virtual River, Virtual Dating</td>
<td><a href="http://sciencecourseware.org/VirtualRiver/index.html">http://sciencecourseware.org/VirtualRiver/index.html</a></td>
</tr>
<tr>
<td>WV Fossils: Global Warming Test</td>
<td><a href="http://www.geocraft.com/WVFossils/GlobWarmTest/start.html">http://www.geocraft.com/WVFossils/GlobWarmTest/start.html</a></td>
</tr>
</tbody>
</table>

Resources presented in Appendix B are restricted to some of the open source sites used in the study. Copyright domains and permission rights preclude including .edu sites accessed for the homework used.
Appendix C.1

**Project Description**

Each group will be responsible for writing a research paper that looks for a relationship between the variables stated in the project theme. The research paper will contain at least three distinct sections: an introduction, a body, and a summary.

The introduction should define the question being investigated and indicate the methods and scope of the investigation. This is also an appropriate place to include research on actual relationship that exist between your variables by citing other external working group efforts: such as research done by accredited national science organizations, experts in the field, etc…NO WICKIPEDIA. The body of the paper will present the findings (data collected) and the analysis of that data, where applicable. The analysis needs to include an interpretation of the results. The summary should succinctly state conclusions derived from the investigation, any observation derived from those conclusions, and questions generated by the investigation.

Each member of the group will be asked to assume very specific responsibilities in the preparation of the paper. These responsibilities could go under headings such as: production manager, graphics provider, word processor, data analysts, and researcher. You are asked to declare your specific responsibility.

Each group member is expected to contribute one posting per week during the four weeks prior to the due date of the project. *These postings account for ~20% of total grade of the group project.*

**Project Guidelines**

On four separate occasions through the semester, twelve groups of four to five students each will do a poster presentation. This will allow for a maximum of 80 students for each unit of instruction. Each group of four students will use the corresponding theme that accompanies a unit as listed below to generate a scientific research report and included in a poster presentation. You are expected to refine your research to the perimeters stated within the theme. You are expected to unify the concepts that are contained within the unit you choose. Due to time constraints and manageability of the project, a maximum of 12 groups will be allowed to sign up for each unit (approximately 50 students per unit). Each group is responsible to bring the poster presentation to class on the due date, as listed below.

**Unit One Theme:**
How does the relationship between types of plate tectonic boundaries and their geographic settings influence the geologic processes that occur along those settings?

Ex: Comparing and contrasting volcanic magma compositions and eruptive styles between a shield and strato-composite volcano: Why are some magmas are more explosive than others?
Unit Two Theme:
What are the geologic relationships that exist between the formation of any of the three family of rocks and the changes they may undergo, considering the environment they were formed in to the environment they exist within?

Ex: How karst topography tells geologists information about the paleoenvironment of a geographic area: Studying sinkholes in West Virginia.

Unit Three Theme:
How are the process such as changing landscape, erosion, transportation and deposition of sediment different given the following environments: glacial, desert, shoreline, ore stream environment.

Ex: Studying the impact of glacial advance on the current New England shoreline during the most recent Ice Age.

Unit Four Theme:
How does the overuse of energy and resources impact and influence environments and how do we respond to these outcomes?

Ex: Levees on the Mississippi: How we have influenced and changed the natural dynamics and processes along the Mississippi Delta: some of the gains and losses.

Due Dates (Due at beginning of class time of due date)

Unit One: February 6 (Friday). Present project on Monday, February 9
Unit Two: February 27 (Friday). Present project on Monday, March 2
Unit Three: April 10 (Friday). Present project on Monday, April 13
Unit Four: April 29 (Wednesday). Present project on Friday, May 1

**Posters will remain on display on easels and bulletin boards throughout the building**
## Appendix C.2

### Rubric for grading Poster/Paper Project

<table>
<thead>
<tr>
<th>Category</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unifying Themes</strong></td>
<td>Relationship of concepts and processes are closely stated throughout report in writing and graphics.</td>
<td>Relationship of concepts and processes are stated throughout report but some connections are missing.</td>
<td>Relationships of concepts and processes are discussed, but not clearly, and not represented in writing and/or graphics.</td>
<td>Relationships of concepts and processes are not stated, and not represented in writing and/or graphics.</td>
</tr>
<tr>
<td>poster = 4 pts.</td>
<td>poster = 4 pts.</td>
<td>poster = 4 pts.</td>
<td>poster = 4 pts.</td>
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<td>paper = 4 pts.</td>
<td>paper = 4 pts.</td>
</tr>
<tr>
<td><strong>Graphic-Relevance</strong></td>
<td>All graphics are related to the topic and make it easier to understand. All borrowed graphics have a source citation.</td>
<td>All graphics are related to the topic and most make it easier to understand. One graphic is missing a source citation or does not fit into theme.</td>
<td>Some graphics do not relate to the theme. More than one graphic does not have a source citation.</td>
<td>Graphics do not relate to the topic or several borrowed graphics do not have a source citation.</td>
</tr>
<tr>
<td>poster = 8 pts.</td>
<td>poster = 8 pts.</td>
<td>poster = 8 pts.</td>
<td>poster = 8 pts.</td>
<td>poster = 8 pts.</td>
</tr>
<tr>
<td><strong>Mechanics-Writing</strong></td>
<td>Capitalization, spelling, and punctuation are correct throughout the paper. All sources are cited accurately.</td>
<td>There is 1 error in capitalization, spelling, or punctuation in the paper or one source citation is missing or not cited properly.</td>
<td>There are 2 errors in capitalization, spelling, or punctuation or more than 2 source citation is missing or not cited properly.</td>
<td>There are more than 3 errors in capitalization, spelling, or punctuation. Citations are missing.</td>
</tr>
<tr>
<td>paper = 8 pts.</td>
<td>paper = 8 pts.</td>
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<td>paper = 8 pts.</td>
</tr>
<tr>
<td><strong>Content- Accuracy</strong></td>
<td>At least 7 accurate facts are displayed on the poster. Content in paper is accurate and thorough.</td>
<td>At least 6 accurate facts are displayed on the poster. Content has few inaccuracies, but is thorough.</td>
<td>At least 4-5 accurate facts are displayed on the poster. Content in paper lacks relevant information and thoroughness.</td>
<td>Less than 3 accurate facts are displayed on the poster. Several inaccurate facts or lack of relevant information in paper.</td>
</tr>
<tr>
<td>poster = 4 pts.</td>
<td>poster = 4 pts.</td>
<td>poster = 4 pts.</td>
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<td>paper = 4 pts.</td>
</tr>
<tr>
<td><strong>Attractiveness- Organization</strong></td>
<td>The poster is exceptionally attractive in terms of design, layout, and neatness. Easy to follow the research topic by presentation. Paper is organized, flows and pulls together themes.</td>
<td>The poster is attractive in terms of design, layout, and neatness. Can follow research topic, but need to look for order in presentation. Paper lacks flow or transitioning of topic.</td>
<td>The poster is acceptably attractive though it is difficult for readers to understand flow or continuity of research topic presentation. Paper is not organized and lacks flow in presentation of material.</td>
<td>The poster is unorganized and thought was not put into design, layout, or neatness. Viewer cannot follow them. Paper lacks organization, thought, and flow.</td>
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| Unifying Themes                | ____________   | ____________   | ____________   | ____________   |
| Graphics                        | ____________   | ____________   | ____________   | ____________   |
| Mechanics                       | ____________   | ____________   | ____________   | ____________   |
| Content                         | ____________   | ____________   | ____________   | ____________   |
| Attractiveness                  | ____________   | ____________   | ____________   | ____________   |
| Accountability                  | ____________   | ____________   | ____________   | ____________   |

| Total Points                    | __________/48 points | __________/48 points | __________/48 points | __________/48 points |

**Group Members:**

| ____________   | ____________   | ____________   | ____________   |

99
Appendix C.3

Group Poster/Paper Project Responsibility Sheet
To be turned in with completed project following presentation.

Group Name: ____________________________________

Group members first and last names and project responsibilities:

______________________________ will assume the task of __________________

In this task, I expect to: (please give specific details on which task you will be evaluated.)

Group members first and last names and project responsibilities:

______________________________ will assume the task of __________________

In this task, I expect to: (please give specific details on which task you will be evaluated.)

Group members first and last names and project responsibilities:

______________________________ will assume the task of __________________

In this task, I expect to: (please give specific details on which task you will be evaluated.)

Group members first and last names and project responsibilities:

______________________________ will assume the task of __________________

In this task, I expect to: (please give specific details on which task you will be evaluated.)
Appendix C.4.1  
Example of Student Poster Work

**Davis Evolution of Landscape**  
Nicole Simpson, Danielle Guzman, Jonathon Prieston, Jessica Seiden & Justine Colland  
Geology 101, Unit 3, Group 13

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**Development**  
William Morris Davis, the father of American geography, came up with the idea of landscape evolution in 1894.  
- Founded the study of geomorphology, defined as the study of the characteristics, origin and development of landforms.

---

**Examples of Development**  
- Old
- Mature
- Young

---

**Things to know to understand Davis’ Theory**  
Water is the number one erosional agent on Earth; it is important because a huge part of Davis’ theory involves understanding the way a stream erodes its channel, therefore its influence on the development of the land surrounding it.

**Factors affecting stream erosion**  
- Velocity
- Channel slope
- Grain size
- Discharge

**Types of valleys**
- **Temporary valleys** – the stream channel is the only a part of the watershed.
- **Permanent valleys** – the stream channel is the only a part of the watershed.
- **Wetlands** – areas of water that are saturated with water.

**Characteristics prevalent in a stream in late maturity:**  
- **Rapids**
- **Waterfalls**
- **Shallow channels**
- **U-shaped valleys**
- **Abundance of flood plains**

**Characteristics prevalent in a stream in early maturity:**  
- **Rivers**
- **Wetlands**
- **Shallow channels**
- **Deep channels**

**Characteristics prevalent in a stream in old age:**  
- **Rivers**
- **Wetlands**
- **Shallow channels**
- **Deep channels**

---

**Stage of Youth**

- Characteristics that are prevalent during this stage are:
  - Rapids
  - Waterfalls
  - Shallow channel
  - U-shaped valley
  - Abundance of flood plains

---

**Stage of Maturity**

- One can identify the early stage of maturity by the following characteristics:
  - Shaped valley alcohol present
  - Flood plain begins to develop
  - Valley is no longer deepening
  - Vertical wall reaches its maximum

---

**Old Age**

- Davis’ stage of old age is also one that has many distinctive characteristics:
  - Stream continues to meander
  - Old flood plains are formed
  - Large flood plain present
  - Land surrounding the stream is flat

---

**Rejuvenation**

- Rejuvenation of a stream is when a stream rewinds back to its youthful stage.
  - The land surrounding the stream shifts and the stream is again surrounded by valleys and the cycle then continues.
  - This can occur at any stage of a stream, however, does not always happen.
Appendix C.4.2

Example of Student Poster Work

Acid Mine Drainage

What is AMD?
- Flow of acidic water from abandoned mines
- Discolors streams and kills all living organisms

Causes of AMD:
- Chemical weathering including air and water
- Oxidation of metal sulfides and flooding of wells

Treatment of AMD:
- Carbonate chips are able to raise pH
- Bacteria have anaerobic activities capable of filtering metals to increase pH

How to Prevent AMD:
- Proper labeling and disposal of acids is now enforced by law.
- Acid-base accounting predicts which strata of rock will potentially produce AMD and is used to plan mining operations and reclamation processes.
- Acid-base accounting measures the maximum amount of sulfur in the strata of rock and then determines how much lime is needed to neutralize the acidity.
Appendix C.4.3

Example of Student Poster Work

---

**Dams and Their Effect on the Environment**

_by Brenton Mask, Thomas Pavlick, Liam Gallagher, Thomas Miller_

**Unit 4 Group 5**

**Harmful Dam Effects**

- Dams cause erosion to be held in reservoirs, causing siltation and downstream be carried to byways.
- Sunlight causes fluvial or construction of fluvial and floodplains.
- A natural movement of animals to alleviate flooding, ultimately causing flooding to reservoirs.
- Fish and water life can be killed and fish are dam.
- Discharge of waste into the water can kill the animals that drink it and live in it.
- Dams increase water pollution by unnecessary chemical spills and reduce vegetation and water.

**Natural Effects**

- Water pollution can cause flooding, damming or water levels to contain vegetation and flooding.
- Living by dam reservoirs can cause flooding, damming or water levels to contain vegetation and flooding.
- Dams may change water levels due to changes in climate patterns, water temperature, and air movements.

**Helpful Dam Effects**

- Can help people that live a life depending on water.
- Dams remove necessary transport of necessary water to areas of need.
- New industries can arise, such as building and flooding in certain areas.
- Land can improve due to better soil being produced.
- Dams can be used to generate hydroelectricity.
- Due to regulation of water temperature and salt and oxygen distribution, a new generation of fish can arise.
- Water flow can be controlled, the water flow of food and increased water circulation is king for well adapted species.

**Outcomes and Preventions**

- Ways to create or control damage from dams.
- Using a system of small check dams to prevent erosion would cause more natural flow and maintain natural stability.
- Using a curved dam can cause damage and prevent structural problems.
- Using a vertical wall to to prevent erosion would prevent structural problems.
- Using rock to protect fractured, weak rock.
- Maintaining of pipe systems.
- Creation of passage ways for the safe transport of fish through dams.
- Continue to create new ways to prevent the structures of dams.

**Lifespan of a Dam**

- A dam is constructed with the best intentions. The well distribution of water and water-electric energy is useful in today's society.
- However, although a dam is safe, negative things can come about. Starting off with the structure, a dam is built with the best intentions and a lot at the time.
- As the beginning, the dam is studied and virtually indestructible, but as time goes along and materials weaken. As the dam ages, structural damages such as fractured walls and leaking water pipes occur. These problems can lead to the destruction of the dam and cause major problems for the surrounding area.
- Natural water flow and severe lands would be lost, not to mention all the lives that would be taken.
- Dams also cause issues for the wildlife surrounding it. Building dams across rivers decreases the carrying out of water into the river. Also, due to some of the boats in the water, fish and their eggs find it very hard to survive. Certain species often face starvation due to the changing surroundings. However, for the fish, dams create a very fertile soil in the surrounding areas.

**Three Gorges Dam, China (World’s Largest Dam)**

- 1.2 billion $277 billion high, and engineered in 770 million $27 billion cost.
Appendix C.5

Example of Paper
(Accompanies poster in Appendix C.4.3)

**Footnote: This report is transcribed as submitted by the group. Typographic errors have been kept in the document to retain authenticity when transposing students' work.**

Unit Four, Group 5: Dams and Their Effects on the Environment

Throughout history man has thrived to create, invent and explore different sources of energy in hopes of finding a cheap, more efficient method to power society. However, in man’s yearning to implement these new forms of technology, one factor was thrown to the wayside, and has subsequently taken a hit due to the irresponsibility of these accomplishments: that factor being the environment. In particular, while the production of modern day dams have had an immensely positive outcome, e.g. providing water for irrigation, creating a reservoir of water and generating hydroelectric power, the dam has also created several negative outcomes, many which are definitely not conducive to the overall health of the environment. The United States Society on Dams and others have done research of their own which our group used for this research. Numerous other sources led a hand in showing our group what we wanted to know such as the Virginia Department of Conservation and Reservation, the United States Geological Survey, who studied the Horsetooth Reservoir located in the foothills of the Rocky Mountains, and William Adams, of the University of Cambridge. Their contributions helped my group to see a little more into how exactly dams effect the environment.

Dams, which were originally created in order to prevent flooding in ancient Mesopotamia by the Egyptians, have today become much more: generating hydroelectric energy, and providing a water supply to towns. While these positive aspects have helped to shape our state of living, they also come with serious consequences. As a result of dam construction, the rivers become blocked off cannot deliver the sediment downstream and it [the sediment] becomes trapped behind the dam. Directly because of this the downstream becomes sediment starved, which in turn cuts down the amount of energy needed to transport the material. The stream
gradient decreases and the amount of sediment the stream can carry diminishes. As this occurs, the effects on the ecosystem start to become apparent.

Tahmiscioglu, along with numerous other scientists studying the effects on the ecosystem from dams saw this relationship and saw that because of the lack of sediments downstream, the fish are restricted to smaller areas to lay their eggs. Since the natural flow of water is disrupted, fish that move upstream to ovulate and mate are confined and thus the fish population drops significantly. As a result of the decrease in fish population, numerous other species would feel the blow, including predatory animals, which use the fish as their main food source. William Adams documented a survey he completed in which he noted that the decrease in water quality also had an immense impact on the human social aspect.

When the water is released from the low outlets in the dam, such as turbines, which extracts energy from the flow of the water passing by, it may have become deoxygenated or rich in hydrogen sulfide. In addition, the water released may have become warmer while passing by the turbine. Adams notes “In Arctic areas dam releases in winter can be unnaturally warm” which can have an impact on the fauna. If the water is toxic or poisonous the fish can become infected, as seen in Arctic rivers where high mercury levels have been reported downstream of dams. A scientific report written by Jean-Claude Bonzongo, et al, from the University of Alabama at Birmingham backs this idea up with their findings. The results showed that the Largemouth Bass population in the Alabama-Mobile River system had unusually high concentrations of mercury poisoning near the reservoir, but downstream where the water was of better quality the numbers went down. However, high levels of Mercury are not the only danger; water sourced illnesses ranging from Cholera to Malaria can also be increased.

Because the dam hinders the stream’s movement half of the water is likely to become stagnant. When this occurs, the water becomes ideal for snails, which help breed water-borne diseases. In addition, mosquitoes, which breed in stagnant water, carry the Malaria parasite, and can infect a human via a bit. Since the rise of the Narmada Sagar and Sadar Sarovar dams the number of Malaria reports have increased. According to the Madhya Pradesh Council of Science and Technology, “the incidence of malaria, filarial, cholera, gastroenteritis, viral encephalitis,
goiter and some other water borne diseases is likely to increase which can apparently be directly connected with the construction of the two dams.

Along with the effect on fauna and human society, dams also have a profound impact on the flora. Tahmiscioglu noted “Water-soil-nutrient relations, which come into existence downstream related to the floods occurring from time to time in a long period of time, change. Depending on this fact, compulsory changes come into existence in the agricultural habits of the people living in this region and also in the flora and fauna” which coincides with the concept of the sediment being block off on one side. Gregor T. Auble et al performed a study in which they looked at the vegetation of the Horsetooth Reservoir in Colorado after the removal of a tall dam. Their studies found that even four years after the removal of the dam the plant life had not grown as much as hoped. Their results state “after four years of exposure suggest that vegetation recovery following tall dam removal will follow a trajectory very different from a simple reversal of the response to dam construction, involving not only long time scales of establishment and growth of upland vegetation, but also possibly decades of persistence of legacy vegetation established during the reservoir to upland transition” which in essence shows that plant life will remain to debilitated even years after the elimination of a dam. These long lasting effects to the vegetation, coupled with the damage done to animals and human society, leave a bittersweet taste in the mouths of men.

While dams do have numerous advantages and abilities, the downside is evident, and seen in the ecosystem. Numerous surveys, reports and documents prove that the overuse and over construction of dams can seriously injure the environment. Sediment is disrupted, which decreases the quality of water and limits the breeding ground of fish. The lack of fish combined with the decrease of water quality spurn disease. Disease effects human society and it quickly comes full around to create a circle. The results of the above mentioned studies all point out flaws in the construction and overuse of dams, pointing out innumerable facts and statistics which all indicate the truth in their words.
Works Cited


Appendix D

Student Interview Guide

Introductory comments and Questions

1. Thank you for agreeing to participate in this interview.

2. This interview is part of my school work at West Virginia University.

3. Some people do or do not like to learn science. I am going to ask you some questions about this and why.

4. Some people prefer to learn new information in science by different methods. I am going to ask you some questions about this and why.

5. There is no right or wrong answers to the questions. So, please answer them as honestly as possible. Also, for each question, please provide me with as many examples as you can remember.

6. Your name will not be associated with your answers. So, please feel free to answer honestly.

7. I would like to use a tape recorder to help me record your answers instead of me writing everything down. Is that OK with you?

8. First, I would like to ask you some background questions.
   a. How good are your grades in science?
   b. Have you taken science courses before because you want to take them?
   c. Are there any topics of Geology that are of personal interest to you?

Main Questions:

I am going to ask you some questions about things that influence your perceptions and attitudes about science, geology, in particular. I am interested in learning how different teaching strategies and methodologies used in a large lecture introductory Geology course may influence your attitudes about learning. I am also interested in what teaching strategies you feel are the most effective towards providing meaningful learning.

Question 1: What type of a learner would you describe yourself as?

Question 2: Does the Exploratory Question opening bring about feelings associated with the concept, or realignment of prior conceptions about a new concept being introduced?
**Question 3:** Is discussing solutions or problems with other classmates helpful in learning?

**Question 4:** What strategies and methods are most effective in learning new geology concepts?

**Question 5:** What activities in class are the most engaging?

**Question 6:** Doing cooperative work: i.e. did the projects help to learn geology concepts better?

**Question 7:** Was enough time given for in-class activities?

**Question 8:** Do test questions correlate with the class instruction?

**Question 9:** Did homework reinforce learning?

**Question 10:** If you could change anything within the instructional presentation of geology material, what would you do differently?

**Question 11:** If you could change anything within the teaching methodologies used within the classroom, what would you do differently?

**Question 12:** Is there anything that I failed to discuss in the interview?
Appendix E  Interview generated matrix linking program processes to program outcomes

| PRS  |
|---|---|---|---|
| SYSTEM | Introductory Questions/ Concept Test Questions | Social Dynamics | Attitudes | Format | Outcomes/ Grades |
| -Students allowed to interact like real world setting.  
- Nice to have your own little group.  
- Simplicity to change to learn from peers.  
- We get an opportunity to talk.  
- We challenge one another. | - Students see self-awareness in learning.  
- Problem solving expands knowledge.  
- Liked recalling past knowledge on topic.  
- Excited if I knew what the answer was | - Motivator to come to class.  
- Provides engagement and focus.  
- Helps to gauge learning by having histograms display percentages of responses to answers.  
- Provides feedback.  
- I liked the clicker ?’s, but not the clickers! | - Good study tool.  
- Good practice for preparing for test format.  
- See strengths/weaknesses for test prep, giving direction for studying. |

| HW | - My friends and I always did HW together.  
- Project work developed friendships and we then always did our HW together. | - Length of time to complete HW appropriate.  
- Never too difficult or time consuming.  
- Articles and activities on line bring learning to life.  
- Helped develop technology skills necessary out of the classroom. | - Repetition of material is good.  
- The outside resources were informative, especially other school sites.  
- On line labs and drawing were helpful.  
- Helps to develop in class activities.  
- Directly related to class topic. | - Good review material for exam.  
- Homework helped with overall grade. |

| PROJECT | - Provides life skills similar to work setting.  
- Made friends that became semester study buddies.  
- Self responsibility with work completion similar to real work setting.  
- Defending group work good work preparation. | - Students like accountability system built into project.  
- Opportunity to learn new professional skills.  
- Proud of work.  
- Uncomfortable for some students to work with strangers. | - Rubric gives students ability to have expectations of work for grade, giving them control over grade.  
- Reasonable work and fun.  
- Liked being able to choose topic for development in group work.  
- Expands learning by having to search out resources. | - Where project topic overlapped test, students did well. Otherwise, project did not help for test.  
- Project helped with overall grade.  
- Fair portion of grade.  
- Graded by effort, so good.  
- Some group members did not do their share of work and therefore cheated with their grade outcome. |

| LABS | - Some students learn material best when explained by another student.  
- Nice to bounce ideas off of other students.  
- Group work is helpful in learning.  
- We each defended our own opinions. | - Made me feel better when someone else was clueless.  
- Ties together concepts learned in class.  
- I had no clue what was going on.  
- Reinforces/expands learning.  
- Builds interest when you get to work with something.  
- Hands on and paper work is better. | - Do more!  
- Explained and executed well.  
- Students found graphs and drawings worked best.  
- Give more time to do labs!  
- Some students would prefer to take labs home as HW and review b/f submission in class. | - Helpful for test prep.  
- Not worth enough points. |

| TLC | - Social dynamics mirror real life.  
- Sets an atmosphere in the class.  
- Developing relationships in class is a motivator to come to class.  
- Make friends by working together. | - Student becomes teacher.  
- Work becomes relevant.  
- Good transition from high school to college.  
- I pay attention to what I am looking at now (re. geologic processes) | - Doing things keeps the student involved.  
- Variety in learning tools is helpful.  
- Gives deeper learning.  
- Breaks up monotony of class.  
- Provides ability to control part of grade.  
- Accommodates different learning styles.  
- Distribution of points helpful.  
- Learning goes beyond classroom into life applications and decisions. | - |
I. Example of Introductory Engagement Activity

Introductory questions were used to start daily instruction. Questions

Question of the Day

In November 1985, the Cheat River, in WV, experienced a 500 year flood event. Here, a cow carcass is entangled with flood debris beneath the Cheat River Bridge in Saint George. The average discharge of the Cheat River is 1,000-5,000 cu. ft/s. What was the peak discharge during this event?

Answer:
During this historical event, the Cheat discharged ~190,000 cu. ft/s (Approximately 40% the discharge rate of the Mississippi River, which drains water from 38 states within the U.S.A.) What do rivers have to do with groundwater? They are part of the same system.
Appendix F.2

II. Examples of Concept test Questions

Following daily instruction, the students completed 10-12 Concept test questions. Questions were presented by ppt display and answered with the interactive communication system (PRS) used in the classroom (i.e.: clickers.) Following the time allotment given for answering a question, a histogram displayed the percentage of answers for each of the answer choices. Many of the graphics were taken from SERC: the Science Education Resource Center at Carleton College, a science education resource center providing projects that support educators.

1. The regional water table

The four schematic cross sections show the potential groundwater resources for an area of hills and valleys. Assume the region receives plentiful rainfall and is underlain by an open aquifer composed of sand and gravel. Predict which diagram is the best representation of the relationship between topography and the water table.

http://www.serc.carleton.edu/NAGTWorkshops/assess/conceptmaps.html

Answer choices: A, B, C, or D

2. Confined vs. Unconfined Aquifer

Liquid hazardous waste is disposed of by pumping it down injection wells. Which well location would be the most suitable to use for an injection well?

http://www.serc.carleton.edu/NAGTWorkshops/assess/conceptmaps.html

Answer choices: A, B, or C
Appendix F.3

III. Example of In-class Activity

Groundwater

Cave formation is complex and dependent upon several factors. Propose a hypothesis for cave formation. Watch the demonstration on cave development. Draw the sequence to cave development as shown on the site, listing factors involved in cave development. Answer the following questions.


1. Where must limestone be located in order for cave development to occur?
   - Above or below the water table and why?

2. \( \text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{H}_2\text{CO}_3 \)
   - What is the influence of acid rain on cave development?
     - Sulfuric acid dissolves the limestone
     - Carbonic acid dissolves the limestone
     - Carbonic acid erodes the limestone
Appendix F.4

IV. Example of Homework

Chapter 1: Earth and Its Place in Space

Solar System Questions

To answer set one (1-10), double click the underlined words below, which are hyperlinked to the referenced URL. OPEN AND READ THE TOPICS.
In the margin under Space Topics; open and read:
Asteroids and Comets
Earth: click to get to
  >The Big Blue Marble: open to get to
  >Earth stats

JUST IN CASE YOU ARE HAVING DIFFICULTY WITH THE LINK,
URL: http://science.nationalgeographic.com/science/space/solar-system

1. A comet’s tail (2 pt)
   As comets path approaches the Sun, the tail of frozen water becomes ionized and vaporized by the Sun. The solar wind causes the tail to ________ the Sun.
   o 1. Point away from
   o 2. Point towards

   Cosmic microwave background radiation in the Universe is thought to be a tangible remnant of:
   o 1. The formation of our Solar system
   o 2. Evidence of other galaxies
   o 3. Early supernovas
   o 4. Leftover light from the ‘Big Bang’

Chapter 1: Earth and Its Place in Space

Star Questions

To answer set two (11-18), double click the underlined phrase below, which is hyperlinked to the referenced URL.

Build your own Star. Read the introductory page.
To open the laboratory, double click the star inset on the right side of the page. This virtual experiment allows you to build stars of various sizes. You will see that the size as well as the amount of metal influences the life span and resultant stellar body that results. Play around,

http://www.planetseed.com/node/20127
make stars of different mass sizes (remember that 1 mass = our Sun’s size) with different metal contents, and then answer the following questions about stars.

JUST IN CASE YOU ARE HAVING DIFFICULTY WITH THE HYPERLINK, http://www.planetseed.com/node/20127

12. The pressure in a star (3 pt)
   The pressure due to the internal heat pushes a star towards
   o 1. The center of the Universe
   o 2. Contraction
   o 3. Expansion
   o 4. Equilibrium

13. Life span/Metal content (2 pt)
   If we increase the metal content of a star whose mass = 1 from 0.001 to 0.02, what influence does this have on the life span of the star?
   o 1. It lengthens the stars life span.
   o 2. It shortens the stars life span.
Appendix G
West Virginia University Internal Review Board Approval Process

1. Research Proposal
2. Consent Approval Form
3. Letter of Assent for Interview
4. Interview Protocol
5. Letter of Advisement to Department
6. Internal Review Board Approval Number

1. Research Proposal

I. Title: Using Active Learning Strategies to Investigate Student Learning and Attitudes about Geology in a Large Enrollment, Introductory Geology Course.

II. Investigator: Stacy J. Berry

III. Hypothesis, Research Questions, or Goals of the Project: The goal of this study is to determine if learner perceptions about science, in particular geology, and grades in an introductory Earth science course will be influenced or changed as a result of a more student centered approach to learning.

IV. Background and Significance: Research indicates that there needs to be a revitalization and restructuring of teaching methodologies in science to further promote scientific literacy and meaningful learning. The National Science Board (NSB), the governing body for the National Science Foundation recognizes this as a problem of national importance and recommends that it be addressed through the development of student centered instructional styles.

The Learning Cycle is a three phase instructional design that allows students to be active participants in their own learning. Supplemental web based activities and in class collaborative activities offer a variety of student-centered instructional styles to be used within the development of all three phases: [exploration (E), instruction (I), and application (A)]. As an instructional model, the Learning Cycle provides the active learning experiences recommended by the National Science Education Standards (National Research Council, 1996). The intention is to increase both quantitative and qualitative aspects associated with an introductory Earth Science course.

Research Method, Design, and Proposed Statistical Analysis: This study is a triangulated mixed methods design that will integrate quantitative and qualitative data so that each dataset carries equal weight, priority, and consideration. Data will be triangulated from content assessments; overall letter grades and attitudinal surveys from
both sections. Open ended interviews will be conducted with eight to ten students from the student-centered, experimental section at the end of the semester. A Three Phase Learning Cycle (Exploration, Instruction, and Application) will be implemented by the researcher in Section 006 in the spring semester of 2009. The instructional design is student-centered, inquiry based, and actively engages the student in all phases of learning. A collaborative research paper and poster project will be undertaken in the course. Supplemental web based and book based weekly homework will support the Learning Cycle Design. The control section for use of this study will be Section 001, which is taught in a more traditional lecture style format.

The sampling method for interviews will be a combination of theory sampling within a group in order to discover or generate a theory. A comparison method will be used to generate and connect raw data to codes, codes to categories, and categories to themes. Theories from the themes will emerge from this process that will be compared to the quantitative results. In this way, using the combination of sampling methods will produce qualitative data from multiple perspectives in order to best represent the complexity of the teaching instructions used and a holistic view of the participants.

V. Human Subject Interaction

A. Sources of potential participants: Regularly enrolled students in Section 001 and Section 006, Geology 101, WVU; Spring Semester, 2009.

B. Procedures for the recruitment of the participants: Students in this section will be asked to sign a consent form for grade and demographic information to be used in the study. Students who agree to be interviewed will sign an assent form indicating such. The researcher will codify all entries as to ensure that confidential information is not revealed. Interviews will be audio taped.

C. Procedure for obtaining informed consent: A consent form will be given to the participants for their signature and an assent form will be provided for the students that volunteer to be interviewed.

D. Research Protocol: Students will be asked to complete a demographic sheet and to sign a consent form at the beginning of the semester. Students will fulfill course requirements as specified in the course syllabus distributed at the beginning of the semester for both sections. In addition, interviews will be conducted with volunteer participants from Section 003, Geology 101 at the close of the semester.

E. Privacy and confidentiality of participants: If the results of this research are published or presented at scientific meetings, the identity of the participants will not be disclosed. Any reports derived from the research will not reveal anyone’s true names, but pseudonyms will be used instead or the data will be aggregated without the use of names.
F. Confidentiality of the research data: The data will be in the form of papers, audio tapes, and computer files that will be kept in the PI’s office; 141 Brooks Hall, Geology Department, WVU. They will be stored in a locked file cabinet and when working with them, every effort will be made that they are not easily viewed or accessible to others in proximity. Files stored on computer will be password sensitive.

G. Research resources: Data will be managed through computer (ecampus), accessible to students and the PI through personal or school computer. Qualitative data from the study (i.e. interviews) will be kept at 141 Brooks Hall.

VI. Risks: No other physical or mental discomforts are foreseeable.

VII. Benefits: All students may benefit quantitatively and/or qualitatively in this study.

VIII. Sites or agencies involved in the research project: The Geology Department in Brooks Hall, West Virginia University will be the site where the research will be performed. Approval from this site is still processing.
2. Consent Approval Form

Informed Consent to Participate in Research

West Virginia University, Morgantown

You are being asked to participate in a research study. This form provides you with information about the study. The Principal Investigator (Stacy Berry) will provide you with a copy of this form to keep for your reference, and will also describe this study to you and answer all of your questions. Please read the information below and ask questions about anything you don’t understand before deciding whether or not to take part. Your participation is entirely voluntary and you can refuse to participate without penalty or loss of benefits to which you are otherwise entitled.

Title of Research Study: Using a Three Phase Learning Design in a large lecture introductory Geology course in higher education to investigate effect on learner outcomes and attitudes towards science.

Principal Investigator: Ms. Stacy J. Berry, Ph.D. student 304-641-4334

Funding Source: Not applicable

What is the purpose of this study? The purpose of this study is to determine if a student centered teaching design implemented in a large lecture introductory Geology course will have a positive effect on learner outcomes and attitudes towards science.

What will be done if you take part in this research study? Participants are regularly enrolled students in Section 001 and Section 003 of Geology 101; spring semester, 2009. Both sections will follow the course requirements as set out in the syllabus. Demographic information will be obtained on a voluntarily basis and submitted by computer to the researcher. Class grades from the traditional lecture format in the spring will be used as a comparison with grades obtained from the student-centered format in the spring semester of 2009. Some students will be interviewed outside of class time to be able to triangulate attitude data with content data of the study.

What are the possible discomforts and risks? No physical or mental discomforts are foreseeable.

What are the possible benefits to you or to others? There are no tangible benefits by participating in the interview.

If you choose to take part in this study, will it cost anything? There is not a cost.

How will your privacy and the confidentiality of your research records by protected?
If the result of this research are published or presented at scientific meetings, your identity will not be disclosed. Any reports derived from the research will not reveal anyone’s true names, but pseudonyms will be used instead or the data will be aggregated without the use of names.

If in the unlikely event it becomes necessary for the Institutional Review Board to review your research records, then West Virginia University, Morgantown will protect the confidentiality of those records to the extent permitted by law. Your research records will not be released without your consent unless required by law or a court order. The data resulting from your participation may be made available to other researchers in the future for research purposes not detailed within this consent form. In these cases, the data will contain no identifying information that could associate you with it, or with your participation in any study.

Signatures:

You have been informed about this study’s purpose, procedures, possible benefits and risks, and you have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time. You voluntarily agree to participate in this study. By signing this form, you are not waiving any of your legal rights.

<table>
<thead>
<tr>
<th>Printed Name of Participant</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signature of Participant</td>
<td>Date</td>
</tr>
</tbody>
</table>

As a representative of this study, I have explained the purpose, the procedures, the benefits, and the risks that are involved in this research study:

<table>
<thead>
<tr>
<th>Signature of Principal Investigator</th>
<th>Date</th>
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</table>
3. Letter of Assent for Interviewees of Research Study

Letter of Assent
Title: Surveying perspectives of instructional design and teaching methodologies used in Geology 101; spring, 2009, at West Virginia University.

West Virginia University, Morgantown

You are being asked to be part of a study. This form provides you with information about the study. The person in charge, Ms. Stacy Berry, will describe this study to you and answer all of your questions. Please listen to the following information, which is stated below and ask any questions you might have before deciding whether or not to take part. Your participation is entirely voluntary. You can refuse to participate without any consequences. You can stop the interview at any time. To do so simply tell Ms. Berry you wish to stop.

The purpose of this study is to learn about quantitative and qualitative differences in student’s scores and attitudes through use of a student centered teaching format.

If you agree to be in this study, I will ask you to do the following things:
• Be willing to be interviewed outside of Geology class.

Total estimated time to participate in interview will be 45-60 minutes.

Risks and Benefits of being in this study:
• This study will not hurt you.

Compensation
• There is no compensation.

Confidentiality and Privacy Protections:
• Your name and anything about you will be kept confidential and no one outside of the study will know these things.

Contacts and Questions:
If you have any questions about the study please ask now. If you have questions later or want additional information, talk with Ms. Berry. If you feel like something is wrong please contact Ms. Berry’s advisor, Dr. Jack Renton at (304) 293-3405, ext. or email

Statement of Assent:
I understand about participating in this study. I would like to participate in the study.

Signature: ______________________________ Date: ________________
Signature of Investigator: __________________________ Date:__________________
4. Interview Protocol

See Appendix D
5. Letter of Advisement to WVU Geology Department

January 8, 2009

Informational Cover Letter
(Surveys)

Dear Participant,

This letter is a request for you to take part in a research project to investigate how teaching methods affect student grades and attitudes about geology. This project is being conducted by Stacy Berry; Doctoral student, at WVU, with supervision of Dr. John Renton, professor of Geology; WVU and Dr. Patricia Obenauf, professor of Curriculum and Instruction; WVU. Your participation in this project is greatly appreciated. Two surveys are being administered that you are being asked to answer. One survey will be administered through ecampus and will take approximately 10 minutes to complete. You may complete this on your own time at the beginning of the semester. The other survey will be administered in class, four times through the semester.

Your involvement in this project will be kept as confidential as legally possible. All data will be reported in the aggregate. You must be 18 years of age or older to participate. I will not ask any information that should lead back to your identity as a participant. Your participation is completely voluntary. You may skip any question that you do not wish to answer and you may discontinue at any time. Your class standing will not be affected if you decide either not to participate or to withdraw. West Virginia University’s Institutional Review Board acknowledgement of this project is on file.

Your involvement will include the filling out of two surveys:
1) a Demographic Survey (online: ecampus)
2) Student Self-Assessment of Learning (completed in class with P.R.S.)

I hope that you will participate in this research project, as it could be beneficial in understanding the impact of teaching methods on student performance and attitudes. Thank you very much for your time. Should you have any questions about this letter or the research project, please feel free to contact Stacy Berry at sberry@mix.wvu.edu.

Thank you for your time and help with this project.

Sincerely,

Stacy J. Berry
6. Protocol Number

West Virginia University Institutional Review Board # H-21354