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Engaging Bioanthropology College Students: The Role of Active and Cooperative Pedagogies

By

Kathaeryne Elizabeth Soluri

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy

in

Anthropology

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Assistant Professor Sabrina C. Agarwal, Chair

Professor Rosemary A. Joyce

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Spring 2010

Engaging Bioanthropology College Students: The Role of Active and Cooperative Pedagogies

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by Kathaeryne Elizabeth Soluri

Abstract

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Kathaeryne Elizabeth Soluri

Doctor of Philosophy in Anthropology

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Assistant Professor Sabrina C. Agarwal, Chair

This dissertation examines the design and implementation of an active, cooperative pedagogy in an undergraduate biological anthropology course. The research draws upon a theoretical framework constructed from anthropology, education, and psychology research. The pedagogy studied was developed for and used in the laboratory component of a large, introductory course at the University of California at Berkeley. As such, the results of this research are relevant to not only other biological anthropology courses but also other large, introductory courses or laboratory-based courses in related disciplines.

The dissertation evaluates the efficacy of the stated pedagogy by answering the following questions: Does the pedagogy effectively engage students of all learning styles in higher-level thinking? Does the pedagogy effectively promote high quality student learning, particularly learning of high-level course material? Does the pedagogy effectively foster long-term retention of key course concepts and higher-level thinking across students of various learning styles? Three lines of evidence are employed to answer these research questions. To address issues of student engagement, classroom observations of students are qualitatively evaluated. Student performance on the final exam in the course is statistically analyzed to answer questions related to initial student learning. In considering issues of student retention from a longitudinal perspective, student performance on a follow-up survey (administered between three months and two years after course completion) is statistically analyzed.

Research presented here suggests the pedagogy does effectively promote student engagement with course material and foster students' long-term retention of learned course material. This efficacy is similar for students of different learning styles and generally applies to both low-level and high-level course material. Preliminary findings also suggest the pedagogy effectively promotes high quality student learning, including learning of high-level material.

It is argued that the stated pedagogy is effective and that this and similar pedagogies could be usefully employed in similar courses in anthropology and biology. Within higher education, generally, and the discipline of anthropology, specifically, there is growing concern over how to effectively teach undergraduate students. The research discussed here provides evidence that active, cooperative approaches to undergraduate anthropology instruction are successful in promoting student engagement, learning, and retention. This research also provides a template for the evaluation of pedagogical approaches that can be applied to future investigations of various pedagogies used in anthropology instruction.

*For my grandparents:
Kay and Jim Camp
Madeline and Val Soluri*

TABLE OF CONTENTS

ABSTRACT	1
DEDICATION	i
LIST OF FIGURES	v
LIST OF TABLES	vii
ACKNOWLEDGEMENTS	ix
CHAPTER ONE: INTRODUCTION	1
The Changing Landscape of Higher Education	1
Overview of Dissertation Research	3
Implications of Research	4
Outline of Dissertation	4
CHAPTER TWO: THEORY	6
Memory	6
<u>Encoding</u>	6
<u>Retention</u>	8
<u>Transfer</u>	8
<u>Summary</u>	10
Active Learning	10
<u>Historical Context</u>	10
<u>Goals of Active Learning</u>	11
<u>The Active Learning Continuum</u>	12
<u>Critiques of Active Learning</u>	15
<u>Benefits of Active Learning</u>	16
<u>Applications of Active Learning in College Classrooms</u>	17
<u>Summary</u>	19
Cooperative Learning	19
<u>Historical Context</u>	19
<u>Goals and Benefits of Cooperative Learning</u>	20
<u>Critiques of Cooperative Learning</u>	22
<u>Applications of Cooperative Learning in College Classrooms</u>	23
<u>Summary</u>	24
Discussion-based Teaching	25
Bloom's Taxonomy	26
<u>Historical Context and Goals</u>	26
<u>The Taxonomy</u>	26
<u>Critiques and Benefits</u>	27
<u>Summary</u>	28

Learning Styles.....	29
<u>Historical Context and Goals</u>	29
<u>Critiques and Benefits</u>	30
<u>Summary</u>	30
Conclusion.....	31
CHAPTER THREE: MATERIALS	32
Overview of Anthropology 1: Introduction to Biological Anthropology	32
Student Diversity	33
The Pedagogy of Anthropology 1	34
The Laboratory Section	35
The Laboratory Workbook	37
Implementation of the Laboratory Workbook	38
The Paleoanthropology Labs	40
The Full-Length Workbook	40
<u>Chapter Seven: The Cenozoic: Early Primate and Hominin Evolution</u>	40
<u>Chapter Eight: The <i>Australopithecus</i> Genus, the <i>Paranthropus</i> Genus, and the Early <i>Homo</i> Genus</u>	42
<u>Chapter Nine: Later Hominins and Culture</u>	45
The Condensed Workbook	50
<u>Chapter Four: Comparative Anatomy and Early Primate and Hominin Evolution</u>	51
<u>Chapter Five: The Fossil Hominins (<i>Australopithecus</i> through <i>Homo</i>)</u>	52
Summary	57
CHAPTER FOUR: METHODS	58
Evaluating Student Engagement	58
Evaluating Initial Student Learning	62
Evaluating Student Retention	63
<u>The Paleoanthropology Content Questions of the Survey</u>	69
Summary	71
CHAPTER FIVE: RESULTS	72
Student Engagement	72
Initial Student Learning	74
Student Retention of Learned Course Material	83
CHAPTER SIX: DISCUSSION	99
Student Engagement	99
Initial Student Learning	101
Student Retention of Learned Course Material	105
Summary	109

CHAPTER SEVEN: CONCLUSION	110
Suggestions for Future Research	111
Implications of the Research	112
Summary	114
BIBLIOGRAPHY	115
APPENDIX ONE: Paleoanthropology Unit of the Laboratory Workbook (Full-length Version)	121
APPENDIX TWO: Paleoanthropology Unit of the Laboratory Workbook (Condensed Version)	154

LIST OF FIGURES

Figure 2.1	The Active Learning Continuum.....	13
Figure 3.1	Anthropology 1 Student Majors.....	34
Figure 4.1	Anthropology 1 Student Majors: A Comparison of the Summer 2009 Term to the Total.....	61
Figure 4.2	Survey Administered to Former Anthropology 1 Students.....	65 – 66
Figure 5.1	Student Final Exam Performance by Semester.....	75
Figure 5.2	Bivariate Fit of Student Performance on Paleoanthropology Exam Questions by Student Performance on Non-Paleoanthropology Exam Questions.....	76
Figure 5.3	Bivariate Fit of Student Performance on Lecture-based, Paleoanthropology Exam Questions by Student Performance on Lab-based, Paleoanthropology Exam Questions.....	77
Figure 5.4	Oneway Analysis of Variance of Student Performance on Lab- based, Paleoanthropology Exam Questions by Student Performance on Lecture-based, Paleoanthropology Exam Questions (Spring 2007).....	78
Figure 5.5	Oneway Analysis of Variance of Student Performance on Lower- level Thinking, Lab-based Exam Questions by Student Performance on Lower-level Thinking, Lecture-based Exam Questions.....	82
Figure 5.6	Bivariate Fit of Student Performance on Lab-based, Higher-level Thinking Exam Questions by Student Performance on Lecture- based, Higher-level Thinking Exam Questions.....	83
Figure 5.7	Student Final Exam and Survey Performance.....	87
Figure 5.8	Distribution of Survey Population Paleoanthropology Exam Averages and Overall Population Paleoanthropology Exam Averages by Semester.....	88
Figure 5.9	Distribution of Survey Population Total Exam Averages and Overall Population Total Exam Averages by Semester.....	89

Figure 5.10	Bivariate Fit of Student Performance on Survey Questions and Student Performance on Paleanthropology Exam Questions.....	90
Figure 5.11	Bivariate Fit of Student Performance on Survey Questions and Student Performance on the Final Exam Overall.....	91
Figure 5.12	Student Performance on Lower-level Thinking and Higher-level Thinking Survey Questions by Semester.....	92
Figure 5.13	Student Performance on the Final Exam and Survey by Learning Style.....	94
Figure 5.14	Student Performance on the Final Exam and Survey by Learning Style and Semester.....	96
Figure 5.15	Chi-square for Contingency Analysis of Student Performance on the Lower-level Thinking Survey Questions and Student Learning Style.....	97
Figure 5.16	Oneway Analysis of Variance of Student Performance on Higher-level Thinking Survey Questions by Student Learning Style....	98

LIST OF TABLES

Table 3.1	Summary of Graduate Student Instructors in Spring 2007 Semester.....	39
Table 3.2	Sample Take Home Quiz Questions for Chapter Seven in the Full-Length Workbook.....	41
Table 3.3	Sample Laboratory Station Tasks from Chapter Seven in the Full-Length Workbook.....	42
Table 3.4	Take Home Quiz from Chapter Eight of the Full-Length Workbook.....	44
Table 3.5	Sample Laboratory Station Tasks from Chapter Eight in the Full-Length Workbook.....	45
Table 3.6	Take Home Quiz Chart One (Fossil Species) from Chapter Nine in the Full-Length Workbook.....	47
Table 3.7	Take Home Quiz Chart Two (Stone Tools) from Chapter Nine in the Full-Length Workbook.....	48
Table 3.8	Sample Laboratory Station Tasks from Chapter Nine in the Full-Length Workbook.....	49
Table 3.9	Discussion Questions from Chapter Nine in the Full-Length Workbook.....	50
Table 3.10	Sample Take Home Quiz Questions from Chapter Four in the Condensed Workbook.....	51
Table 3.11	Sample Laboratory Station Tasks from Chapter Four in the Condensed Workbook.....	52
Table 3.12	Take Home Quiz Chart One from Chapter Five in the Condensed Workbook.....	54
Table 3.13	Take Home Quiz Chart Two from Chapter Five in the Condensed Workbook.....	55
Table 3.14	Sample Laboratory Station Tasks from Chapter Five in the Condensed Workbook.....	56
Table 4.1	Anthropology 1 Student Majors: Further Comparison of the Summer 2009 Term to the Total.....	62

Table 4.2	Survey Response Rates by Semester.....	69
Table 5.1	Sample Lecture-based and Lab-based, Paleoanthropology Exam Questions.....	77
Table 5.2	Means and Standard Deviations for Oneway Analysis of Variance of Student Performance on Lab-based, Paleoanthropology Exam Questions by Student Performance on Lecture-based, Paleoanthropology Exam Questions (Spring 2007).....	79
Table 5.3	Sample Lower-level Thinking and Higher-level Thinking Paleoanthropology Exam Questions.....	80
Table 5.4	Means and Standard Deviations for Oneway Analysis of Variance of Student Performance on Lower-level Thinking, Lab-based Exam Questions by Student Performance on Lower-level Thinking, Lecture-based Exam Questions.....	82
Table 5.5	Sample Survey Questions and Paired Final Exam Questions.....	85
Table 5.6	Survey Questions Excluded and Included by Semester.....	86
Table 5.7	Sample Student Majors and Corresponding Learning Style Assignments.....	93
Table 5.8	Means and Standard Deviations for Oneway Analysis of Variance of Student Performance on Higher-level Thinking Survey Questions by Student Learning Style.....	98
Table 6.1	Number of Survey Participants Taught by each of the Professors during the Period Studied.....	105
Table 6.2	Number of Survey Participants Taught by each of the Graduate Student Instructors (GSI) during the Period Studied.....	105
Table 6.3	Survey Participants with Higher Survey Score Averages than Paleoanthropology Exam Question Averages.....	106

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CHAPTER ONE: INTRODUCTION

It is often assumed that anyone who is an expert in their field can successfully impart their knowledge on college students, particularly at the introductory level where much of the course material is general and/or “simplified.” However, ask any person who has taken college courses, and they will have stories of the professor whose course was boring and resulted in very little student learning, despite their expertise. This is especially the case in introductory courses where students are inexperienced in the discipline and often overwhelmed by the amount and range of content in a large survey course. If being an expert in the content and methods of a discipline is not enough to be a good instructor, then what is the key to effective teaching? With questions like this in mind, academics from many disciplines have begun taking a closer look at the pedagogy they employ.

For example, in the last ten years, anthropologists have turned their eyes toward the issue of how to effectively teach anthropology. Some of this work is broad in scope, such as that of Hamilakis (2004) who explores the larger political context of anthropology education. Others, such as Lightfoot (2009) and Walker and Saitta (2002), take a narrower perspective, focusing on a particular aspect of anthropology education—the archaeological field school. This dissertation seeks to address both the small and large scale of anthropology education. It examines the design and implementation of active and cooperative pedagogy in a specific biological anthropology course, while simultaneously examining how this type of pedagogy can usefully inform the teaching of anthropology as a whole.

The Changing Landscape of Higher Education

Over the last thirty years, there has been increasing concern over the quality of college education and how best to improve student learning. This has had a profound impact on many academic disciplines and the teaching programs they advocate. Foremost in these recent debates about educational quality is the issue of active pedagogy and its implementation in college courses. For example within the sciences, the last fifteen years have been marked by growing interest in active pedagogy as a way to engage students in science learning and develop high quality understandings of often complex and abstract concepts. Exemplifying this movement, Ashmore (2005) observes that college students often have numerous misconceptions about the nature of evolution. In an effort to address this issue, Ashmore (2005) designs and implements a K-12 active learning pedagogy that explores human evolution in a hands-on, interactive way in order to better equip students for later college-level coursework in evolution and evolutionary theory. While work along these lines seeks to avoid problems in college courses by preventing earlier mis-learning, other scientists have turned their attention to ways of dealing with and preventing poor quality learning in the college classroom itself.

For instance, Jensen and Finley (1996) contend active pedagogies result in high quality learning in biology lectures, and Paulson (1999) demonstrates the utility of active learning in organic chemistry lectures. At the same time, Michael and Modell (2003) argue in favor of active learning in college science courses, in general, as a way to improve the quality of student learning. In addition to research examining active pedagogy in science lectures, research has also been conducted highlighting the efficacy of active learning strategies in laboratory contexts specifically (e.g. Leonard 1994).

While there are differences in course format, content, and discipline-based objectives in science and anthropology classrooms, research has shown that many of the same active pedagogy approaches can be usefully applied in both disciplines. The recent trend exploring issues of pedagogy within anthropology has been far-reaching, with research conducted in the United States, United Kingdom, Australia, and South Africa (e.g. Coleman 2002, Colley 2004, Hamilakis 2004, Owen 2007). This work has taken many forms, but the majority has focused on three issues: 1. improving the relevance of what we teach and engaging students in their learning, 2. using active pedagogy in anthropology classrooms, and 3. improving the quality of critical thinking among anthropology students.

Anthropology as a discipline has inherent relevance to people because it is the study of people. However, anthropologists have recently noted that we do not always highlight this relevance for our students, leaving them feeling disconnected from course material and without a true understanding of key anthropological concepts. Even at the start of this growing research trend, Upham et al. (1988) observe that anthropology courses need to be made more overtly relevant to students' everyday lives, using realistic examples and relevant issues to explore anthropological concepts. Coleman and Simpson (1999) offer a similar suggestion as they argue in favor of anthropology coursework that bridges the apparent gap between the classroom and the world beyond the classroom. Additionally, Newman (1990) argues the issue of relevance is particularly important for non-traditional students from diverse backgrounds and with varied prior educational experiences. Identifying that anthropology courses must be made relevant to student life outside the classroom, raises concern over how best to make this shift and truly engage students in anthropology learning.

In anthropology pedagogy research, this dovetails with the issue of employing active learning pedagogy. Active learning pedagogy specifically seeks to engage students in the learning experience, and many anthropologists are now turning to this pedagogical approach as a way to improve student engagement and overall learning quality. For example, Pedelty (2001) encourages students to act-out the roles of people studied, in order to fully engage students and explore the complexities of self and other. Many archaeologists also advocate the use of interactive tasks and assignments to engage students in active learning of archaeological concepts. Exemplifying this trend, Burke and Smith (2007) provide the first edited volume to summarize active learning and outline a range of interactive tasks—including role-playing scenarios, games, and hands-on activities—for an audience of archaeology instructors. Additional active learning tasks for archaeology classrooms are also interspersed throughout the literature, such as Mazur-Stommen's (2006) employment of an exercise where students track their eating and foraging habits in order to better understand optimal foraging theory.

The final major issue in recent pedagogical research further examines how best to facilitate students' understanding of the nuances of the discipline—specifically how to help students develop important critical and reflexive thinking skills. The successful promotion of critical thinking skills has been explored in non-traditional classrooms, such as an anthropology class at a state prison (Cohen and Panich 2009) and in archaeological field school contexts (Lightfoot 2009 and Walker and Saitta 2002). In more traditional classroom contexts, work like that of Hamilakis (2004) is particularly relevant, as he advocates the use of student journals as a means of nurturing student critical and reflexive thinking practices. When taken together, these various authors explore not just how to improve the overall quality of anthropology education, in general, but specifically the quality of critical thinking skills.

This dissertation builds on these growing trends in pedagogical research in anthropology. I examine the use of active learning pedagogy as a means of effectively engaging students in the learning process and fostering the development of higher-level thinking skills, particularly in introductory biological anthropology. Biological anthropology is a subfield of anthropology with ties to the biological sciences; therefore the research presented here is grounded in themes seen in science and anthropology education research. It is also grounded in more over-arching themes seen in education and psychology research related to active learning pedagogy in general, the nature and quality of learning, and the retention of learned information. This dissertation studies a particular pedagogical device—a laboratory workbook and associated assignments for laboratory sections. However, it is broadly applicable to other introductory anthropology and science courses.

Overview of Dissertation Research

During the summer of 2005, I worked with Dr. Sabrina Agarwal to redesign the pedagogy of the undergraduate Anthropology 1: Introduction to Biological Anthropology course at the University of California, Berkeley. Specifically, I designed an active and experiential approach to the laboratory sections that are a part of this course, including a Laboratory Workbook for the course with original text, homework, laboratory assignments, and lesson plans for instructors. This workbook and its corresponding assignments draw heavily from active and cooperative pedagogies in an effort to engage students and foster high quality learning of course material, and the laboratory pedagogy is designed to particularly facilitate the development of both factual content knowledge and higher-level thinking skills. Moreover, because of the diverse educational backgrounds and learning styles represented among students in introductory biological anthropology courses, the laboratory pedagogy is designed to benefit students of multiple learning styles. This dissertation quantitatively and qualitatively evaluates the effectiveness of this pedagogy over the course of its implementation in four terms from the spring 2007 semester to the summer 2009 semester.

In order to successfully evaluate this pedagogical approach, I consider the effectiveness of the approach at multiple scales of analysis and using multiple lines of evidence. First, I examine the extent of initial student engagement with course material in the laboratory classroom. I evaluate this using observations made in laboratory sections during the implementation of the pedagogy in the summer 2009 term. These observations focus on the degree of student participation, cooperation, and demonstrated thinking beyond given in-class activities and questions. The second scale of analysis focuses on the initial learning of course content, as facilitated by the laboratory pedagogy. I consider this issue using final exam data from the semesters under study. The exam data reflects student learning at the time of being in the course and participating in the laboratory pedagogy on a regular basis. The final scale of analysis addresses student retention of learned course material. I evaluate this using a follow-up survey designed to re-test students' retention of key course content and skills well after they have completed the course. Because the survey was administered at one time to students from different terms, it provides a longitudinal perspective of student retention at three month, one year, and two year intervals. These three scales of analysis combine to address the effectiveness of the laboratory pedagogy in fostering: initial student engagement, high quality initial student learning, and high quality retention of learned information.

With these scales of analysis in mind, this dissertation seeks to answer the following primary research questions as they relate to the implementation of the laboratory pedagogy: 1.

Do students meaningfully engage with course material in the classroom? 2. Do students demonstrate initial high quality learning of key course material? 3. Do students retain their understanding of course material long after the course has ended? To further consider the issue of the pedagogy's effectiveness across multiple learning styles, the following secondary research questions are added: 1. Do all students, across various learning styles, engage with course material equally? 2. Do all students demonstrate initial high quality learning to similar degrees? 3. Do all students retain course material equally through time? Finally, in order to examine the effectiveness of the pedagogical approach in fostering the development of higher-level thinking, as well as factual knowledge, the remaining secondary research questions are also considered: 1. Do students of all learning styles demonstrate engagement with and use of high-level thinking skills in the classroom? 2. Do students of all learning styles demonstrate initial learning of high-level thinking skills? 3. Do students of all learning styles demonstrate retention of high-level thinking skills after the course's conclusion?

Implications of Research

Biological anthropology shares much in common with other closely related fields. Like many biological sciences, it is grounded in genetics and evolutionary theory, and it seeks to address questions about the evolutionary history of the human species and where we fit in a larger biological context. At the same time, biological anthropology brings an anthropological perspective to these biological issues, examining the role of culture in shaping our lineage. Finally, it includes such work as bioarchaeology, which employs many biological anthropology and osteology methods in a distinctly archaeological context. With this in mind, the pedagogical issues addressed in this dissertation are important not only to biological anthropology instruction but to the instruction of other related courses in anthropology and biology, as well.

The research presented here has the potential to impact and improve the quality of student learning in biological anthropology courses, as well as courses in other related disciplines. This work examines the utility of active and cooperative pedagogies in these contexts, including the impact of these pedagogies on both student factual knowledge and higher-level thinking skills. Moreover, this research particularly considers the utility of these pedagogies for students of multiple learning styles. The results of this work may usefully inform the application of these and similar pedagogies in introductory level courses in biological anthropology and in numerous other disciplines that also draw a broad cross-section of students.

In its evaluation of the particular pedagogical device under study here, this dissertation also explores both qualitative and quantitative approaches to the examination of student learning and pedagogical efficacy. By considering pedagogical efficacy at multiple scales of analysis and drawing from multiple lines of evidence, this work models a well-rounded assessment technique that can be applied throughout numerous academic disciplines. Thus, in addition to the theoretical implications of this work for anthropologists and biologists, there are far-reaching methodological implications that span countless disciplines.

Outline of Dissertation

The remainder of this dissertation examines the issues discussed above in greater detail. In Chapter Two, I present the theoretical framework for the research conducted. I draw from work in psychology and education in a consideration of memory and learning, in general, as well as active and cooperative pedagogies, more specifically. Discussion techniques, learning style variations, and levels of thinking and learning are also closely considered in order to adequately

frame the pedagogical concerns of the course under study. Whenever possible, recent research in college science and anthropology courses is brought into these discussions to more tightly frame the context of the dissertation research.

In Chapter Three, I provide a summary of the course under study. I describe the overall structure and pedagogy of the course. I then provide an overview of the laboratory workbook and its corresponding laboratory assignments. I pay particular attention to the paleoanthropology unit of the laboratory pedagogy. This is one of four units in the laboratory pedagogy, and it comprises the case study I specifically examine in this dissertation. I explicitly outline the paleoanthropology unit, and I discuss the similarities and differences between the semesters under investigation.

In Chapter Four, I describe the research questions and methods employed in this dissertation. I clearly delineate the multiple scales of analysis and the lines of evidence used at each scale. In-class observations of student practices and behaviors are used to assess student engagement with the learning tasks and material; student final exam performance is used to evaluate the quality of initial student learning; and a survey that re-tests student knowledge and thinking skills is used to investigate the quality of student retention of learned material. I also describe the study subject populations at each of these levels of analysis.

In Chapter Five, I report the results of data analyses at each of these three levels of research. I review the qualitative, observational data; and I use various statistical analyses to examine the quantitative data more closely.

In Chapter Six, I discuss the results and interpretations of the research. This chapter examines the research questions in light of each of three levels of analysis and corresponding data sets. It also provides summary interpretations of the research overall.

In Chapter Seven, I provide a conclusion that considers the implications of these research results for biological anthropology educators, other anthropology educators, science educators, and college educators more generally. I also offer suggestions for future research.

CHAPTER TWO: THEORY

In examining the effectiveness of any teaching approach, it is necessary to first consider what is meant by “effective teaching.” Once this is properly established, attention must then be turned to ways to measure and improve teaching quality and success. This chapter seeks to provide the framework necessary for a consideration of these issues. I begin with a look at the learning process as informed by cognitive psychology perspectives. I then turn to various teaching approaches as discussed and operationalized in both education in general and anthropology more specifically. These approaches form the foundation for the pedagogy applied in the instruction of the Anthropology 1: Introduction to Biological Anthropology laboratory sections studied in this dissertation.

Memory

In recent decades, education researchers and practitioners have increasingly turned to cognitive psychology for new perspectives on learning and how learning can be maximized through different pedagogical approaches. Specifically, the research of cognitive psychologists is used to understand the learning process, the retention of learned information, and the later application of that learned information in novel contexts. These three issues are at the heart of all educational endeavors, and thus an understanding of them must be at the heart of the most effective teaching methods.

Prior to the Cognitive Revolution in American psychology in the 1960’s, psychology in the United States was largely associationist-behavioral (Bruning 1994). That is, psychology research emphasized the learning of information through habit and reinforcement (Bruning 1994). Beginning in the 1960’s, however, psychology research shifted to a focus on meaningful learning, rather than habitual learning (Bruning 1994). With this shift in focus came a growing emphasis on the cognitive processes involved in learning, such as memory, thinking, and the individual’s construction of their knowledge (Bruning 1994). The human mind was no longer conceived of as a blank slate waiting to be written on through mere repetitive practice; rather, it was seen as a series of processes whereby the individual takes in new information, relates it to existing information, remembers it, and can apply it in new contexts in the future (Bjork 1994, Michael and Modell 2003). In this way, cognitive psychology stresses the importance of: encoding (learning), retention (remembering), and transfer (application).

Encoding

“Encoding” refers to the actual process of taking in new information, connecting it to existing information, and meaningfully storing it for later use; therefore, it will be used synonymously here with “learning.” Successful encoding, then, is achieved when an individual gains an understanding of new information and properly associates it with other related concepts and knowledge already in memory (Bjork 1994). With this in mind, cognitive psychology stresses the importance of foundational knowledge (upon which current and future encoding is based), as well as the learning process itself (making meaningful connections between existing and new knowledge). Both of these key aspects of the encoding process have been taken up by education and psychology researchers in order to develop more effective means of encouraging learning among students.

Foundational, or pre-existing knowledge, is central to the learning process because internalizing and remembering *new* information requires making connections to *existing* information in the mind. The teacher, then, should provide a learning environment in which the student can engage with the new knowledge in such a way that they are then able to link it to their old knowledge, resulting in successful encoding of the new information (McGilly 1994, Michael and Modell 2003). Creating an environment where students must articulate their understanding to others, as in cooperative or collaborative learning contexts, maximizes this linking of new and old knowledge (Michael and Modell 2003). This linking is also facilitated by multiple encodings, where the student is repeatedly expected to think about and make meaningful the same new information (Bjork 1994). Ideally, these multiple encoding events are properly spaced to reinforce the connections made (Bjork 1994, Dempster 1996) and draw on multiple modalities, such as visual, auditory, and tactile (Michael and Modell 2003).

Of course, the dependence on pre-existing knowledge in this perspective of learning creates additional challenges for the educator. If all learning is based on already learned knowledge, then current learning can only be as good as that existing base. When existing knowledge is faulty and based in misconceptions, learning new knowledge is compromised (Michael and Modell 2003). It is, therefore, the responsibility of the teacher to assess students' prior knowledge in order to help students to correct misconceptions and set appropriate learning goals (Michael and Modell 2003). Misconceptions may also arise during the learning process itself as students make faulty connections between new and old information (Michael and Modell 2003). To address this difficulty, Michael and Modell (2003) advocate using active learning approaches that allow students to test their mental models and make adjustments when those models are flawed. This process of identification and adjustment of faulty models is not possible when students are simply told they are wrong; students must be given the opportunity to work these problems out for themselves because they are responsible for constructing the model that encodes new information in their own mind (Michael and Modell 2003).

If individuals are responsible for constructing their own knowledge, linking their existing knowledge with new information, then it follows that individuals would benefit from a greater awareness of their learning process. This argument is central to cognitive psychology perspectives of learning and is referred to as "metacognition" (Brown and Atkins 1988, Bruning 1994). Metacognition can be loosely defined here as thinking about thinking. Helping students to understand their own learning and be critically aware of it through instruction in metacognition improves the encoding process (Brown and Atkins 1988, Bruning 1994), as do teaching methods that expose the learning process. Thus, through the cooperative and active learning contexts advocated by Michael and Modell (2003), students gain the opportunity to articulate their understanding to others and expose their thought processes for deeper consideration and possible critique. This consideration and critique can then lead to more corrective learning and fewer misconceptions—a generally higher quality encoding event.

In summary, learning (or encoding) is best accomplished when: individuals make successful links between their old knowledge and new information, individuals are given multiple opportunities to encode information via different lines of information input or modalities, and individuals are given the opportunity to express and question their thought processes and encoding links. Based on this, cooperative or collaborative learning in an active classroom that provides multiple, different exposures to course content is the ideal context for the most effective forms of encoding new information.

Retention

Of course, to be truly effective, learning must result not only in appropriate and meaningful encoding but also in long-term retention of encoded information. Learning is useless if what is learned is only remembered long enough to pass an exam or a test immediately following the learning event. Truly high quality learning should encode information so well in one's mind that it can be retained for long periods of time, allowing the individual to draw on the information in countless future situations. In the political climate of the United States today where teacher evaluation, earnings, and promotion are often closely linked to student test performance, there has been an unfortunate shift, particularly in K-12 education, toward preparing students for exams. This has led to rapid and superficial learning, rather than deep and long-lasting learning. In the college classroom, it is safe to say that for now at least, educators still emphasize the importance of deep and lasting learning over simple and short-lived learning. This is largely due to the fact that college courses are often designed to prepare students for professional life and/or further study in a particular discipline. In order to properly prepare students for these futures, college educators tend to give pedagogical attention to the development of generalized thinking skills and deep learning.

This emphasis on knowledge retention is dependent on the encoding issues discussed above; when encoding is weak, retention is weak and vice versa. Therefore, successful retention requires making links between old and new information in one's mind, which in turn allows for effective, long-term storage (Ausubel 1968, Christina and Bjork 1991, Michael and Modell 2003). Ausubel (1968) famously refers to this style of successful encoding as "meaningful learning." Meaningful learning is the assimilation of new knowledge into one's existing cognitive structure such that it is stable, less open to interference, and better retained (Ausubel 1968:90-92). While Ausubel's (1968) views of meaningful learning are useful for framing a consideration of the role of encoding in retention, his arguments in favor of expository teaching as a means to maximize these events flies in the face of the vast literature to the contrary.

The importance of cooperative, active classroom contexts in the improvement of encoding (and thereby retention) was noted above. Similarly, Christina and Bjork (1991) advocate involving the learner as an active participant, through such techniques as cooperative learning and peer teaching, in order to improve retention. While not directly addressing a college classroom context, the support of active pedagogical approaches put forward by Christina and Bjork (1991) certainly reinforces the parallel support for these approaches considered above. In addition to being improved via active classroom pedagogies, retention is also improved via properly spaced and designed practice or review (Christina and Bjork 1991, Dempster 1996).

Successful long-term retention of learned information is an important goal of college education, and it is improved via: effective and strong initial encoding, active classroom contexts, and appropriate practice and review.

Transfer

Just as retention of learned information is dependent on learning or encoding itself, transfer or application of information is dependent on both the learning of that information and the retention of that information until the transfer event and beyond. If as noted above one of the goals of college education is preparation for later life, then transfer of learned knowledge is a necessary component of this education. However, there exists some disagreement about what type of knowledge is most desirable for future applications.

Ausubel (1968) calls for an emphasis on theoretical knowledge in order to prepare students for transfer in future classroom contexts. In contrast, Covington (1998) advocates an emphasis on more general, practical knowledge, such as problem-solving skills, in order to prepare students for any potential future transfer event. The disagreement between these authors seems to lie in a difference between their expectations of the role of classroom learning. Ausubel (1968) seems to believe that classroom learning is meant to prepare students for further classroom learning, while Covington (1998) takes a more generalized perspective that seems to suggest classroom learning should prepare students for life. In the context of lower levels of education, Ausubel (1968) may well be right. However, I argue that in higher education the more general perspective taken by Covington (1998) is more appropriate, as not all students will continue with further coursework. With this in mind then, it seems that college classrooms should emphasize preparation for general transfer contexts that may extend beyond the classroom itself.

Christina and Bjork (1991) examine the issue of transfer as related to procedural skills in adults. This work relates well to the context of college classroom learning as it addresses preparation for various future transfer situations. Christina and Bjork (1991) argue in favor of several educational techniques to enhance later transfer that seemingly fly in the face of logical understandings of training. For example, the authors contend that interference during training improves the breadth of learning, the quality of retention, and the likelihood of later transfer (Christina and Bjork 1991). This perspective contrasts with other views that favor learning within a context that is similar to the transfer context, such as situated learning or apprenticeship. Reder and Klatzky (1994) explore this relationship between similar learning and transfer contexts further and argue that similarity between the contexts may not be appropriate for all types of learning. While identical training and performance contexts may be helpful in some situations and improve transfer, it is often impossible to fully mimic all the potential performance experiences; and variable practice may be useful to account for this (Reder and Klatzky 1994). These perspectives on variable learning contexts and their improvement of transfer in assorted future contexts is reminiscent of the advocacy of general skills development put forward by Covington (1998) and myself above in order to prepare students for a variety of potential transfer events.

Another key technique suggested to improve transfer of learned knowledge focuses on the role of practice and testing in the learning process. As in encoding, the spacing of practice or review events plays a significant role in later transfer (Bjork 1988, Dempster 1996). Presumably, this is due to the fact that review spacing impacts learning, which in turn impacts retention and future application of knowledge. In addition to practice spacing, the sequencing of practice (Bjork 1988) and information presentation (Ausubel 1968) are also factors in transfer. Again, this would seem to relate to the role of these factors in the encoding process. Of particular interest, Bjork (1988) notes that practice itself, in the form of tests or other application tasks, improves later transfer. "The act of retrieving an item from memory facilitates subsequent retrieval access to that item" (Bjork 1988:396). By retrieving stored information from memory, one is practicing the process of retrieval of that information (Bjork 1988). It would follow then that the more practice an individual has in retrieving a piece of information, the more readily they will be able to continually access that information for future transfers. Thus, any review or testing that asks for information retrieval during learning facilitates both the learning of and future application of that information.

The successful transfer of learned information to new contexts first requires successful encoding and retention of that information, so as educators we must try to maximize these learning processes in our students. Assuming that most college classrooms are trying to prepare students for diverse transfer contexts, college educators ought to also help students to develop general skills like problem-solving in varied learning contexts. Finally, we should also be aware of the key role that practice plays in learning and later transfer, and we should provide appropriate practice opportunities in order to improve learning and transfer.

Summary

The shift toward cognitive psychology approaches and their incorporation into educational theory and practice led to a reinvention of our understanding of learning. The insights offered by this field have been usefully converted to suggestions for effective teaching that improves learning, retention, and transfer of knowledge. Active learning incorporating multiple forms of exposure to course content and the development and practice of general skills is an effective approach to teaching because it serves to improve student encoding, remembrance, and application of information.

Active Learning

Having considered the learning process and briefly touched on ways to improve student learning in the classroom, I now turn to a closer examination of active learning approaches and their role in shaping effective teaching methods. It should be noted here that there are multiple terms in use that all refer to what I will generally label as an “active learning” approach. These terms include such things as: progressive education, learner-centered teaching, student-centered teaching, experiential learning, and problem-based learning. Although there are often subtle differences between these concepts, they all share a common emphasis on the active role of the learner in the learning process. While I do address some of the variation in pedagogical perspectives included in this blanket category below, I stress the overlap and similarities between these perspectives and will therefore discuss them all together as “active learning.” Thus, for my purposes here, active learning is defined generally as: a perspective of learning and/or teaching that underscores the importance of the learner’s active participation in the learning experience. The next two sections of this chapter are devoted to further consideration of particular teaching approaches that I also consider to be active learning (cooperative learning and discussion-based teaching). These approaches are treated largely in the following sections due to their specific influence on the pedagogy used in the Anthropology 1: Introduction to Biological Anthropology laboratory sections, but as will be made clear, my separate treatment of cooperative learning and discussion-based teaching in this chapter is not in any way meant to suggest that I consider them to be wholly removed from active learning.

Historical Context

As early as the 1930’s, John Dewey began calling attention to the failures of the United States educational system and called for a new, more active approach to classroom learning (Phillips and Soltis 2004). Dewey’s work influenced many educators and educational researchers, and a new “progressive education” was born (Phillips and Soltis 2004). This progressive education emphasized learning through active experience rather than the passive reception largely stressed in education at the time (Dewey 1997 [1938]). I argue that this shift, introduced to education by John Dewey, parallels the later paradigm shift in psychology from

behaviorist to cognitive approaches in that both call attention to the active involvement of the learner in the educational experience. Behaviorist approaches in psychology, particularly prior to the 1960's, emphasized learning as closely tied to extrinsic rewards and reinforcements (Brown 1994). The cognitive revolution of the 1960's marked a major paradigm shift in psychological research, as previously discussed. This cognitive revolution gave rise to new approaches to teaching and learning that emphasized learners as active constructors of their knowledge, making links between existing and new information in their minds (Brown 1994, Bruer 1994). Therefore, I contend that both the approach suggested by Dewey (1997 [1938]) and the ideas put forward by the cognitive revolution advocate active learning through their emphasis on the important role the learner plays in the learning context.

Paulo Freire (1983 [1970]), beginning in the 1970's, also called for an emphasis on the active involvement of learners, particularly learners in oppressed communities. Freire (1983 [1970]) takes issue with what he terms a "banking" approach to education, where students are seen as passive depositories waiting to be filled with information deposited by a teacher. In place of this, Freire (1983 [1970]) promotes a teaching method where teachers and students work together to create knowledge and everyone involved learns from the experience. The banking model critiqued by Freire (1983 [1970]) is remarkably similar to the traditional education system as described by Dewey (1997 [1938]), where students are passive recipients of knowledge. At the same time, Freire's (1983 [1970]) suggested solution to this problematic system bears a striking resemblance to Dewey's (1997 [1938]) "progressive education" and cognitive psychology's emphasis on individuals developing their own knowledge. All of these perspectives highlight the active involvement of students in the educational experience. The correlation between these perspectives reflects the variety of researchers and practitioners who took a growing interest in the development and implementation of active learning in the twentieth century.

During this time, undergraduate education also underwent a similar paradigm shift. Barr and Tagg (1995) refer to this transition as a shift from an "Instruction Paradigm" to a "Learning Paradigm." In the past, colleges primarily focused on instructing students by transmitting chunks of information from teachers to students (Barr and Tagg 1995). Under this instruction paradigm, emphasis was placed on the teacher in the educational experience (Barr and Tagg 1995). In more recent years, many colleges are shifting away from this to a learning paradigm, where the focus is on creating learning environments where students actively construct their knowledge (Barr and Tagg 1995). Under this learning paradigm, emphasis is placed on the student in the educational experience (Barr and Tagg 1995). This change in undergraduate education illustrates the mounting influence of active learning perspectives and cognitive psychology on all levels of education.

Goals of Active Learning

The primary goal of an active learning approach is to engage learners in the educational experience. This can be done largely through creating the appropriate classroom tasks and learning environment (Dewey 1997 [1938], Weimer 2002). Classroom activities should be experiential, involving the students in actions and processes that help them construct knowledge (Dewey 1997 [1938]). One of the main ways this is accomplished is through the use of various problem-solving activities, such as those advocated for science classrooms by Michael and Modell (2003). These authors suggest a range of activities in science lecture, discussion, and laboratory contexts that involve learners in thinking about and physically doing science (Michael

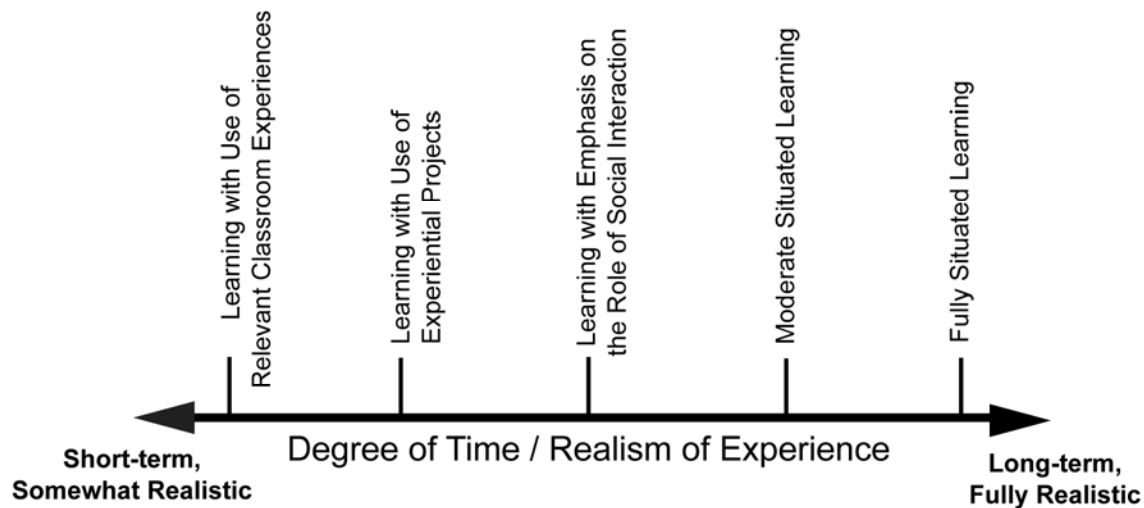
and Modell 2003). Of course, in order to be truly effective, classroom experiences should not be abstract but relevant to real life situations instead (Dewey 1997 [1938]). Michael and Modell (2003) bear this in mind when suggesting science activities where students act the role of the actual scientist, constructing and implementing research rather than simply following cookbook-like laboratory assignments. By working through relevant problem-solving activities, students engage with course material, develop general skills that will help them in later life (Covington 1998), and recognize connections between sometimes abstract course content and the real world thereby increasing student interest in the course (Farrar 1990).

Creating classroom activities is only part of the active learning approach; another significant factor to be taken into consideration is creating the appropriate classroom environment for student involvement in learning (for more on this, see Michael and Modell 2003). Unlike in non-active classrooms, where teachers are often authoritarian and control all aspects of learning, active classrooms require a shift in the balance between student and teacher, such that both are involved in learning (Clouston 2005, Dewey 1997 [1938], Freire 1983 [1970], Michael and Modell 2003, Weimer 2002). The teacher is no longer responsible for disseminating information to be absorbed by student sponges. Rather, the teacher is the facilitator, guiding and helping students through their own construction of knowledge (Clouston 2005, Michael and Modell 2003, Weimer 2002). Adjusting to this role may be challenging for teachers, and it requires a great deal of patience and the flexibility to respond to unexpected classroom events (Weimer 2002). However, it is necessary for educators to make this shift if we are trying to effectively implement active learning and help students construct their knowledge.

The Active Learning Continuum

As noted previously, active learning takes a variety of forms. For the purposes of this work, it is not necessary to clearly delineate the nuances of each type. Rather, I outline some of the major trends in active learning in order to better conceptualize the pedagogical approach implemented in the Anthropology 1: Introduction to Biological Anthropology laboratory design. I perceive the various forms of active learning as distributed along a continuum (See Figure 2.1). On one end of this continuum, I place types of active learning that emphasize the engagement of students in short-term, relevant classroom experiences. On the other end of the continuum, I place types of active learning where learners are fully situated in real life experience for extended periods of time, as in apprenticeship. On the surface, this continuum may seem like a ranking of the simplest active learning methods to the more complex; however this is not my intention. In determining the placement of a method on the continuum, I primarily consider the length of time spent on the task and the degree of realistic experience involved in the method; but these same methods could easily be categorized using other elements and result in a different continuum. At the same time, I have purposefully conceived of this as a continuum in order to highlight the overlap between the methods and the likelihood that in any one classroom, multiple methods may be brought to bear at once.

Figure 2.1
The Active Learning Continuum



Turning to one end of the continuum, we find methods that emphasize student engagement in realistic, short-term tasks. An example of this is the work of Dewey (1997 [1938]) who advocates engaging students in experiences that are agreeable and are relevant to student life outside school. Another active learning method along these lines is put forward by Leonard (1994) who argues in favor of unstructuring college laboratory assignments, such that students are given a problem and set of supplies with which they carry out their own experiment. In doing this, students become more involved in designing and implementing experiments and gain greater understanding of the material, as well as a greater range of real scientific skills (Leonard 1994). Similarly, Caulkins et al. (1999) favor the use of student-initiated research design and implementation using ethnographic databases as a way to engage college anthropology undergraduates and help them to develop the skills used by real anthropologists, such as research question development, data collection, and analysis of ethnographic data. I also place Freire's (1983 [1970]) work on this end of the continuum. For Freire (1983 [1970]), the purpose of education should be to help learners recognize their situations in life and equip them to make a change if they desire. Thus, education should be centered on the concerns of the students and issues that are relevant to the students' lives, as determined through extensive dialogue between instructors and students (Freire 1983 [1970]). This clearly coincides with the emphasis on relevancy addressed by the other authors in this part of the continuum. In addition, Freire's (1983 [1970]) actual methods for implementing his approach lie largely in problem-posing and the development of critical thinking skills. For example, Freire (1983 [1970]:117-118) suggests an instructor could ask students to identify a theme important to them, such as nationalism; and the instructor could then formulate a problem for further consideration, such as

a series of questions related to the significance of nationalism. This problem-posing approach parallels the methods discussed by authors at this point in the continuum.

The next section of the continuum is devoted to methods that use longer-term experiential projects and/or more realistic activities, such as role-playing. Here, I place classroom activities like those referred to as “serious games” by Covington (1998). These games engage students in realistic problems, develop important general skills, and are based in experience, much like the activities discussed in the previous part of the continuum. What sets these games apart is that, like the “global gambit” game presented by Covington (1998), they are often longer-term projects, spanning multiple class meetings, an entire semester, or an entire year. While serious games often involve longer-term student engagement, the incorporation of performance in the active classroom involves more realistic engagements through embodiment and role playing. Pedelty (2001) advocates just this sort of active methodology in college anthropology classrooms in order to maximize student involvement as well as cultural sensitivity. By physically acting out and playing the role of “the other,” students embody and understand this concept more than they would simply through reading and abstract thinking alone (Pedelty 2001).

The middle of the continuum is devoted to active methods that show an increasing interest in the role of social interaction in learning. Social interaction is central to everyday human experiences, and by emphasizing the importance of social interaction in instructional contexts, the methods in the middle of the continuum incorporate even more realism in learning experiences than those methods previously discussed. While they do not explicitly discuss active learning, Newman et al. (1989) do implicitly advocate an active learning approach that emphasizes the importance of social interaction. The authors draw on cognitive psychology and Vygotsky’s (1978 [1935]) “zone of proximal development” to highlight the necessity for improved social interaction in the classroom, as it mirrors real life and maximizes learning by allowing learners to interact with and seek guidance from more experienced people (Newman et al. 1989). Others, like Bruer (1994) also argue that we must consider the importance of social or cultural variables in learning, such as social interaction. However, Bruer (1994) also warns that this cannot be done at the expense of considering any biological and evolutionary bases; the social and biological must both be taken into account.

The remainder of the continuum holds the methods that place even greater emphasis on the importance on the social aspects of learning. As such, these methods involve long-term, highly realistic experiences. At the far end of the continuum, I place fully “situated learning” in the style of Lave and Wenger (1991). Between the continuum’s middle (with an initial interest in the social) and the continuum’s end (with a primary emphasis on the social), I locate what I will call “moderate situated learning.” Moderate situated learning methods may or may not be explicitly identified as situated learning by their authors, but they draw from situated learning literature and emphasize the importance of social interaction more than authors such as Newman et al. (1989) and slightly less than authors such as Lave and Wenger (1991). The ideal example of moderate situated learning is found in the method that works with “communities of learners” (Brown 1994, Brown and Campione 1994, Campione 2007). This work draws explicitly from situated learning literature to frame the communities of learners approach, and it places great emphasis on the importance of social interactions and relationships in learning (Brown 1994, Brown and Campione 1994, Campione 2007). Students in a class choose a topic that they will explore as a group; they form a community of learners with their classmates, perhaps students from other classes, the teacher/s, and outside experts on the topic; and they use their community of learners to explore and formulate a project based in the topic (Brown 1994, Brown and

Campione 1994, Campione 2007). This method brings people with varying levels of knowledge on the topic together, from novice students to expert outsiders, so that they can all learn from each other through their active social interactions (Brown 1994, Brown and Campione 1994, Campione 2007).

Following moderate situated learning on the continuum is what I refer to as “fully situated learning,” such as the work of Lave and Wenger (1991). These methods often require long-term experiences and are the most realistic in nature. Situated learning, as proposed by Lave and Wenger (1991), is a method that advocates learning within a “community of practice,” such that novices are legitimate participators in learning, although their participation may be more on the periphery than that of experts. Classic examples of situated learning can be found in apprenticeship contexts, where novices learn by doing tasks and being with experts (Lave and Wenger 1991). From the situated learning perspective, learning and social interaction are tightly interwoven; they are not and should not be separated from one another (Lave and Wenger 1991). This method emphasizes social interaction more than any other method discussed here; it requires that learners interact with experts in fully realistic contexts for extended periods of time. Because of this, it is located at the end of the continuum representing the highest degree of realism and time commitment found among the active learning methods.

Active learning methods vary greatly, but I have provided a brief overview of these methods as distributed along a continuum differentiated by the degree of realism and time investment advocated by the method. This continuum ranges from the use of short-term, relevant problems and experiences in the classroom to long-term, full immersion in the social learning experience. Understanding this range of approaches provides a framework for the continuing discussion of active learning in general and its utility for the Anthropology 1: Introduction to Biological Anthropology laboratory pedagogy, specifically.

Critiques of Active Learning

When considering active learning in general, many concerns have been raised about its application and use. Ausubel (1968) takes particular issue with how what he calls “progressive education” results in an overemphasis on student creativity without appropriate guidance and interference from the teacher. Other authors also note potential worries surrounding the teacher’s sharing some control with students in active learning (e.g. Coleman 2002, Weimer 2002). However, Ausubel (1968) seems to assume that all active learning classrooms are full of students running wild without any sort of teacher involvement. Of course, as was previously discussed, the teacher’s role does change with active learning; but the role is not eliminated. The teacher is not an authoritarian figure, but the teacher is expected to be involved in the learning process, helping students construct their own knowledge and understanding.

Ausubel (1968) also suggests that students learn more through expository teaching (lecturing) than they do through active methods. While it is generally recognized that active learning may mean a loss of some course content in exchange for the increased time spent on classroom activities, it is also generally recognized that this results in a re-focused and streamlined course with the best possible quality of learning (Covington 1998, Paulson 1999, Weimer 2002). Certainly, if we want to emphasize the *quantity* of learning, Ausubel (1968) may be justified in his critique. However, if one chooses to emphasize the *quality* of learning, active methods are indeed quite appropriate because they encourage deep understandings and retention of key concepts. As Paulson (1999:1139) writes, “I would much prefer my students to have a

good grasp of fewer topics than to have been deluged with information they will not remember six months later.”

Finally, it has been suggested that students initially resist active learning because they find it to be too challenging or too different from their prior classroom experiences (Huntington 2005, Weimer 2002). This problem is often avoidable, however, if time is spent at the beginning of an active learning course discussing the reasons for using this approach, the expectations of the teacher, and the expectations of the students (Huntington 2005, Weimer 2002).

While there are certainly some concerns with active learning in general, fully situated learning, specifically, is subject to even further critique. The fully situated approach to learning emphasizes the importance of social interaction more so than any other method on the continuum. This may be a factor in why there are potential problems with this approach that are not necessarily found in the other active methods discussed here. Most importantly Lave and Wenger (1991) take a very negative stance on classroom learning, and although they suggest that their approach could be usefully applied in a classroom context, they do not provide any realistic ways of doing so. This may, in part, be why when researchers apply situated learning to classroom contexts, they do so using a more moderate form of the method (as was noted in the active learning continuum above). Certainly, in a classroom, particularly one at the introductory undergraduate level, there are real limits to the use of the situated learning approach. We often do not have the class time to devote to an immersive, apprentice-based system of learning. We may be teaching material that is not conducive to the apprentice-style learning of skills and practices, and as Reder and Klatzky (1994) point out situated learning may not be appropriate for every learning environment. There are also potential problems with the learning context advocated under situated learning. Lave and Wenger (1991) suggest that situated learning should take place in the real context where the skills learned are also practiced, as in apprenticeship. However, as was previously discussed and as Bjork (1994) notes, introducing some difficulties and interference during learning improves learning. Thus, it may be better for some learning to go beyond the real context and involve added difficulties (Bjork 1994).

Benefits of Active Learning

Despite the above critiques, both of active learning in general and situated learning in particular, the use of these approaches has a significant impact on improving the quality of learning. Active learning improves student self-confidence and motivation (Weimer 2002). Under active approaches, students are not treated as passive recipients of information, but rather as active participants in the learning process. This gives students greater control over the learning experience and improves student motivation and student-teacher relationships (Covington 1997, 1998, Pintrich 1994, Weimer 2002). It naturally follows that the more motivated a student is, the more time they devote to classroom tasks, improving the quality of learning (Weimer 2002). At the same time, the more students participate in and benefit from active learning experiences, the greater self-confidence they build and the more motivated they are to continue in similar high-quality learning endeavors (Covington 1998). Active learning creates a cycle where student control facilitates motivation, which facilitates quality learning, which facilitates self-confidence, which facilitates further interest in learning (Covington 1998). The learning itself becomes a reward (Covington 1998). There is some concern about the best way to reward students such that they continue their interest in learning, rather than an interest in getting rewards (Covington 1998). However, many researchers agree that when rewards are appropriate, like the intrinsic rewards inherent in achieving your own learning success, they do

serve to improve both motivation and interest in further learning (Covington 1997, 1998, Feltz 1994).

In addition to improving student self-confidence, motivation, and interest in further learning, active approaches also encourage student engagement with course material. Student engagement can be encouraged in a number of ways, such as through the choosing of a topic that captures the imagination of students (e.g. Murad 1988). What sets active learning apart is that it engages students in *every* step of the learning process; the learner is the key to learning. In all of the active approaches on the continuum discussed previously, students are involved in learning through tasks and experiences that are relevant to the students' lives and therefore encourage greater participation. These engaging and inherently interesting assignments improve student motivation and learning quality (Covington 1998, Covington and Wiedenhaupt 1997, Smith and Burke 2007). The more interested a student is and the more involved they are in the learning process, the more motivated they are and the better the learning outcomes (Pintrich 1994, Weimer 2002).

I believe the central goals of education are to: improve the quality of knowledge, prepare students for their futures, and help students to develop a lifelong interest in learning. All of these things will help students in their lives, whether in further academic pursuits or not, by preparing them with a strong knowledge base, relevant skill set, and attraction to continued learning experiences. If these are the criteria upon which we are to judge the effectiveness of a particular pedagogical approach, then active learning meets all of the requirements. Active approaches effectively engage students in relevant tasks and give students greater control of learning, which improves student self-confidence, motivation, interest in learning, and quality of learning.

Applications of Active Learning in College Classrooms

Before turning to a closer examination of cooperative pedagogical approaches, I would like to briefly review some of the ways in which active learning methods have been usefully applied in college classroom contexts. Because the field of biological anthropology bridges the biological sciences and anthropology, I will consider the use of active learning in both types of courses. This will serve to contextualize the use of active pedagogy techniques in the Anthropology 1 course studied here.

Most applications of active pedagogy in college science courses fall near the end of the active learning continuum that emphasizes engaging students in somewhat short-term but relevant experiences in the classroom. Paulson (1999) notes that the incorporation of active learning techniques and discussions in college organic chemistry lectures results in greater student enjoyment of the subject, student participation, and student learning. Michael and Modell (2003) take this one step further noting similar benefits in their analysis of the use of active learning in science lectures, discussions sections, and laboratories. Of particular interest for my purposes, Jensen and Finley (1996) test the effectiveness of different teaching strategies in altering student misconceptions of evolution. The central underlying theme in introductory biological anthropology courses is evolution, and in my experience it is one of the hardest concepts for students to grasp, in part because they have faulty understandings of evolution before ever entering the classroom. If, as cognitive psychology suggests, learning is about linking new information to old in one's mind, then having faulty pre-existing information is a huge detriment to successful learning. Thus, it may be important to consider how we might effectively impact the learning experience in evolutionary science classrooms to correct faulty misconceptions and guide our students to strong knowledge building and learning. In their study

of different teaching methods in an evolutionary science classroom, Jensen and Finley (1996) seek to determine how best to bring about this desired correction of misconceptions and successful learning. The authors find that an approach based in problem-solving yields more successful outcomes than a traditional expository approach (Jensen and Finley 1996). Together with the work of Paulson (1999) and Michael and Modell (2003), the work of Jensen and Finley (1996) demonstrates the effectiveness of active approaches in improving student interest, engagement, and learning in college science classrooms.

Recently, in an effort to foster higher quality learning, retention, and later transfer of knowledge, anthropology instructors have also taken a growing interest in the use of active pedagogy in their college courses (Smith and Burke 2007). Most of these efforts also lie with the above science classroom methods at the short-term, experiential learning end of the continuum. For example, Mazur-Stommen (2006) uses a student-centered activity to help anthropology students understand complex optimal foraging concepts. Students track their own subsistence practices for one week and then analyze it using the optimal foraging model (Mazur-Stommen 2006). This application of active methods helps students to better understand and learn an often challenging concept because they are engaging with it personally through their lived experiences (Mazur-Stommen 2006). Similarly, Owen (2007), working with anthropology students in South Africa, uses a series of “township walk” assignments where students visit nearby neighborhoods and make observations using an anthropological perspective. In doing this, the students are actively engaged with real people and doing real anthropology, which helps the students to learn better and gain a richer appreciation for cultural diversity (Owen 2007).

Some of the uses of active learning in anthropology are situated a little further along the continuum, somewhere between the basic experiential learning and the more in-depth experiential learning. These applications often simulate actual long-term anthropological research endeavors. Caulkins et al. (1999) advocate active learning in anthropology through the use of ethnographic databases for student-led anthropological research projects. Students choose a topic, develop research questions, use the ethnographic databases to find evidence, and report their findings (Caulkins et al. 1999). In this way, students are actively engaged not just in a single, short, active task; they are actually pursuing a course-long research program that suits their interests and immerses them in anthropological data and research techniques. Similarly, Spindler and Spindler (1990), argue in favor of the use of case studies for inductive, active learning in anthropology courses. Students actively engage with case studies, personally tackling the nuances of data and interpretation, which helps them develop a deeper understanding not only of the specific case but of anthropological research in general (Spindler and Spindler 1990). These two approaches involve in-depth classwork that places students in realistic scenarios like those of actual anthropologists, and they result in high student engagement and quality learning (Caulkins et al. 1999, Spindler and Spindler 1990).

The remaining applications of active learning in anthropology courses lie soundly in the second area of the continuum devoted to truly in-depth, experiential learning. These applications largely focus on internships and field experiences. Moore (2001) highlights the various forms of internship and service learning available for college anthropology students. In all forms, the students benefit from applying skills and concepts in real settings and developing a critical and reflective outlook (Moore 2001). Field schools, where students participate in on-going field research as part of a larger student and expert team, are also a key form of active learning used in anthropology, particularly archaeology. Archaeological field schools help students to learn archaeological skills and develop an understanding of ethical practices by engaging students in

the actual practice of archaeology (Lightfoot 2009, Walker and Saitta 2002). Field schools negotiate a delicate balance between full, immersive (and perhaps situated) learning on the one hand and the practical limitations of college instruction (time, expense, and grading) on the other (see Lightfoot 2009 for more on the expense of field schools). In fact, they are perhaps the most feasible form of situated learning for college level instruction. Whether conceived of as situated learning or not, field schools are active learning contexts that foster high quality learning through in-depth experiences.

Summary

Beginning in the early 1900's, and after receiving further support following the cognitive revolution of the 1960's, active learning approaches have become increasingly popular and widely applied. Though these approaches vary considerably, they can be usefully conceived of as distributed along a continuum based on the type of activities they advocate. All of the active learning methods share the goal of engaging students in the actual experience of learning, fostering both student interest and quality learning. Though some critiques have been voiced regarding the actual implementation of these approaches, they have been very effectively applied in a variety of contexts, including college science and anthropology courses similar to the Anthropology 1 course examined here.

Cooperative Learning

Because cooperative pedagogy is a subsidiary of active pedagogy, all of the issues discussed above relating to the effectiveness of active approaches in general are also applicable to a cooperative pedagogy. However, I give these cooperative approaches particular attention in this section in order to highlight their unique benefits for the course examined in this study. It should be noted at the outset that cooperative learning is another cumbersome term that includes numerous approaches and is often not clearly defined. Specifically, it is often conflated with collaborative learning, due to the close relationship between these pedagogies.

Where cooperative learning emphasizes the importance of students working together, collaborative learning takes this one step further to emphasize learning environments where students work together on tasks that they could not complete on their own (Michael and Modell 2003). Thus, I metaphorically conceive of cooperative learning as a quilt composed of a patchwork of learning and teaching techniques, including collaborative learning. With this in mind, I will now discuss cooperative learning more generally, and I will specifically note when I am talking about collaborative approaches in particular.

Historical Context

Cooperative learning, like active learning, has a long history beginning in the late 1800's and early 1900's (Gillies and Ashman 2003, Jacobs et al. 2002, Johnson et al. 1991); and both approaches are rooted in the early work of John Dewey at this time (Gillies and Ashman 2003). As was previously discussed, Dewey (1997 [1938]) draws attention to the need for educational techniques that engage students in dynamic learning processes. This emphasis on the interactive nature of learning set the stage for researchers and practitioners to explore the effectiveness of cooperative classroom methods (Gillies and Ashman 2003). From the 1930's through the early 1950's, research along these lines demonstrated the benefits of cooperation, rather than competition, in learning contexts (Gillies and Ashman 2003). However, this work petered out in the 1950's and was not recommenced until the 1970's (Gillies and Ashman 2003, Jacobs et al.

2002). At the time of this rejuvenated interest in cooperative learning, researchers stressed the benefits of peer tutoring and learning over individual learning (Gillies and Ashman 2003). More recent research in cooperative learning, like recent work in active learning in general, examines the importance of social interaction in learning—a cornerstone of cooperative pedagogy (Gillies and Ashman 2003). Throughout this history of research and practice in cooperative learning, it has been demonstrated that cooperative pedagogy promotes higher-level thinking and quality of learning, as well as improved social behavior among students (Gillies and Ashman 2003, Johnson et al. 1991).

Goals and Benefits of Cooperative Learning

Like with active approaches in general, cooperative learning's primary goal is to engage students in the learning process in order to foster higher quality learning. Cooperative learning is often contrasted with competitive and/or individual learning approaches. In a competitive classroom, students are pitted against one another for a limited amount of rewards (such as high grades) (Covington 1997, 1998, Johnson et al. 1991). These classrooms lead to negative feelings among students, such as the celebration of other students' failures (Johnson et al. 1991). In an individualistic classroom, students are evaluated based on individual performance, ignoring other students and focusing largely on their own self-interests (Johnson et al. 1991). Although it is suggested that both of these classroom situations may be appropriate in some circumstances (Jacobs et al. 2002, Johnson et al. 1991), this is certainly a debated point of view (see Covington 1997, 1998 for more).

Whereas competitive classrooms emphasize extrinsic rewards, cooperative contexts allow for greater intrinsic rewards through shared pride in achievements and increased interest and engagement in course material (Millis and Cottell 2003). Students work together, sharing their perspectives and teaching each other (Michael and Modell 2003). This involvement of the students as true participators in the learning experience allows students to feel more empowered in their own knowledge building (Ventimiglia 1995). As was noted previously with active approaches in general, higher degrees of student engagement and empowerment in the cooperative classroom relate to improved student motivation and interest in learning (Jacobs et al. 2002).

With increased student motivation and interest, we also see increased learning quality. Cooperative techniques, in part due to their improvement of student motivation and in part due to their ability to address complex topics effectively, result in higher quality learning, particularly higher-level thinking skills and improved understanding of abstract concepts (Brown and Atkins 1988, Cohen 1986, Cooper 1995, Jacobs et al. 2002, Johnson et al. 1991, Lotan and Whitcomb 1998). By working in cooperative groups, students are asked to share opinions, discuss alternatives, and often reach consensus; thus cooperative methods foster critical thinking skills and allow students to help each other better understand abstract concepts (Brown and Atkins 1988, Cohen 1986, Cooper 1995, Jacobs et al. 2002, Johnson et al. 1991, Lotan and Whitcomb 1998). This sharing and discussion of alternate ideas also encourages important social skills, such as effective communication (Brown and Atkins 1988, Johnson et al. 1991, Lotan and Whitcomb 1998, Ventimiglia 1995). These skills are important for students' academic performance in further levels of education; and as Covington (1998) notes, these skills are also important for students' lives outside of the classroom, particularly in a world that increasingly requires cooperation in any number of workplaces. Finally, by promoting thoughtful consideration of others' viewpoints and opinions, cooperative learning facilitates acceptance of

diversity in and outside the classroom (Cohen 1986, Jacobs et al. 2002, Lotan and Whitcomb 1998). This is especially beneficial to women and minority students (Cooper 1995) and to low-achieving students (Shachar 2003), whose perspectives and needs are often overlooked in the traditional, non-cooperative classroom and beyond.

Cooperative classrooms are clearly very unlike competitive or individualistic contexts, and they therefore require significant modifications to learning environments and classroom tasks, as was seen with active learning classes, in general. The learning environment must foster every student's participation in the tasks. As with other active learning contexts, this requires teachers to delegate some responsibility to students; students must take responsibility for their own learning through participation in the learning process (Cohen 1986, Lotan and Whitcomb 1998). This does not mean that the teacher has no responsibility or authority in the classroom; it is merely a sharing of these things with actively participating students. In fact, as will be demonstrated shortly, the teacher still plays a significant role in designing and implementing classroom tasks and fostering positive group experiences. In addition to an environment where students take on responsibility for learning, cooperative strategies require an environment where students engage in face-to-face interactions with one another on a regular basis (Johnson et al. 1991). This allows students to support one another through discussions of concepts and tasks, and it requires the teacher to create an environment conducive to this through appropriate seating arrangements and assignment timing (Brown and Atkins 1988, Johnson et al. 1991, Michael and Modell 2003). Finally, the teacher must create an environment that emphasizes "positive interdependence," linking students in fruitful, interdependent relationships (Johnson et al. 1991).

Creating an interdependent classroom largely rests in task assignment and management. Teachers must develop assignments that require participation from every group member, and they should assign roles to each member to guarantee that everyone participates (Johnson et al. 1991, Lotan and Whitcomb 1998). The teachers should also create the learning groups in order to successfully balance ability levels and skills across groups (Cohen 1986, Johnson et al. 1991). Finally, teachers should make sure that there is individual accountability for cooperative tasks (through individual evaluation and grading), thereby promoting each student's involvement and preventing one student from doing more work than another under the radar (Johnson et al. 1991). By doing these things, teachers assure that all students are working together in a mutually beneficial and interdependent way.

It should not be assumed, however, that by simply assigning a cooperative task that meets these requirements, students will be capable of successfully working together in cooperative groups (Cohen 1986, Johnson et al. 1991, Samuelson 1995). One of the benefits of cooperative learning is that it helps to build cooperative social skills useful in life outside the classroom (Covington 1998), but these skills must be taught. In order for cooperative assignments to be successful, cooperative skills of communication, conflict management, and decision-making should be taught from the beginning; and trust should be established through group-building activities (Cohen 1986, Jacobs et al. 2002, Johnson et al. 1991, Lotan and Whitcomb 1998, Lyman 1995). These skills are then fostered through the cooperative tasks, and they should be reinforced afterward through group-processing tasks where students evaluate their own cooperative relationships (Johnson et al. 1991). All of these adjustments to the learning environment, task design, and task implementation maximize the achievements of cooperative learning techniques, such that students develop higher quality understandings of course material and beneficial social skills.

Critiques of Cooperative Learning

Cooperative learning has received criticism largely in reaction to concern over the potential sacrifice of content and the high time demands associated with this approach. Many authors take issue with the potential loss of course content in a cooperative learning classroom (Davis 1993, Millis and Cottell 1998, Paulson 1999, Ventimiglia 1995). The argument is that so much time is spent doing cooperative activities that the coverage of some content is sacrificed in exchange. This is particularly problematic in introductory courses where it is necessary to cover large amounts of foundational information (Millis and Cottell 1998). However, many of these same authors note that while some content may be lost, the content that *is* covered is addressed in a more intensive and interactive way leading to more in-depth understandings among students and higher quality learning (Davis 1993, Millis and Cottell 1998, Paulson 1999, Ventimiglia 1995).

Issues of time commitment and additional planning difficulty for the teacher are closely related to critiques of content coverage in cooperative contexts. The design and implementation of cooperative tasks is often time consuming and requires a substantial commitment on the part of the instructor (Lotan and Whitcomb 1998, Millis and Cottell 1998, Ventimiglia 1995). Certainly, the use of cooperative activities in the classroom is time consuming and, as discussed above, may result in a loss of some content. Again, however, this time commitment results in great benefits for the quality of student learning (Millis and Cottell 1998, Ventimiglia 1995). The issue of time spent in preparing cooperative tasks can be easily ameliorated by starting out small, incorporating some cooperative tasks to an existing course gradually (Jacobs et al. 2002, Millis and Cottell 1998) and asking other like-minded instructors for support and guidance (Lotan and Whitcomb 1998).

In addition to concerns about course content and time management raised in response to cooperative approaches, there is concern regarding the ability of students to work well in groups. Students may not have the necessary skills, or they may participate unequally in cooperative tasks (Cohen 1986, Davis 1993). These, too, are potential difficulties that can readily be avoided. By clearly outlining and teaching expected cooperative behaviors and promoting high levels of participation from all group members, teachers can prevent inappropriate or low levels of student engagement in cooperative tasks (Cohen 1986, Davis 1993).

A final critique of cooperative pedagogy argues that students, parents, and other faculty may resist cooperative learning and make it challenging, if not impossible, to use this approach effectively in the classroom. People may perceive cooperative tasks as too easy and believe the tasks result in low levels of actual learning (Millis and Cottell 1998). Similarly, students may not like group tasks, preferring the competitive or individual instruction that is more familiar (Davis 1993, Millis and Cottell 1998, Owen 2007). The biggest concern with these negative opinions is that they may undermine an instructor's use of cooperative methods in the classroom (Lotan and Whitcomb 1998). However, as with the other critiques discussed above, these concerns can be avoided through proper planning and discussion. Cooperative tasks should be designed to be relevant to students' lives in order to avoid problems with student interest, and tasks should be challenging in order to promote high quality instruction (Millis and Cottell 1998). If students, parents, and/or fellow instructors are concerned about the effectiveness of a cooperative approach, the teacher should openly discuss the benefits and reasons for using the approach in the course (Davis 1993, Lotan and Whitcomb 1998). As with active learning approaches, critiques of cooperative pedagogy can also be addressed through careful planning

and implementation of the technique. At the same time, the benefits of a cooperative approach for quality of learning outweigh some of the potential problems with content coverage.

Applications of Cooperative Learning Techniques

While some authors suggest that cooperative approaches are not often used in higher education (Cooper 1995, Michaelsen 1994), others argue these approaches are gaining ground in college courses (Millis and Cottell 1998). Here I will trace some of these college level applications of cooperative pedagogy. Cooperative learning techniques are applicable in all college classroom contexts, including lectures, discussion sections, and laboratory sections. Thus, the techniques used vary considerably depending on the context.

Many proponents of cooperative learning in college recognize that lectures are a valuable element of college courses, but argue that cooperative assignments should be used in conjunction with lectures in order to promote deeper understanding among students (Millis et al. 1995, Paulson 1999). This can be easily done by incorporating such activities as jigsaw, roundtable, think-pair-share, and small group discussions or problem-solving into a lecture context (Henderson and Nash 2007, Michaelsen 1994, Millis and Cottell 1998, Millis et al. 1995, Paulson 1999). Cooperative tasks are readily incorporated as “bookend” activities prior to and following a topic in lecture or interspersed throughout a lecture (Johnson et al. 1991). One useful technique in these contexts is pairing students to discuss an aspect of the lecture for a few minutes, allowing them to work out any confusion and properly synthesize what is presented (Johnson et al. 1991). This discussion pair technique is very similar to another cooperative technique known as “think-pair-share,” which is appropriate to both lectures and discussion sections (Jacobs et al. 2002, Millis et al. 1995). This technique asks student to think individually about a question or topic, discuss their thoughts with a student partner, and then share those thoughts with another pair group or the class as a whole (Jacobs et al. 2002, Millis et al. 1995). In these techniques, students work together to formulate thoughts about course material. Thus, rather than passively absorbing presented information, students actively engage with course content. They do so in a cooperative nature, benefiting from the insights and potentially alternate perspectives of other students.

For example, in organic chemistry lectures, Paulson (1999) finds it helpful to assign problems for small groups to consider before engaging in a whole class discussion. Similarly, Owen (2007) notes cooperative tasks are helpful for reading, learning, and discussing anthropology course content. Cooperative assignments encourage student self-reflection and consideration of alternate perspectives—both of which are key aspects of anthropological training (Owen 2007).

In discussion sections, cooperative techniques such as roundtables (a version of brainstorming) or jigsaw tasks are particularly appropriate (Jacobs et al. 2002, Johnson et al. 1991, Millis et al. 1995). Roundtables help stimulate ideas for further discussion; they engage all students; and they expose students to alternate viewpoints for consideration (Millis et al. 1995). Jigsaw tasks are so named because they are tasks that are broken into pieces such that each student becomes responsible for some part of the whole—they are given a piece of the jigsaw puzzle (Jacobs et al. 2002, Johnson et al. 1991, Millis et al. 1995). This technique is particularly helpful in fostering interdependence because it requires each student to contribute their jigsaw “piece” in order to solve the whole “puzzle” (Jacobs et al. 2002, Johnson et al. 1991, Millis et al. 1995). Other cooperative tasks like group problem-solving, peer-editing, reading pairs, and

study groups are also appropriate for discussion contexts in order to provide structure to complex discussion topics and maximize student learning (Brown and Atkins 1988, Johnson et al. 1991).

In addition to small, cooperative tasks in lecture or discussion section, college courses also often employ cooperative learning in laboratory contexts (Johnson et al. 1991). Though, in the past, laboratory classes largely emphasized student observations of demonstrated laboratory experiments, laboratory classes today increasingly call for students to work in laboratory groups or pairs to complete laboratory tasks or stations (Brown and Atkins 1988, Cohen 1986, Johnson et al. 1991). In fact, having students work in small laboratory groups or pairs is “one of the most common ways to involve students actively in learning” (Johnson et al. 1991:77).

Cooperation on these laboratory tasks often varies a bit from other forms of cooperative tasks. For example, it may not be appropriate to assign individual roles to students in these types of cooperative groups (Johnson et al. 1991). Despite variations of this nature, cooperation on laboratory activities, like cooperation in lecture and discussion section, can be useful in building in-depth understandings of course content. Ashmore (2005) notes great success with cooperative laboratory groups in helping learners to understand complex issues of human origins and diversity, even among middle school students.

Ventimiglia (1995) suggests simple cooperative tasks (like those discussed above) are well-suited to introductory courses, but more advanced courses allow for more complicated and increasingly collaborative class assignments. Samuelson (1995) advocates similar extensions of cooperative tasks into “group investigation” projects when appropriate. Selecting one of several optional topics, students work in groups to research and develop a report on the topic (Samuelson 1995). This is a more involved and longer-term cooperative task than the forms usually inserted into lecture, discussion sections, or laboratory sections; and it requires clear guidance and support from the instructor (Samuelson 1995).

Just as cooperative techniques may vary depending on the level of the course, cooperative techniques also often vary depending on the age of the students. Dansereau and Johnson (1994) call attention to the fact that in high school and college, students often have more developed social skills than do grade school or middle school students. This changes slightly how cooperative tasks are structured in order to accommodate their already more developed group skills (Dansereau and Johnson 1994). At the same time, high school and college courses often operate at a faster pace than in grade school or middle school and involve more complex tasks, resulting in cooperative episodes that are more focused and intense (Dansereau and Johnson 1994). The variations in cooperative learning situations introduced by introductory versus advanced courses and the age and social skills of the students are of great importance to the introductory, college classroom I examine in this study. In this particular context, it is expected that simple but focused laboratory tasks are the most appropriate cooperative technique to employ.

Summary

Cooperative learning, as a subset of active pedagogy, is rooted in a similar historical trend toward increasing engagement of students in learning processes. Using a cooperative approach, as opposed to a more competitive or individualistic approach, requires substantial changes be made in both classroom tasks and the learning context as a whole. Though sometimes critiqued for sacrificing content in order to allow for a greater time investment in cooperative activities, I have demonstrated that various cooperative techniques can be usefully applied in college courses, such that students achieve deep understandings of content, high levels

of interest, and preparation for life outside the classroom walls. Cooperative learning, like other forms of active pedagogy, is an effective approach to teaching that can be fruitfully applied in the context of college science and anthropology courses.

Discussion-based Teaching

I now turn to a consideration of discussion-based teaching, which I also characterize as a subfield of general active pedagogies. Though this connection is not explicitly noted by many of the authors mentioned here, I believe discussion is inherently active (and potentially cooperative). Like other active pedagogical techniques considered here, the use of discussion promotes high quality learning and the development of skills appropriate for life beyond the classroom. Discussion was initially advocated in classrooms as a way to promote democratic values (Henning 2008), and this goal is still important to many discussion practitioners (e.g. Brookfield and Preskill 2005). In addition, discussion-based teaching has been shown to enhance student engagement, deeper levels of understanding, critical thinking skills, and moral development (Brookfield and Preskill 2005, Henning 2008).

Discussion-based teaching faces several challenges in its implementation. To be successful, discussions must be well-designed and implemented, and the teacher must be flexible and able to accommodate unanticipated student responses (Henning 2008). In designing and implementing classroom discussions, it is particularly important that the instructor set realistic expectations, lay clear ground rules, model positive participation techniques, and integrate the discussion into the overall course pedagogy and grading system (Brookfield and Preskill 2005). The instructor must also play an active role in the discussion itself, occasionally summarizing and re-focusing student attention when appropriate (Frederick 1994). In order to be productive, these interventions must be balanced with student involvement in the discussion, otherwise the discussion turns into a lecture given by the teacher (Frederick 1994).

In higher education, students enrolled in large lecture courses are often encouraged (or required) to enroll in a related discussion section, giving the students a chance to engage more actively with course content (Foyle 1995). However, in reality, discussion sections do not always successfully promote active learning (Foyle 1995). Students may participate differentially, and students may feel uncomfortable or afraid of sharing opinions in front of unfamiliar peers (Foyle 1995). In order to avoid these potential problems, Foyle (1995) suggests using the think-pair-share activity to stimulate discussions. This active and cooperative technique helps students become comfortable sharing in small pairs before discussing with the whole class, and this greater comfort and confidence leads to higher levels of participation in the larger discussion (Foyle 1995). When done correctly, discussion-based teaching furthers student engagement, giving students a greater sense of empowerment and motivation (Brookfield and Preskill 2005, Frederick 1994), and as noted previously, higher levels of engagement also often result in higher quality learning.

While not appropriate for every classroom topic (Brookfield and Preskill 2005), discussion does allow for consideration of very complex issues in the classroom (Frederick 1994). Through consideration of complexities and nuances, group discussions encourage the development of important skills like communication, synthesis, and critique (Brookfield and Preskill 2005, Frederick 1994). Thus, students involved in classroom discussions are more likely to build higher-level, critical thinking skills. Discussion also requires students to consider multiple perspectives, promoting important skills for life beyond the classroom, such as an appreciation for diversity and a more self-reflective approach to thinking (Brookfield and

Preskill 2005). Overall, then, like other active approaches, discussion-based teaching is effective in that it promotes student engagement, high quality learning, and crucial life skills.

Bloom's Taxonomy

Active pedagogies (including cooperative learning and discussion-based teaching) are effective approaches that yield high quality learning. However, they do not necessarily provide a clear framework for what constitutes higher levels of learning. Nor do they *specifically* suggest how instructors might help students build particular levels of knowledge. Bloom's taxonomy, on the other hand, does offer a framework for understanding levels of knowledge and tasks that target specific levels. Although, as I discuss below, this taxonomy is designed as a way to theorize learning objectives and evaluation, it can play a valuable role in helping educators create tasks that promote deeper understanding among students.

Historical Context and Goals

Bloom's taxonomy was devised during the 1950's when behaviorist approaches dominated psychology and education (Rohwer and Sloane 1994). However, at that time, neobehaviorism was taking root, introducing the idea of qualitatively different types of learning (Rohwer and Sloane 1994). Working in this context, the taxonomy creators emphasized the hierarchical nature of learning, whereby different types of learning built on one another in the construction of deeper understandings and generalizable skills and abilities (Rohwer and Sloane 1994).

The published taxonomy is the result of a series of meetings between various educational researchers and practitioners (Krathwohl 1994). During these meetings, attention was focused on creating a system for classifying the goals of educational programs, termed educational objectives (Bloom 1994). In doing so, it was believed that the taxonomy would help primarily with the design and implementation of appropriate educational assessments (or tests) and research on testing in educational contexts (Bloom 1994, Bloom et al. 1956). The taxonomy appears in parts, related to different priorities in the original meetings emphasizing cognitive versus other domains (Bloom 1994). The volume related to the cognitive domain highlights issues related to knowledge recall and the "development of intellectual skills and abilities" (Bloom 1994:2). Therefore, it is the volume most widely applied by educators and educational researchers, and it will be the focus of the discussion here.

In order to clearly classify the educational objectives, the taxonomy focuses on those objectives that can be described in terms of observable student behavior (Bloom 1994). The objectives are then arranged hierarchically to stress the relationship between any one objective and the other objectives, as well as the inherently hierarchical and cumulative nature of learning (Bloom 1994, Bloom et al. 1956, Rohwer and Sloane 1994). The taxonomy was specifically designed so that it could be applicable in any number of contexts (Bloom 1994, Bloom et al. 1956). As such, the taxonomy creators sought to maintain neutrality by including objectives from various educational orientations (Bloom 1994, Bloom et al. 1956); and based on the broad applications of the taxonomy in many fields worldwide since its inception (Anderson 1994, Bloom 1994, Krathwohl 1994), it seems the neutrality goal was achieved.

The Taxonomy

The taxonomy divides different levels of learning or thinking into six distinct classes, ordered from the simple to the complex (Bloom et al. 1956). The first and most simple class is:

knowledge, memorized facts and concepts (Bloom et al. 1956). Traditionally in education, knowledge has been given primary emphasis, perhaps because it is an important foundation for all other educational purposes and because it is believed to be simple to both teach and learn (Bloom et al. 1956). What has been missing, however, is a sense of the generalized techniques necessary for the application of knowledge in new situations (Bloom et al. 1956). Others often call these techniques “critical thinking,” “problem-solving,” or “reflective thinking,” however the creators of the taxonomy refers to these techniques as “intellectual abilities and skills” (Bloom et al. 1956:38). Particularly in a rapidly changing world, these generalized abilities and skills are necessary for addressing the countless unanticipated situations one may encounter (Bloom et al. 1956). Given their significance, these techniques are incorporated into the taxonomy as the remaining five classes of learning or thinking (Bloom et al. 1956).

The second class is devoted to: comprehension, “understanding the literal message contained in a communication” (Bloom et al. 1956:89). This includes such skills as translation, interpretation, and extrapolation (Bloom et al. 1956). The third class is: application, which requires the student to draw on their past experience in a new situation (Bloom et al. 1956). This is distinguished from comprehension, where students draw on what is provided to them in the situation (Bloom et al. 1956). For example, imagine a student has been given two primate crania and told that one cranium has teeth designed for crunching insects and the other has teeth designed for grinding plants. We then ask the student which primate cranium has which diet. The student is making an extrapolation (judgment), but it is based directly on the information provided about crunching vs. grinding teeth. This is a comprehension skill. Now, imagine that a student has learned in a previous class meeting about the association between tooth form and diet. In this class meeting, we give the student a single primate cranium and ask them to determine the diet without providing any further leading information about crunching vs. grinding teeth. The student is now using an application skill because they are forced to draw solely from a previous learning experience, rather than any additional information presented directly at the time.

The fourth class in the taxonomy focuses on: analysis, the ability to break down material and understand the relationships between the parts (Bloom et al. 1956). An example of this would be the ability to distinguish between a fact and a hypothesis and to note how they relate to each other (Bloom et al. 1956:144). Where analysis emphasizes breaking apart material, the fifth class emphasizes putting material together: synthesis (Bloom et al. 1956). This is generally a more creative skill and requires mixing existing and new knowledge together to create a cohesive whole (Bloom et al. 1956). While some things, like essays, are often assumed to employ synthesis skills; they only do so if they actually create an entirely new product, not just a description of separate elements (Bloom et al. 1956:162-163). The final class is: evaluation, using one’s own criteria (or those provided) to make qualitative or quantitative judgments about the value of some material, idea, or solution (Bloom et al. 1956:185). This is the final class because it includes the previous classes, not because it is believed that thinking ends here; and it is recognized that the lines between some of the classes are often blurry depending on the nuances of the particular situation in which the skills are put to use (Bloom et al. 1956).

Critiques and Benefits

The primary critique of the taxonomy centers on the hierarchical organization of the levels of thinking. Many authors take issue with the linear, progressive nature of the classification scheme, arguing that learning does not always follow this sort of trajectory (Furst

1994, Kreitzer and Madaus 1994, and see Newman et al. 1989 for a critique of learning hierarchies more generally). Also, the taxonomy draws apparently clear distinctions between each level of thinking, creating perhaps false separations between related skills (Furst 1994, Kreitzer and Madaus 1994, Postlethwaite 1994). For example, Marzano (2001) critiques the taxonomy hierarchy for differentiating levels based largely on level of difficulty despite the fact that some difficult things can be done easily with minimal effort. Instead, he offers an alternative taxonomy based on the flow of mental processes (Marzano 2001). Of particular concern for many authors is the taxonomy's division between knowledge and all other intellectual skills, when, in fact, knowledge may require these skills (Kreitzer and Madaus 1994, Postlethwaite 1994). Interestingly, research since the taxonomy's introduction, though yielding mixed results, generally supports the idea of a cumulative hierarchy in learning (Kreitzer and Madaus 1994).

Another issue with the taxonomy may be that it is too rigid and places too much weight on behavior. Some have suggested that the taxonomy constrains teachers and results in military-like teaching (Bloom 1994). Bloom (1994) notes this is the result of overly narrow interpretations and applications of the taxonomy. By emphasizing the importance of knowledge application and problem-solving skills, the taxonomy inherently avoids rote learning techniques (Bloom 1994). Other critics worry that basing the taxonomy in behavior is problematic (Furst 1994). The taxonomy is certainly grounded in a behaviorist context, as was discussed previously, but it is not completely out of line with cognitive approaches. Rohwer and Sloane (1994) note that while cognitive perspectives disagree with some aspects of the taxonomy, such as hierarchical learning; they do generally agree with other aspects, such as cumulative knowledge. Remember from earlier discussions above, cognitive approaches argue learning is a process of relating new information to old information in one's mind; therefore, knowledge must be cumulative, building on the pre-existing.

In spite of these critiques, the taxonomy has many useful benefits. Most importantly, it serves as a useful framework for understanding knowledge in a variety of contexts (Anderson 1994, Krathwohl 1994). In research contexts, the taxonomy is not usually studied in terms of the six individual classes; rather emphasis is placed on low-level versus high-level thinking (Anderson 1994). While this does lead to some disagreement among researchers regarding where to draw the line between the two levels (Anderson 1994), the taxonomy does serve as a useful heuristic for considering the difference between memorized knowledge and other, more general, thinking skills (Krathwohl 1994). The taxonomy is also useful for educational practitioners. It serves as a guide for teachers as they specify learning objectives, prepare tests, and design activities to target specific cognitive levels in the taxonomy particularly those levels beyond simple knowledge (Anderson 1994, Postlethwaite 1994). For example, Michael and Modell (2003) use the taxonomy to conceive of general differences between rote learning and meaningful learning. This helps the authors to foster deeper understanding and meaningful learning in science classrooms through the use of active pedagogy (Michael and Modell 2003).

Summary

Working within a behaviorist approach, Bloom et al. (1956) suggest a taxonomy of learning and thinking that facilitates the design of learning activities, objectives, and assessment methods. Though the taxonomy has some pitfalls, it is useful as a guiding framework for teachers and researchers. Of particular importance, it highlights the cumulative nature of learning and makes distinctions between memorized knowledge and intellectual skills. The

taxonomy sets the stage for designing coursework that helps students construct their knowledge effectively and fosters the development of knowledge and higher-level intellectual abilities.

Learning Styles

My final useful framing device returns us to the field of cognitive psychology. Anyone who has tried to teach a group of people—be it in a formal educational context or at your last family game night—recognizes that not every person approaches learning in the same way. In the classroom, this can be an incredibly frustrating and seemingly insurmountable situation for both the instructor and the students, especially when the course does not meet the cognitive needs of everyone involved. In the Anthropology 1 course studied here, variations in learning pose a significant challenge. Thus, in designing the laboratory pedagogy of the course, I take into account cognitive psychology research that examines these learning differences. This is not to say that I believe cognitive variation supersedes other forms of student variation, such as socioeconomic, cultural, and linguistic differences. It is simply to say that in this particular situation, cognitive variation is of great import.

Historical Context and Goals

Beginning in the 1940's and continuing with the cognitive revolution of the 1960's, self awareness and reflection became important staples in effective learning (Morgan 1997). This is seen in the growing concern for metacognition discussed previously, and it led to the development of research on how individuals perceive and conceptualize their experiences (Morgan 1997). These individual differences are variously referred to as cognitive styles, multiple intelligences, and learning styles. Here, I choose the term "learning style" to highlight the importance of these differences for the learning experience.

Learning style work takes assorted forms (Claxton and Murrell 1987), but most learning style researchers emphasize the relationship between the learner and the learning environment (Morgan 1997). By examining this relationship, we can begin to understand how best to create a learning environment that is appropriate for different learners and learning styles. This is often accomplished by providing a variety of experiences and assignments in the classroom (see Prosser and Trigwell 1999 for alternate view).

Gardner (1993) proposes that there are seven approaches to learning and thinking: musical, bodily-kinesthetic, logical-mathematical, linguistic, spatial, interpersonal, and intrapersonal; and an individual's style is grounded in both their biological proclivity and their unique cultural experiences (Gardner 1993). While many researchers believe that an individual has only one style, Gardner (1993) argues everyone has abilities in all seven styles but each individual is stronger in some than others. For Gardner (1993), then, education should be individualized with tasks and experiences that match an individual student's style, helping them develop their style and prepare for life beyond school. To some this may sound radical, as if it flies in the face of such approaches as cooperative learning. However, Gardner (1993) is not advocating individualistic schooling in that sense; rather he suggests assignments should be flexible, offering components or options appropriate for each style. Thus, rather than simply assigning an essay to every student in a course, a teacher could give the option of completing an essay assignment, performance-based assignment, or visual arts assignment. In this way, the instructor is providing equal opportunities to multiple learning styles. For most learning style researchers like Gardner (1993), understanding and accommodating students' learning styles is

necessary for providing effective and equitable learning experiences for every student in the classroom.

Critiques and Benefits

Of course, learning style work is not without its critiques. Often these critiques focus on the static and rigid nature of learning styles (e.g. Perry 1981). Some research characterizes learning styles as static and over-arching, such that an individual is stuck with one learning style for their entire existence (Gardner 1993, Perry 1981). As was noted above, Gardner (1993) disagrees with this depiction of learning styles as distinct and singular within an individual, arguing instead that an individual has abilities across all learning styles. Perry (1981), too, takes issue with the sometimes static view of learning styles, suggesting that an individual's style may change as they mature. Finally, Kolb (1981) suggests learning style and academic discipline correlate, such that students majoring in a certain discipline in college are more likely to have a particular learning style than students in another discipline. This is due in part to the fact that an individual with a particular learning style may be drawn to a discipline that emphasizes that style (Kolb 1981). It is also likely due to the fact that throughout coursework and training in a discipline, the appropriate learning style is fostered (Kolb 1981). This potential for fostering a specific learning style would seem to further suggest that these styles are somewhat flexible. Certainly, learning styles may be nuanced, such that individuals have multiple styles and/or a person's style may change throughout their academic career or lifetime. As will be discussed in the following chapter, in the context of the Anthropology 1 classroom, I need to be particularly mindful of Kolb's (1981) work. The Anthropology 1 course draws students from a range of disciplines, each of whom may already be undergoing the development of a discipline-appropriate learning style, resulting in an incredible assortment of learning styles within the classroom.

In spite of potential problems regarding the exact nature of learning styles and the extent of their flexibility, learning style research makes a valuable contribution to educational contexts. Most importantly, work along these lines suggests it *is* possible to avoid the frustrating feeling of not being able to reach all of the students in our classrooms. Paulson (1999) notes that by varying teaching methods, we can usefully foster learning among students of different learning styles. Thus, incorporating active and cooperative tasks into an organic chemistry lecture course provides more opportunities to engage students of different learning styles than does lecturing without active and cooperative tasks (Paulson 1999). In general, cooperative learning techniques allow student group members to compensate for and maximize differences in learning styles and abilities, as they work together on tasks that may not be easily accomplished alone (Cohen 1986, Lotan and Whitcomb 1998). Through the use of active pedagogy and varying assignment forms, teachers are better able to accommodate students with different learning styles in the same classroom.

Summary

Learning styles have been studied since the mid-twentieth century in order to better understand potential student variation and methods for accommodating that variation in the learning context. By taking into account variations in learning styles, educators are better able to develop and implement pedagogies that are appropriate for all students, rather than a mere subset of students. Therefore, truly effective pedagogy like that sought here must take into account the valuable contributions made by learning style researchers.

Conclusion

My work here is grounded in a range of significant psychological and educational theory and research. I believe that in order to fully understand “effectiveness” in teaching, we must start by understanding the processes of learning, remembering, and applying knowledge as outlined by cognitive psychologists. In seeking approaches that facilitate these processes, I have highlighted the benefits of active pedagogy in general and cooperative and discussion-based approaches more specifically. I argue that Bloom’s taxonomy serves as a useful framework for conceptualizing assignments that encourage higher-level thinking, and I submit that if I hope to engage *all* students in these assignments and learning processes, I must take into account variation in student learning styles.

CHAPTER THREE: MATERIALS

Traditionally, in the United States, the field of anthropology is broken into four sub-fields—social/cultural anthropology, linguistic anthropology, anthropological archaeology, and physical/biological anthropology. Physical anthropology, or biological anthropology as it is increasingly referred to today, focuses largely on the study of human evolution. It is usually conceived of as four, related specialties—genetics and evolutionary theory, primatology, paleoanthropology, and modern human biology. There is a great deal of overlap between these specialties, and they are not the only specialties within biological anthropology. Other specialties include forensic anthropology and bioarchaeology, which link biological anthropology to other anthropological fields like archaeology. However, the four basic specialties make up the backbone of all introductory coursework in the field, and they are often presented in introductory courses and textbooks as the four major units of the subject. The course considered here is an introductory, undergraduate course in biological anthropology that is largely structured around these four primary specialties.

Overview of Anthropology 1: Introduction to Biological Anthropology

At the University of California, Berkeley, like many anthropology departments nationwide, undergraduate majors in anthropology are required to take an introductory course in biological anthropology. This course is listed as Anthropology 1: Introduction to Biological Anthropology (Anthropology 1). The course has traditionally been offered in both the fall and spring semesters, as well as in an intensive six-week summer session. Beginning in the 2005 – 2006 academic year and continuing to the present, the course is only offered in one of the regular semesters (fall or spring) and a six-week summer session per each academic year. The semesters under study here fall within this time of reduced course offering.

As at most colleges and universities throughout the country, the Anthropology 1 course at UC Berkeley meets several undergraduate requirements for graduation. It is not only required of all anthropology majors, it also satisfies a requirement for the psychology major on campus and meets a breadth requirement for four of the seven undergraduate colleges at the university. Thus, the course attracts a wide range of students from various departments on campus.

In a fall or spring semester, the course usually has enrollment between 300 and 450 students. These students are required to attend two hours and forty minutes of lecture per week, divided into two equal, one hour and twenty minute sessions. The students are also required to attend a fifty minute laboratory section once a week. In the summer session, enrollment is generally between 25 and 50 students. These students attend seven hours and forty minutes of lecture per week, divided into two equal, three hour and fifty minute meetings. They also attend two hours and forty minutes of laboratory section per week, divided into two equal, one hour and twenty minute sessions. Laboratory sections are not held during the first week of class and are often not held for one additional week in the fall or spring (in order to accommodate holiday breaks for Thanksgiving and Washington's Birthday). Lectures are led by anthropology department faculty, and laboratory sections are led by anthropology graduate student instructors from sociocultural anthropology, biological anthropology, or archaeology backgrounds.

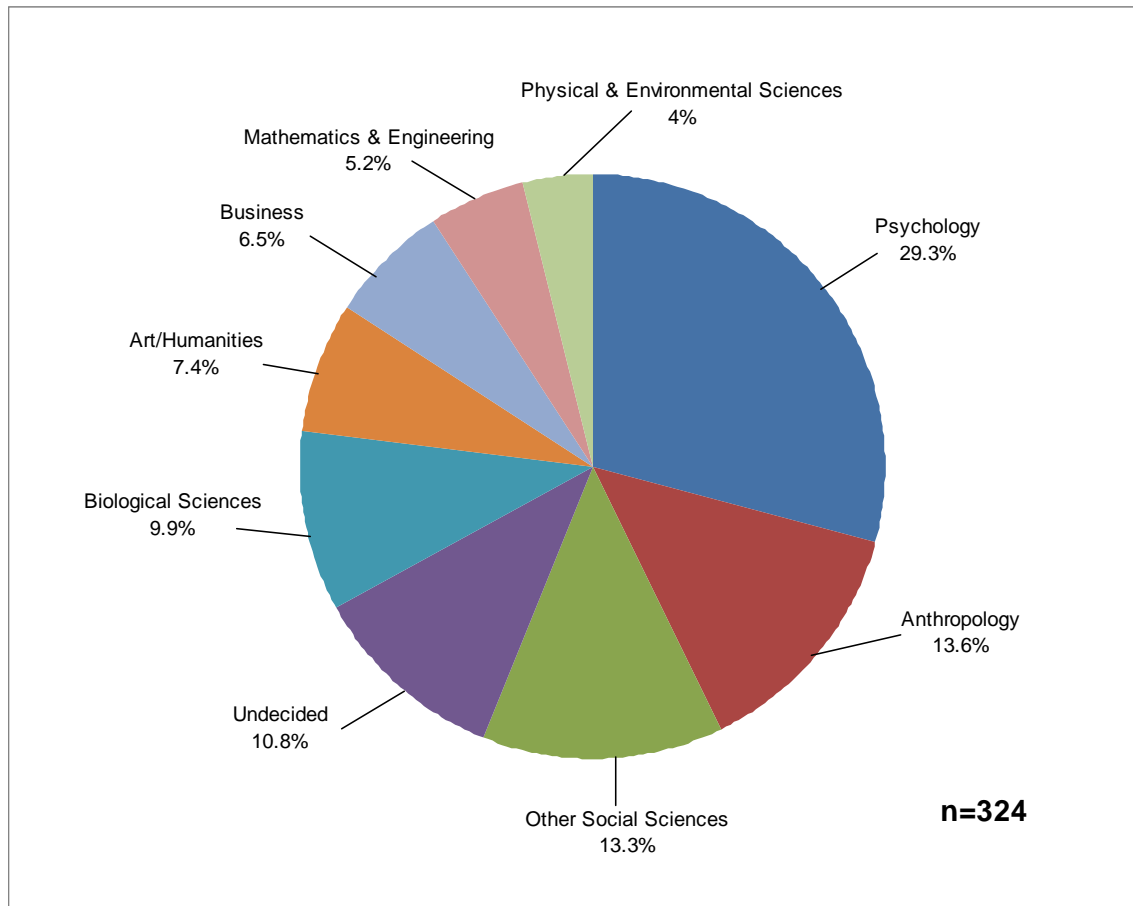
Student Diversity

In the previous chapter, I noted the Anthropology 1 course presents a challenge in that it includes students of widely different learning styles. The course attracts students from a remarkably wide range of majors across campus because it satisfies many graduation requirements. Kolb (1981) demonstrates through multiple studies of colleges across the country that undergraduate major correlates strongly with learning style. For example, an engineering major is more likely to be of one learning style, while an anthropology major is more likely to be of another learning style; and a biological science major is more likely to be of yet another learning style (Kolb 1981). Different fields encourage different approaches to thinking and evaluation that appeal to different learning styles (Kolb 1981). Students often pursue majors that suit their existing learning style, and their learning style is further reinforced through coursework in that field (Kolb 1981). Therefore, it is safe to say that the wide range of undergraduate majors represented by the students enrolled in Anthropology 1 denotes a similarly wide range of learning styles among those students.

As discussed previously, then, in an effort to promote effective teaching and learning, one of the main goals of the Anthropology 1 laboratory pedagogy is to teach to all learning styles, rather than to just one or two learning styles. We recognize the importance of making the course content relevant and accessible not just to anthropology majors but to countless other enrolled students of various majors and learning styles. This is particularly important considering the vast majority of our students are in fact *not* anthropology majors. For the semesters under investigation here, anthropology majors accounted for only 13.6% of the students (See Figure 3.1). The remaining students were primarily psychology majors (29.3%) or majors in another social science field (13.3%). However, we also see fair numbers of students with majors in the biological sciences, humanities, business, mathematics and engineering, or physical sciences. As noted above, the work of Kolb (1981) suggests the students in our classroom are likely to be representative of a wide range of learning styles similar to their variation in major field pursuits. With these issues in mind, the laboratory pedagogy seeks to engage a wide variety of learning styles in order to benefit all of our students, no matter what their major or personal approach to thinking and learning.

Figure 3.1
Anthropology 1 Student Majors

The chart is based on students' self-identifying responses to the question, "What is your (intended) major?" on anonymous feedback forms administered at the end of the course. The data includes students from the spring 2007, summer 2007, summer 2008, and summer 2009 semesters together; and for ease of presentation it excludes an additional 81 students from these semesters who either did not provide any major or provided more than one major in response to the question.



The Pedagogy of Anthropology 1

The two primary goals of the Anthropology 1 course are: to help students build an understanding of basic biological anthropological concepts and to help students see the relevance of these issues in modern life. To achieve these goals, lectures are used in conjunction with active laboratory assignments and a student-directed research project. The course draws from ideas presented by Bloom et al. (1956) regarding learning and thinking. We seek to promote higher-level, critical thinking skills in the course, and we design assignments and activities so that they build from more foundational knowledge and skills to higher-level skills.

The research project is one example of this. In fall or spring semesters, the research project is an independent paper that examines the validity of student-identified, biological

anthropology topics as presented in popular literature. In the summer session, the research project is a scholarly poster addressing a current issue in biological anthropology, prepared by a small group of two or three students and presented at an in-class poster session. These assignments are broken into several parts, including a summary, bibliography, and the final product. This system allows the students to build their understanding of the issues before developing a critical perspective and argument in their final project. It also allows us to provide continual feedback to the students regarding their progress.

All together, these research assignments make up forty percent of a student's final grade in the course. Another forty percent of the grade is determined by a midterm and final exam (each worth twenty percent) that employs multiple choice and various short answer formats (matching, fill-in-the-blank, identification in anatomical diagrams, and open-ended questions). In the summer session, the remaining twenty percent of a student's grade is based on lecture attendance and participation (ten percent) and laboratory section attendance, participation, and workbook completion (ten percent). In fall or spring semesters, the remaining twenty percent of a student's grade is based solely on laboratory section attendance, participation, and workbook completion.

The workbook is collected at the end of the semester, and in the fall or spring, it may also be collected halfway through the semester. It is graded largely based on level of student effort and completeness, rather than correctness of answers; and both the take home quizzes and laboratory exercises are considered when determining the grade. The laboratory section participation grade is based on a student's level of active participation in class discussions and in small groups during laboratory station exercises and cooperative tasks.

The Laboratory Section

The laboratory section is led by graduate students from the anthropology department, like myself, representing sociocultural anthropology, biological anthropology, and archaeology. Acting as teaching assistants, these graduate students attend lectures, meet regularly with the entire teaching staff (including the professor), contribute to exam writing, grade exams and assignments, and facilitate laboratory sections. The teaching assistants also hold regular office hours in order to address student questions and concerns more individually.

The primary goal of the laboratory section is to facilitate student learning of concepts presented in lecture and assigned texts. Entirely new information is not presented in the laboratory section, rather existing information is re-presented through the laboratory workbook, laboratory assignments, and supplemental readings in order to allow students to better learn and understand course material. As an introductory course addressing a vast research discipline, Anthropology 1 covers a wide array of concepts and topics that are often challenging for students, but as was discussed in the previous chapter, even challenging material can be effectively learned through multiple exposures to the material. With this in mind, we use the laboratory section to reinforce major concepts from elsewhere in the course that may be particularly challenging or abstract.

This emphasis on reinforcement of abstract concepts makes the laboratory sections ideal for active learning pedagogy. I employ laboratory tasks that seek to engage the students as active participants in their knowledge construction, involving the students in working through problems, making their own mental connections and structures of understanding. This helps students construct stronger, deeper understandings of course material. The subject of biological anthropology is particularly ideal for an active learning approach because so much of it is based

in interpretations of the anatomy and adaptations of living and extinct species. Thus, instructors can readily engage students in laboratory tasks that encourage them to examine, observe, touch, and discuss casts of these materials in an-depth way, far beyond what can be accomplished from watching lectures or reading texts alone.

When compared to the active learning continuum discussed in the previous chapter, the approach I apply in the Anthropology 1 laboratory is similar to the majority of active anthropology and science classroom techniques located on the “short-term, somewhat realistic” side of the continuum. The laboratory assignments are short-term tasks completed in the span of one class meeting. They place students in somewhat realistic situations where they are asked to examine and evaluate biological anthropology material and concepts, and they foster student development of analytical, evaluative, and synthesizing skills used by expert biological anthropologists. However, the tasks are not long-term or realistic enough to be considered part of the middle or opposite end of the active learning continuum, where situated learning approaches are located.

To further engage students in the learning of biological anthropology, Anthropology 1 students work in small cooperative groups often of two to three students on most laboratory tasks. As discussed in the previous chapter, employing cooperative techniques encourages students to share their views and opinions with one another, resulting in the high quality learning of complex topics and the increased development of communication skills. Therefore, by having the students work in cooperative groups, the laboratory pedagogy helps the students gain greater confidence, see the material from a different perspective, and build important social skills.

The laboratory section is based on Bloom et al.’s (1956) taxonomy. Laboratory assignments are designed to help students build from foundational knowledge to critical thinking skills. This is primarily accomplished through the structure of the laboratory workbook. The workbook provides background text, a take home quiz, and an in-class laboratory exercise for each laboratory meeting. Mirroring the overall course structure, I designed the workbook to follow the four main topics of the course: genetics and evolutionary theory, primatology, paleoanthropology, and modern human biology. Multiple laboratory meetings exist for each of the topics, and they are structured such that early laboratory meetings within a unit focus largely on basic knowledge construction, while later laboratory meetings focus more on in-depth comparisons, analyses, and in-class discussions.

The use of an active, cooperative approach and the structuring of assignments to build higher-level thinking skills in the laboratory sections and workbook are designed to maximize student learning. This, in turn, maximizes student retention and their ability to apply these concepts in and out of the classroom in the future. In order to maximize *every* student’s learning, no matter what their learning style, I incorporate a variety of types of laboratory exercises. Some activities draw on diagrams and maps that appeal to visual learners. Other activities are based on manipulating objects to act out evolutionary principles, in order to target tactile learners. All activities require communication and discussion with fellow classmates to appeal to auditory learners. For any one, individual concept not all of these activity forms are necessarily used. However, in each of the four major units of the course, multiple types of activity are utilized. In this way, I have designed the laboratories such that they reinforce the major aspects of the course, using active and cooperative activities that build from foundational knowledge to critical thinking skills and are appropriate for as many learning styles as possible.

The Laboratory Workbook

In the fall 2005 semester with funding from the University of California, Berkeley Graduate Student Instructor Teaching and Resource Center and under the direction of Dr. Sabrina Agarwal (Assistant Professor of Anthropology), I designed an active, cooperative pedagogy for the Anthropology 1 laboratory sections. This original design resulted in the creation of twelve laboratory section exercises emphasizing active, cooperative learning and the building of critical thinking skills for multiple learning styles. It was initially implemented in the fall 2005 semester as a series of documents on the course website that students printed, brought to class to complete, and submitted for grading. Beginning in the summer 2006 semester and continuing to today, I converted these laboratory exercises to a laboratory workbook where all twelve assignments, with the addition of corresponding reading and take home quizzes, were compiled as a single course reader students purchased and used throughout the course.

The workbook for fall or spring semesters (full-length workbook) includes: an introduction explaining the workbook format and its use; a table of contents listing; twelve chapters*, one for each of the laboratory section assignments; a special section explaining the classification of primates and the format for writing genus and species names; and a glossary with definitions of key terms highlighted in bold throughout the rest of the workbook. In the summer session over the course of the entire six-week period, students spend approximately the same amount of time in laboratory section as do students in the full-length, fall or spring course. However, this time is concentrated, and the lab workbook is condensed into seven longer laboratory assignments for the summer session (condensed workbook), rather than twelve shorter assignments. A very small number of assignments are lost during this condensing, but the key assignments under consideration here are virtually identical between the full-length workbook and the condensed workbook. While the laboratory exercise chapters vary slightly, the condensed workbook maintains the other sections of the full-length workbook, such as the introduction, special section, and glossary.

As was previously discussed, the workbook is designed to build levels of thinking within each of the four major units of the course. Additionally, each individual laboratory chapter in the workbook is structured to further support this development of learning. Each chapter begins with several pages of text that re-present the major themes, information, and terms relevant to that laboratory task. The text component concludes with a take home quiz asking basic review questions. Students are expected to read the relevant text and complete the take home quiz before coming to class for that laboratory meeting. Similar to Michaelsen's (1994) "minitests," the take home quizzes help the students to take responsibility for their learning, efficiently cover concepts, and provide students with a sense of their progress with the material. The chapters conclude with a labwork section that provides the questions and task instructions for the in-class laboratory exercise. The labwork section is completed by students in class and requires them to apply their knowledge in active, cooperative contexts. This structuring of each chapter is designed such that, by reading and completing the take home quiz, students are reviewing foundational knowledge before applying that knowledge in more complex, critical thinking tasks in their laboratory section. The format reinforces the building of levels of thinking from basic knowledge to higher-level skills and abilities.

* In the past, the spring semester at UC Berkeley has been one week longer than the fall semester. The workbook under examination here, having been initially designed for a fall semester, left one laboratory week open for an additional, non-workbook assignment in the spring 2007 semester.

The laboratory assignments that comprise the labwork section of each chapter emphasize active, cooperative learning. Many advocates of these pedagogical approaches highlight the importance of designing tasks that are relevant and interesting (Cohen 1986, Davis 1993, Michaelsen 1994). By using activities that are inherently interesting and relevant both to the course content and to the students' lives, instructors are better able to engage students in the learning process. However, we must also ensure that tasks are appropriate for the students, challenging them without being beyond their capabilities (Cohen 1986, Davis 1993). The Anthropology 1 laboratory exercises often challenge students by providing meaningful questions that help them see the larger significance of the course material and methods, an approach encouraged by Leonard (1994). For example, the exercise may ask students to first compare physical traits they observe on two fossil casts. It then asks students to reflect on how these trait similarities and differences may impact the way the fossil species are classified. In doing this, the exercise challenges students to think about the implications of the observations they make, rather than making the observations alone. Finally, as Cohen (1986) suggests, I implement laboratory tasks that employ multiple skills and senses, such as sight and touch. The laboratory tasks encourage students to fully interact with materials in the laboratory, increasing their engagement and providing outlets for students with different learning styles. As previously noted, a range of student learning styles is targeted throughout the course by employing a variety of laboratory task formats.

In addition to the workbook text, take home quiz, and labwork for each chapter; at least one supplementary assignment is given in each of the four major units to further promote critical thinking skills. This often takes the form of an in-class discussion. Students are provided an extra article to read on the course website and asked to participate in a discussion of that reading in laboratory section. Questions for the discussion are provided in the laboratory workbook in advance to help students structure their reading. Targeted questions encourage students to identify the main arguments and issues put forth in the reading, and open-ended questions ask students to critique these arguments and evaluate them using knowledge gained elsewhere in the course. As discussed in the previous chapter, the use of such in-class discussions helps students to further develop their higher-level, critical thinking skills.

Implementation of the Laboratory Workbook

While these Anthropology 1 laboratory assignments and/or workbook have been used since fall 2005, I only focus on their use in the spring 2007, summer 2007, summer 2008, and summer 2009 semesters in this dissertation. During these semesters, three different anthropology faculty members acted as the professor for the course. In the spring 2007 and summer 2007 semesters, the professors were two different visiting faculty members, both of whom have experience teaching equivalent courses elsewhere. In the summer 2008 and summer 2009 semesters, the professor was a regular faculty member from the anthropology department (Dr. Sabrina Agarwal) with experience teaching this course in earlier semesters at UC Berkeley and equivalent courses elsewhere.

The graduate student instructors facilitating the laboratory sections also varied from one semester to the next. Having previously facilitated laboratory sections for the course in six earlier semesters, I also was a graduate student instructor in all of the semesters under consideration here. During the summer sessions, I was the only graduate student instructor and was responsible for 100% of the laboratory sections for the course. The spring semester of 2007 had a total of seven graduate student instructors from the anthropology department, including

myself (See Table 3.1 for summary). For the purpose of protecting anonymity, all graduate student instructors, including myself, were randomly assigned a letter from A to G that will be used to identify and discuss them anonymously throughout this dissertation. Most of the graduate students in the spring 2007 semester were responsible for four laboratory sections (14.3% of the total), though one had fewer sections and one had more. Previous experience teaching Anthropology 1 varied considerably. Graduate students C, D, and F had facilitated laboratory sections in a similar format in the fall 2005 semester. Graduate student G had facilitated laboratory sections in the course in previous semesters, but the pedagogy and format employed in the sections at that time were not the pedagogy and format discussed here. The remaining graduate students had not previously facilitated any laboratory sections for Anthropology 1 at UC Berkeley. The research focus and experience of the graduate student instructors *at the time* spanned three fields of anthropology. The majority of graduate students had an archaeology focus; one graduate student had a bioarchaeology focus, a field closely related to biological anthropology; one graduate student had an explicitly biological anthropology focus; and, one graduate student had a sociocultural anthropology focus.

When taken all together, this suggests there is a high degree of variation between the laboratory section facilitators in both experience with biological anthropology subject matter, as well as actual biological anthropology instruction. This variation is typical of the teaching staff for Anthropology 1 at UC Berkeley. As such, the lab workbook was designed with the intention that it would help standardize laboratory instruction, despite this variation in laboratory facilitators. By assigning the same workbook and in-class laboratory activities to all students, no matter whom their graduate student instructor, it was hoped that all students would have similar learning experiences and opportunities. This would then help compensate for graduate student instructors with less experience in the subject or teaching of biological anthropology, and it would promote high quality learning among all students.

Table 3.1
Summary of Graduate Student Instructors in Spring 2007 Semester

Graduate Student Instructor	# of Laboratory Sections Facilitated	% of Laboratory Sections Facilitated	Previous Experience Teaching Anthropology 1	Personal Research Focus at Time
A	4	14.3	None	Archaeology
B	4	14.3	None	Archaeology
C	4	14.3	Yes	Archaeology
D	6	21.4	Yes	Biological Anthropology
E	4	14.3	None	Bioarchaeology
F	2	7.1	Yes	Archaeology
G	4	14.3	Yes (however, different format and pedagogy)	Sociocultural Anthropology

The Paleoanthropology Labs

Introductory courses in biological anthropology are staples at many colleges and universities nationwide, meeting various requirements for undergraduate degree progress. These courses therefore attract students from diverse majors across campus and of remarkably different learning styles. Certainly, this is the case with the Anthropology 1 course at the University of California, Berkeley. This challenges instructors to provide a learning context that suits these diverse needs. In meeting this challenge, the lab workbook is designed to help students build higher-level thinking skills through reading, take home quizzes, and a range of active, cooperative in-class activities.

A full analysis of the effectiveness of the entire laboratory workbook is beyond the scope of this dissertation. Therefore, I focus on an analysis of only one unit of the workbook, the paleoanthropology unit. I have chosen this unit specifically because it is emblematic of the pedagogy used throughout the workbook and laboratory sections. The paleoanthropology unit also covers a variety of factual content as well as larger conceptual material. In this way it is also emblematic of the content and pedagogy for the entire course.

Below, I discuss the laboratory workbook and section content for the labs that make up the paleoanthropology unit. In doing so, I consider both the workbook and laboratory section content in the context of the laboratory pedagogy. This provides a framework for my analysis of the effectiveness of this material. First, I present and examine the full-length workbook used in the spring 2007 semester. I then discuss the condensed workbook used in the summer 2007, summer 2008, and summer 2009 semesters, and I consider how the condensed workbook differs from the full-length version.

The Full-Length Workbook

In the full-length workbook used in the spring 2007 semester, the paleoanthropology unit consists of three workbook chapters and corresponding laboratory sections (See Appendix One). This unit is preceded by a unit in evolutionary theory and genetics and by a unit covering issues in primatology. The paleoanthropology unit begins with: “Chapter Seven: The Cenozoic: Early Primate and Hominin Evolution.” This chapter considers major fossil groups and species important to primate evolution. It also includes a consideration of the earliest possible fossils in our unique human evolutionary history: the pre-Australopithecines. The next chapter in the paleoanthropology unit is: “Chapter Eight: The *Australopithecus* Genus, the *Paranthropus* Genus, and the Early *Homo* Genus.” This chapter guides students forward in evolutionary time to examine more recent key fossil species within the human lineage. The final chapter in the unit is: “Chapter Nine: Later Hominins and Culture.” This chapter continues even further through evolutionary time, beginning with important fossil human ancestors and ending with the rise of our own species. Chapter Nine also considers major changes in culture throughout this more recent time period, particularly stone tool production and use.

Chapter Seven: The Cenozoic: Early Primate and Hominin Evolution

As with all of the other laboratory workbook chapters, Chapter Seven begins with several pages of text for the students to read before coming to their laboratory section. The text in this chapter focuses on both the specific traits of key fossil primates and early human ancestors, as well as the larger trends through this period of evolutionary history. Therefore, the text includes both trait lists for the specific species and full paragraphs at the start of each fossil group (and at

the end of the pre-Australopithecine group) that discuss the importance and implications of the particular fossil finds. These fossils are covered chronologically, from the earliest species to appear in the fossil record to the most recent. For the individual fossil species, traits relating to distribution in time and space, physical characteristics, and important behavioral traits (such as special diets or locomotion) are listed in an easy-to-read bullet point format. The decision to list traits in this format, as opposed to integrating the information into a more traditional paragraph format, was made in an effort to draw students' attention to the traits and allow for easy comparisons across fossil species and groups. The paragraphs at the start of each fossil group are then designed to link the fossil groups to each other and to living primate species. In this way, the text seeks to both explicate important fossil traits and contextualize the specific fossil species within a larger understanding of modern primates and their evolutionary history.

The text portion of the chapter, as in the other workbook chapters, is then followed by a "Take Home Quiz" students complete after reading and before coming to class that week. The quizzes in the workbook are designed to help students assess their knowledge of the material presented in the text for that chapter. The quiz questions, therefore, largely target the lowest level of Bloom et al.'s (1956) taxonomy: knowledge. To effectively target this level of learning, the quiz questions primarily ask the students to describe or identify (See Table 3.2).

Table 3.2
Sample Take Home Quiz Questions from Chapter Seven in the Full-Length Workbook

Quiz Question	Skill	Bloom et al.'s (1956) taxonomy level
Many early ape forms appear in the Miocene epoch. Which of these fossils <i>may</i> be an ancestor to modern orangutans?	Identify	Knowledge
Describe the environment in which the pre-Australopithecines live.	Describe	Knowledge
Describe <i>one</i> form of evidence that indicates these species [pre-Australopithecines] were bipedal.	Describe	Knowledge

When taken together, the text and quiz components of the chapter re-present key information from lecture and the textbook and help students assess their own understanding of that information. Because the text is read and the quiz completed before coming to class, students should arrive to their laboratory section equipped with foundational knowledge and an understanding of factual course content. This is then elaborated on by further laboratory exercises that target the higher levels of Bloom et al.'s (1956) taxonomy. By structuring learning in this way, building from foundational knowledge in the reading and quiz to higher-level thinking in the laboratory exercises, Chapter Seven, like the other chapters in the workbook, applies Bloom et al.'s (1956) taxonomy as a framework for helping students develop deeper understandings and higher-level thinking skills.

This process is capped by the laboratory exercises completed by students in their laboratory section. The laboratory exercise for Chapter Seven, as with many of the labs, consists of laboratory station tasks. Students work in small cooperative groups of two or three people.

The groups move with their workbooks to different places in the classroom where various station activities are set up. They complete the task at a given station and then move to another station. The groups continue in this way until they have completed all of the stations for that class meeting. They are free to visit the stations in any order, which allows each group to work at their own pace without feeling pressure from time constraints. The workbook provides the questions for each station and a place for students to write down their answers and take additional notes. The stations primarily provide materials like fossil casts, maps, pictures, and diagrams to be used in answering the station questions from the workbook.

The laboratory exercise for Chapter Seven includes five laboratory stations. Four of the five stations are devoted to fossil primates, and the fifth station addresses the earliest possible fossils in our human lineage (the pre-Australopithecines). Each station asks students to actively engage with station material—comparing, examining, and touching fossil casts—which is designed to increase student participation in learning and foster deep and long-lasting understandings of course content. These deep and long-lasting understandings are further developed through the cooperative nature of the station exercises, and an emphasis on primarily the higher levels of Bloom et al.’s (1956) taxonomy. The station exercises for Chapter Seven largely target comprehension, application, and analysis (See Table 3.3).

Table 3.3
Sample Laboratory Station Tasks from Chapter Seven in the Full-Length Workbook

Station Question	Skill	Bloom et al.’s (1956) taxonomy level
Compare the morphology of the fossil primate and living primate in front of you. What traits do the two share in common?	Compare	Comprehension
What would you use as evidence to support this primate’s relationship to living apes?	Classify	Application
Why might the pre-Australopithecine finds call the Savannah Hypothesis into question?	--Make connections --See patterns	Analysis

Chapter Eight: The *Australopithecus* Genus, the *Paranthropus* Genus, and the Early *Homo* Genus

Again, this chapter begins with several pages of text for students to read before arriving to class. The text of Chapter Eight follows a similar format to that seen in Chapter Seven. Traits for particular fossil species are provided in a bulleted list format, and paragraphs of text introduce the more general groups of fossils, highlighting their relationships to one another and to fossils discussed in the previous chapter.

The quiz that follows the text in Chapter Eight is unlike the quiz format used in the previous chapter. Where the Chapter Seven quiz asks specific questions, the quiz in Chapter Eight asks students to complete a blank chart of the fossil species covered in the chapter (See Table 3.4). Students complete the chart by writing the traits corresponding to each fossil species

in the relevant box of the chart. Chapter Eight presents a substantial amount of factual trait information that is often hard for students to learn and remember. Because of this, the chart is designed to help students re-experience the text by writing some of the information themselves into the chart. While this quiz does not use the traditional question format seen in Chapter Seven, it does still target the knowledge level of Bloom et al.'s (1956) taxonomy, by asking students to list, describe, and identify information. Once completed, the chart also serves as a visual guide to help students see the similarities and differences between the fossil species. Thus, the chart reinforces the text of the chapter and helps prepare students for their laboratory exercises.

Table 3.4
Take Home Quiz Chart from Chapter Eight in Full-Length Workbook

Genus and Species	Dates	Location and Sites	Cranial Traits	Dental Traits	Postcranial Traits and Locomotor Adaptations	Diet, Behavior, and Culture
<i>Australopithecus afarensis</i>						
<i>Australopithecus africanus</i>						
<i>Paranthropus robustus</i>						
<i>Paranthropus boisei</i>						
<i>Homo habilis</i>						

As in Chapter Seven, the laboratory exercises for Chapter Eight take the form of cooperative and interactive laboratory stations. Here, there are four stations. One examines the Australopithecines; another addresses the members of the *Paranthropus* genus; a third compares the *Paranthropus* genus to early members of the *Homo* genus; and a final station considers the Oldowan stone tool technology. Similar to Chapter Seven, each station targets various levels of Bloom et al.'s (1956) taxonomy, particularly comprehension and analysis (See Table 3.5).

Table 3.5
Sample Laboratory Station Tasks from Chapter Eight in the Full-Length Workbook

Station Question	Skill	Bloom et al.'s (1956) taxonomy level
Compare the fossil hominin [<i>Paranthropus robustus</i>] cranium to the contemporary ape [<i>Gorilla gorilla</i>] cranium. What do you notice is morphologically similar between them?	Compare	Comprehension
What behavior common to both species [<i>Paranthropus robustus</i> and <i>Gorilla gorilla</i>] might have led to these similar adaptations?	--See patterns --Recognize hidden meaning	Analysis
How could they [<i>Paranthropus boisei</i> and <i>Homo habilis</i>] have co-existed for so long without out-competing one another for resources?	--Explain --Recognize hidden meaning	Analysis

Chapter Nine: Later Hominins and Culture

The last chapter in the paleoanthropology unit, Chapter Nine, is in many ways very similar to its two companion chapters (Chapters Seven and Eight). Chapter Nine uses the same mixed format of bulleted text and paragraphs to both list important traits for specific fossil species and highlight general similarities and differences between the larger fossil groups. However, Chapter Nine provides more in-depth information about two fossil species (*Homo erectus* and *Homo ergaster*) than is seen in other chapters. Significant debate surrounds the classification of these species as either the same species or two different species. Because of this, Chapter Nine devotes approximately one page of text—in addition to the pages devoted to each of the species separately—to an explicit comparison of these two species in relation to this classification issue. Chapter Nine also includes a closer look at the various stone tool technologies and other cultural elements associated with fossil hominins than is found in the other chapters.

The quiz for Chapter Nine is very similar to that seen in Chapter Eight. The quiz includes two charts for the students to complete. The first chart in Chapter Nine is virtually identical to the chart used as the quiz in the previous chapter; however the fossil species have been changed to those discussed in Chapter Nine (See Table 3.6). The second chart focuses on the stone tool technologies from the chapter, rather than fossil species (See Table 3.7), but its

purpose and design are very similar to the fossil charts used as quizzes in both this chapter and Chapter Eight. Both charts are designed to help students assess their knowledge and reinforce fundamental information before students complete the laboratory exercises in class.

Table 3.6

Take Home Quiz Chart One (Fossil Species) from Chapter Nine in the Full-Length Workbook

Genus and Species	Dates	Location and Sites	Cranial Traits	Dental Traits	Postcranial Traits and Locomotor Adaptations	Diet, Behavior, and Culture
<i>Homo ergaster</i>						
<i>Homo erectus</i>						
<i>Homo neanderthalensis</i>						
<i>Homo sapiens</i>						

Table 3.7

Take Home Quiz Chart Two (Stone Tools) from Chapter Nine in the Full-Length Workbook

Tool Technology	Dates	Locations	Producer/s	Tool Forms	Production
Oldowan					
Acheulian					
Mousterian					
Upper Paleolithic					

As in the other two paleoanthropology chapters, the laboratory exercises in Chapter Nine include cooperative, interactive laboratory station tasks. There are four stations covering the various fossil species and stone tool technologies from the text and quiz. These activities, like those in the previous chapters, are designed to improve student learning by engaging students in cooperative work that builds on foundational knowledge. The laboratory stations in Chapter Nine particularly target the analysis level of Bloom et al.'s (1956) taxonomy (See Table 3.8).

Table 3.8
Sample Laboratory Station Tasks from Chapter Nine in the Full-Length Workbook

Station Question	Skill	Bloom et al.'s (1956) taxonomy level
The stone tool technology of this species [<i>Homo erectus</i>] remained largely unchanged throughout their existence. Why might this have been the case?	--See patterns --Explain	Analysis
How might this form of stone tool technology [Upper Paleolithic] have impacted the ability of this species [<i>Homo sapiens</i>] to live in a variety of environments?	--Explain --Recognize hidden meaning	Analysis
Describe <i>one aspect of tool production</i> that shows incremental change across these four technologies [Oldowan, Acheulian, Mousterian, Upper Paleolithic]?	--See patterns --Order --Arrange	Analysis

In addition to each chapter of the unit internally building from foundational knowledge to higher-level thinking, the unit as a whole is designed to build from one lab to the next. By the final chapter of the unit (Chapter Nine), students have developed a deep understanding of the primary paleoanthropology course content. As a consequence, some class time may be devoted to developing even higher levels of thinking. In addition to the laboratory stations completed as part of the Chapter Nine laboratory exercises, students also participate in a discussion of assigned reading in their laboratory section. The reading assignment for this discussion is a *Scientific American* article by Kate Wong (2000) about Neanderthals. This article was chosen because it provides a variety of information without necessarily privileging any one interpretation of the data. Students draw on a range of data and evidence from the article to consider and evaluate broad issues and ideas in the class discussion, rather than simply reciting opinions and interpretations presented in the article. The article is also useful in that it is written for a general audience, so it is easy for non-expert students to read and understand the material.

Discussion questions for the article are provided in the workbook, and students are encouraged to consider the questions prior to reading the article. It is hoped that this focuses their reading and helps them think about the discussion before coming to class. In laboratory section after students complete the laboratory stations, these discussion questions are then posed to the group at large and discussed openly by the entire class. The discussion questions are designed to target the two highest levels of Bloom et al.'s (1956) taxonomy: synthesis and

evaluation (See Table 3.9). These taxonomy levels are not easily targeted by station activities but are ideal for a discussion format. Therefore, by incorporating discussions (or similar activities) into each of the four major units of the workbook, I am able to engage students actively in their learning, help students develop important communication skills, *and* round-out the workbook and laboratory sections such that they target *all* levels of Bloom et al.'s (1956) taxonomy.

Table 3.9
Discussion Questions from Chapter Nine in the Full-Length Workbook (NOTE: These discussion questions are identical to those used in Chapter Five of the Condensed Workbook.)

Discussion Question	Skill	Bloom et al.'s (1956) taxonomy level
Is it possible that humans and Neanderthals interacted (through trade, interbreeding, etc.)? What lines of evidence would you use to support your answer?	--Combine information --Draw conclusions	Synthesis
What evidence might support the idea that humans were better adapted to the Upper Paleolithic European environment than Neanderthals? What evidence might contradict this idea?	--Judge --Discriminate	Evaluation
What do <i>you</i> think caused/influenced the extinction of the Neanderthals? Why?	--Combine information --Draw conclusions --Judge	--Synthesis --Evaluation

The Condensed Workbook

In the condensed workbook used in the summer 2007, summer 2008, and summer 2009 semesters, the paleoanthropology unit consists of only two workbook chapters and corresponding laboratory sections (See Appendix Two). As in the full-length workbook, the paleoanthropology unit of the condensed workbook is preceded by the evolutionary theory and genetics unit, as well as the primatology unit. The first chapter of the paleoanthropology unit in the condensed workbook is: "Chapter Four: Comparative Anatomy and Early Primate and Hominin Evolution." This chapter is a combination of Chapter Six and Chapter Seven of the full-length workbook, and it begins with comparative primate anatomy (found in Chapter Six of the full-length workbook). The remainder of the chapter in the condensed workbook is similar to Chapter Seven of the full-length workbook, examining the evolution of primates and early human ancestors (the pre-Australopithecines). However, the condensed version does not cover as many specific fossil primates as the full-length version. The second chapter in the paleoanthropology unit of the condensed workbook is: "Chapter Five: The Fossil Hominins (*Australopithecus* through *Homo*)." This chapter combines Chapters Eight and Nine of the full-length workbook. However, a few

specific fossil species are not covered in the summer session, and the stone tool technologies are not as heavily emphasized.

Chapter Four: Comparative Anatomy and Early Primate and Hominin Evolution

As in the full-length workbook, this chapter combines traits list for individual fossil species with paragraphs of text that consider the general fossil groups. While the chapter does include comparative primate anatomy, as noted above, only the primate and hominin evolution sections of the chapter are considered here, in order to make fair comparisons between this and the full-length workbook. The primate evolution material is condensed to a fewer number of key species, such that only two fossil primate species are considered, whereas nine are considered in the full-length workbook. These two species, however, are two of the species highlighted in the full-length workbook quiz and laboratory exercises. Similarly, while the condensed workbook maintains most of the information on the pre-Australopithecine species found in the full-length workbook, the information is shortened to emphasize locomotor traits and downplay other physical traits. Again, the material that is maintained is the primary information for the full-length version quiz and laboratory exercises. Despite the loss of some content in the condensed workbook, the maintenance of the key fossil species and information results in relatively similar quizzes and laboratory exercises between the condensed and full-length workbooks.

The quiz in Chapter Four includes questions about comparative primate anatomy and fossil primate and hominin evolution. However, the comparative anatomy material will not be considered here. Not all of the full-length version quiz questions about primate and hominin evolution are carried over to the condensed workbook because not all of the same species are discussed. Nevertheless, the questions that do address primate and early hominin evolution in the condensed workbook are identical to some of the questions found in the full-length workbook (See Table 3.10). Therefore, as in Chapter Seven of the full-length workbook, the quiz questions for Chapter Four of the condensed workbook target the knowledge level of Bloom et al.’s (1956) taxonomy.

Table 3.10
Sample Take Home Quiz Questions from Chapter Four in the Condensed Workbook
 (NOTE: These questions are identical to three of the questions found in Chapter Seven of the full-length workbook; see Table 3.2.)

Quiz Question	Skill	Bloom et al.’s (1956) taxonomy level
Many early ape forms appear in the Miocene epoch. Which of these fossils <i>may</i> be an ancestor to modern orangutans?	Identify	Knowledge
Describe the environment in which the pre-Australopithecines live.	Describe	Knowledge
Describe <i>one</i> form of evidence that indicates these species [pre-Australopithecines] were bipedal.	Describe	Knowledge

The laboratory exercises for Chapter Four are also similar to those for the same material in the full-length workbook. The exercises are cooperative, interactive stations that engage students with station materials and build on foundational knowledge to help students develop deeper understandings. There are eight laboratory stations; six of those stations cover comparative primate anatomy and are not considered here. The remaining two stations cover fossil primates and pre-Australopithecines, using identical questions to those used in the Chapter Seven stations of the full-length workbook (See Table 3.11). Similar to the corresponding chapter of the full-length workbook, the laboratory stations in Chapter Four target the application and analysis levels of Bloom et al.'s (1956) taxonomy.

Table 3.11
Sample Laboratory Station Tasks from Chapter Four in the Condensed Workbook (NOTE: These questions are identical to two of the questions found in Chapter Seven of the full-length workbook; see Table 3.3.)

Station Question	Skill	Bloom et al.'s (1956) taxonomy level
What would you use as evidence to support this primate's relationship to living apes?	Classify	Application
Why might the pre-Australopithecine finds call the Savannah Hypothesis into question?	--Make connections --See patterns	Analysis

Chapter Five: The Fossil Hominins (*Australopithecus* through *Homo*)

This chapter is a combination of Chapters Eight and Nine of the full-length workbook, however some content is lost in the condensing. Chapter Five of the condensed workbook does not include the species *Paranthropus robustus*; it does not include an in-depth look at the various stone tool technologies; and it includes only the comparison of *Homo erectus* and *Homo ergaster*, not the additional information about each species separately. The remaining content is the same, and it is presented in the same format combining trait lists and contextualizing paragraphs.

The quiz for Chapter Five is also very similar to those used in the corresponding chapters of the full-length workbook. Students are given two charts to complete, again in hopes that completing the charts will help reinforce students' reading and target the knowledge level of Bloom et al.'s (1956) taxonomy. The first chart is almost identical to that used in Chapter Eight of the full-length workbook, except that the species not covered in Chapter Five (*Paranthropus robustus*) has been removed and the columns for "Dates" and "Location and Sites" have been combined (See Table 3.12). Combining these two columns into one is a consequence of a slight shift in content focus in the much shorter summer terms, where some of the specifics (like individual fossil sites) are not as heavily emphasized. The second quiz chart in Chapter Five is almost identical to the fossil chart used in Chapter Nine of the full-length workbook (See Table 3.13). However, here too the specific fossil sites are downplayed. The Chapter Five quiz does

not include a chart for stone tools like that seen in the full-length workbook because, again, stone tool technologies are de-emphasized somewhat in the shorter summer terms.

Table 3.12

Take Home Quiz Chart One from Chapter Five in the Condensed Workbook (NOTE: This is identical to the Chapter Eight quiz chart, with the exception that the *Paranthropus robustus* row has been removed and the specific sites have been de-emphasized; see Table 3.4.)

Genus and Species	Dates and Locations	Cranial Traits	Dental Traits	Postcranial Traits and Locomotor Adaptations	Diet, Behavior, and Culture
<i>Australopithecus afarensis</i>					
<i>Australopithecus africanus</i>					
<i>Paranthropus boisei</i>					
<i>Homo habilis</i>					

Table 3.13

Take Home Quiz Chart Two from Chapter Five in the Condensed Workbook (NOTE: This is identical to the first Chapter Nine quiz chart (fossil species), with the exception that the specific sites have been de-emphasized; see Table 3.6.)

Genus and Species	Dates and Locations	Cranial Traits	Dental Traits	Postcranial Traits and Locomotor Adaptations	Diet, Behavior, and Culture
<i>Homo ergaster</i>					
<i>Homo erectus</i>					
<i>Homo neanderthalensis</i>					
<i>Homo sapiens</i>					

The laboratory exercises in Chapter Five are again comparable to those used in the corresponding chapters of the full-length workbook. Cooperative, interactive laboratory stations are used to engage students and help them build from foundational information to higher-level thinking, particularly the application and analysis levels of Bloom et al.'s (1956) taxonomy (See Table 3.14). There are four laboratory stations. One station asks students to examine Australopithecines and members of the *Paranthropus* genus, with an eye toward classification of the fossil groups; a second station has students compare the *Paranthropus* genus to early members of the *Homo* genus; another station emphasizes *Homo erectus*; and a final station addresses Neanderthals and humans. The second and third stations in this list are identical to stations used in Chapter Eight and Nine of the full-length workbook, respectively.

Table 3.14

Sample Laboratory Station Tasks from Chapter Five in the Condensed Workbook

(NOTE: The second and third questions are identical to questions found in Chapters Eight and Nine of the full-length workbook; see Table 3.5 and Table 3.8.)

Station Question	Skill	Bloom et al.'s (1956) taxonomy level
How do these differences [in morphology between <i>Australopithecus afarensis</i> and <i>Paranthropus boisei</i>] impact the way we classify these species?	--Classify --Make connections	--Application --Analysis
How could they [<i>Paranthropus boisei</i> and <i>Homo habilis</i>] have co-existed for so long without out-competing one another for resources?	--Explain --Recognize hidden meaning	Analysis
The stone tool technology of this species [<i>Homo erectus</i>] remained largely unchanged throughout their existence. Why might this have been the case?	--See patterns --Explain	Analysis

As was noted above, the workbook units are designed to build to the highest levels of Bloom et al.'s (1956) taxonomy by incorporating a class discussion or other similar activity at the end of each unit. The paleoanthropology unit in the condensed workbook is capped by the same discussion as is found in Chapter Nine of the full-length workbook. Students are asked to read the same article about Neanderthals (available on the course website) and review the discussion questions in the workbook before coming to laboratory section. After completing the four laboratory stations in class, students participate in a class discussion using the questions in the workbook as a guide. These questions are identical to those used in the full-length version (See Table 3.9). As such, this discussion, like its counterpart in the full-length workbook, targets the two highest levels of Bloom et al.'s (1956) taxonomy (synthesis and evaluation) and encourages student engagement with and further understanding of course content.

Summary

Though there are some differences between the condensed and full-length workbooks, most of the differences are minor and are the result of a shifted content focus in the shorter summer term. For the most part, the workbook text, quizzes, and laboratory exercises are comparable if not identical. In both versions of the workbook, the chapters are designed to help students build foundational knowledge through reading and quizzes. This knowledge is then fostered and encouraged to grow into higher-level thinking and deeper understanding through cooperative, interactive laboratory exercises. The workbook units also build to a class discussion or similar activity that targets the very highest levels of thinking and understanding and actively engages students with course content. In the paleoanthropology unit, this takes the form of a discussion about Neanderthals (facilitated by an assigned article on the topic).

In this chapter, I have laid out the overall pedagogy for the Anthropology 1 course. I have drawn particular attention to the laboratory section and laboratory workbook pedagogy as part of this. I have demonstrated how the workbook and section pedagogy are grounded in the theoretical framework outlined in the previous chapter, and I have used the paleoanthropology unit of the workbook as an example to highlight this. In future chapters, this paleoanthropology unit, and the students' learning of this material, is the basis of my consideration of the effectiveness of the overall workbook and laboratory pedagogy.

CHAPTER FOUR: METHODS

In Chapters Two and Three, I outlined my goals in designing an effective pedagogy. These goals are threefold and can be usefully applied to the development and implementation of any effective means of college instruction: 1. meaningful engagement of students in the learning experience, 2. initial high quality student learning of course material, and 3. long-term student retention of learned course material. If these are the three key components of effective teaching, it follows that these should be the components tested when determining teaching effectiveness. As such, I here seek to address the following research questions in evaluating the effectiveness of active and cooperative laboratory pedagogy in biological anthropology instruction: 1. Do students meaningfully engage with course material in the classroom? 2. Do students demonstrate initial high quality learning of key course material? 3. Do students retain their understanding of course material long after the course has ended? To each of these primary research questions, I then add several additional questions.

In addition to my concerns about student learning of course material, I have added the issue of multiple learning styles. In this course, as in many introductory courses, students represent a wide range of learning styles and backgrounds. To address this diversity, I seek to design a pedagogy that benefits students from these various backgrounds. With this goal in mind, I must also ask: 1. Do all students, across various learning styles, meaningfully engage with course material equally? 2. Do all students demonstrate initial high quality learning to similar degrees? 3. Do all students retain course material equally through time?

Similarly, the other goal I outlined specific to this course context was the goal of structuring laboratory assignments in a way that fosters the development of higher-level thinking skills, such as synthesis and evaluation. The research discussed here must therefore also evaluate my laboratory pedagogy along this dimension. This raises three final research questions: 1. Do students of all learning styles demonstrate meaningful engagement with and use of high-level thinking skills in the classroom? 2. Do students of all learning styles demonstrate initial learning of high-level thinking skills? 3. Do students of all learning styles demonstrate retention of high-level thinking skills after the course's conclusion?

All of the research questions considered here are applied only to the paleoanthropology unit of the Anthropology 1 laboratory workbook. As previously noted, evaluating the entirety of the laboratory pedagogy and workbook is beyond the scope of this work, and I therefore choose to focus on this unit as a sample of the larger pedagogy.

It may be noted that all of my stated research questions emphasize the students but are suggested as ways of evaluating my laboratory pedagogy. However, as previously discussed, the laboratory pedagogy I designed and implemented follows an active, cooperative approach that places students at the center of the learning experience. Following this theoretical framework, it is necessary to evaluate the effectiveness of any teaching approach through a consideration of the students, rather than the instructor or instructional tools per se. The research questions addressed here, therefore, emphasize the students as the center of all learning *and* teaching.

Evaluating Student Engagement

Three research questions have been stated that address student engagement. The primary question asks whether students generally engage with course material in the classroom. The two subsidiary questions ask whether this engagement is uniform across various learning styles and

whether student engagement includes engagement with higher-level thinking skills, such as synthesis and evaluation. To answer these questions, I draw from ethnographic experiences. While acting as the Graduate Student Instructor for the Anthropology 1 course in the summer 2009 term, I completed extensive notes on both student practices and my own practices in the classroom. Conducted in the style of participant observation research, this data forms the foundation of my evaluation of student engagement and is hereafter referred to as “the field notes” or “observations.”

During the period of observation in the summer 2009 term, there were a total of forty students distributed relatively equally across three laboratory discussion sections. As previously discussed, in summer terms, each laboratory section meets twice a week for one hour and twenty minutes (a total of two hours and forty minutes per week). Laboratory sections began meeting on Wednesday, May 27, 2009 and continued until Tuesday, June 30, 2009 during the six-week summer 2009 term. There were approximately nine class meetings for each of the three laboratory discussion sections (twenty-seven class meetings total when all three laboratory sections are combined) throughout this time. All together, this term yielded approximately twelve hours of classroom observation for each of the laboratory sections and the forty students distributed across these sections.

Comparing the data presented in Chapter Three regarding students’ self-identified college major across all semesters to a subset of that data from the summer 2009 term alone, it is notable that the summer 2009 students are relatively representative of the general major distributions seen across all the semesters studied here (See Figure 4.1 and Table 4.1). Generally, psychology is the most common student major, followed closely by anthropology and other social sciences. Biological sciences are also common in both the summer 2009 semester alone and the total across semesters. Art/humanities, business, mathematics and engineering, and physical and environmental sciences are all generally less common majors for Anthropology 1 students. However, in the summer 2009 term, mathematics and engineering majors were more common than usual, with 14.3% of summer 2009 students identifying as mathematics and engineering majors compared to only 5.2% of students across all semesters. At the same time, while physical and environmental science majors comprise 4% of student majors across all semesters, none of the summer 2009 students identified as physical and environmental science majors. Finally, some students are undecided about their major, although this was less common in the summer 2009 term than in general (3.6% of students in the summer 2009 term compared to 10.8% of students overall). This may reflect the higher number of transfer students and students in their third or fourth year of college sometimes seen in summer terms. These students often are further into their college experience and may have a clearer sense for their major and degree intentions than a student in their first or second year of college. Despite these differences, the summer 2009 term does seem to offer a range of majors that is in many ways similar to the range seen across all of the semesters studied. As discussed in Chapter Three, these discipline majors are used here as a proxy for recognizing and examining student variation in learning style. Therefore, the summer 2009 term has variation in student majors *and* learning styles similar to that generally seen across the semesters studied.

The field notes address general issues of student engagement through observations of: students’ overall attention to tasks, students’ communication with each other in cooperative tasks, students’ formulation of deeper understandings (as demonstrated through student comments and questions related to but not explicitly required in laboratory tasks or student comments that synthesize information from various sources, such as the laboratory workbook,

lecture, and textbook), and students' participation in discussions. Additionally, because the summer 2009 term has learning style variation similar to that seen across the entirety of the study population, the field notes compiled during this particular term can be used to examine issues of student engagement relative to learning style difference. Finally, the field notes include observations of students at various activities, including laboratory station tasks and in-class discussions. These activities and assignments target different levels of Bloom's taxonomy, including higher-level thinking skills; and data from the field notes may help examine issues of student engagement across these levels of thinking.

Figure 4.1

Anthropology 1 Student Majors: A Comparison of the Summer 2009 Term to the Total

Both of these charts are based on students' self-identifying responses to the question, "What is your (intended) major?" on anonymous feedback forms administered at the end of the course. The chart on the left includes only data from students in the summer 2009 semester. The chart on the right includes data from students in the spring 2007, summer 2007, summer 2008, and summer 2009 semesters together. For ease of presentation, both charts exclude additional students from the semesters in question who either did not provide any major or provided more than one major in response to the question (7 students excluded from chart on left; 81 students excluded from chart on right).

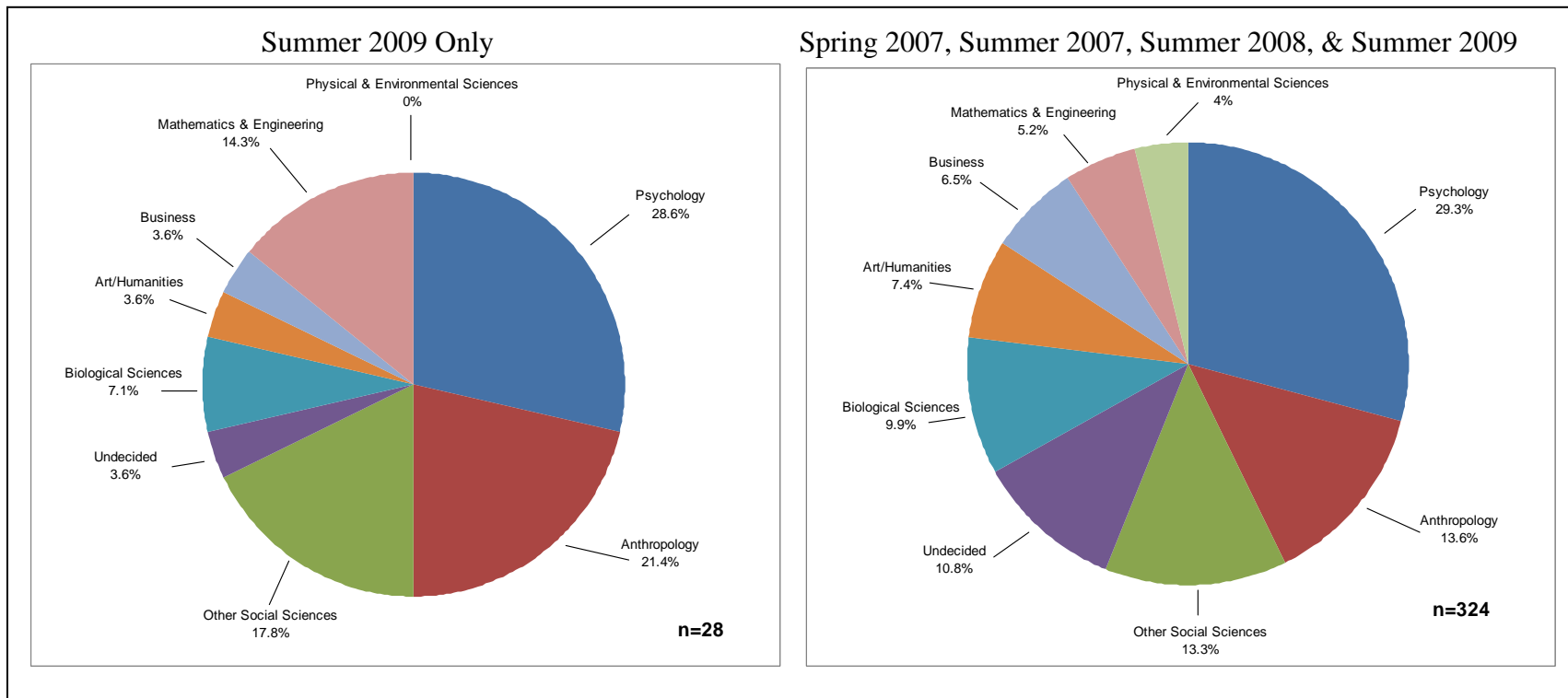


Table 4.1

Anthropology 1 Student Majors: Further Comparison of the Summer 2009 Term to the Total

This table uses the same data as is used in Figure 3.1 and Figure 4.1. It gives the total number of self-identified majors taken from anonymous feedback forms administered at the end of the course. The table provides a comparison of this data as seen only in the summer 2009 term versus as seen in the spring 2007, summer 2007, summer 2008, and summer 2009 semesters combined. Again, to facilitate presentation, that table excludes 81 students from the semesters in question who either did not provide any major or provided more than one major in response to the question.

Student Self-Identified Major	# of Students in Summer 2009 only (n=28)	# of Students Across All Semesters (n=324)
Psychology	8	95
Anthropology	6	44
Other Social Sciences	5	43
Undecided	1	35
Biological Sciences	2	32
Art/Humanities	1	24
Business	1	21
Mathematics and Engineering	4	17
Physical and Environmental Sciences	0	13

Evaluating Initial Student Learning

In addition to the questions related to student engagement, three of my stated research questions tackle issues of initial student learning of course material. The principal question asks whether students generally demonstrate high initial learning of course concepts. The two secondary questions address whether initial learning is similar across all learning styles and whether initial learning of higher-level thinking skills is demonstrated. To evaluate initial learning, I examine results from the final examinations completed by 354 students in spring 2007, 41 students in summer 2007, 32 students in summer 2008, and 39 students in summer 2009 (466 students total). These exams are the only context in which student learning of the paleoanthropology course material is directly quantified during the course. As such, the exams are the most readily applicable source of data for addressing initial student learning.

The final exam in the course is administered at the end of the term. In the spring 2007 semester, it was administered approximately seven weeks after the conclusion of the paleoanthropology unit. In the summer 2007, summer 2008, and summer 2009 semesters, it was administered approximately two weeks after the conclusion of the paleoanthropology unit, due to variation between the length of the spring and summer terms as previously noted. In all terms, the exam is primarily comprised of multiple choice questions. Each question has five possible answer choices from which students must choose the best possible answer. The exam also includes a variety of short answer question formats, including matching, fill-in-the-blank, identification of material in diagrams and pictures, interpretation of anatomy seen in pictures,

and open-ended questions requiring a one to three sentence student response. I will make use of both multiple choice and short answer question data here.

Importantly, the paleoanthropology course material is not the only material tested on the final exam. The exam is cumulative and evaluates student learning of the entire term's course content. However, the exam does emphasize material covered after the midterm—that is the paleoanthropology unit and the modern human biology unit—so the final exams provide ample data relevant to the paleoanthropology unit.

Simply looking at student performance on paleoanthropology-related exam questions is not enough to address the research questions here. This dissertation seeks to specifically evaluate the pedagogy implemented in the laboratory portion of the course, and the exam tests students on content presented in all aspects of the course, including lecture, reading, and laboratory. To target the laboratory pedagogy specifically, I examine student performance on exam questions that address paleoanthropology material explicitly covered as part of the laboratory pedagogy. This material is also often covered in lecture or assigned readings, so the data is not purely related to the laboratory alone. However, I compare student performance on exam questions covering paleoanthropology material from laboratory to student performance on exam questions covering paleoanthropology material from lecture. This helps me to examine whether the laboratory pedagogy, in particular, promotes high quality initial student learning. The hypothesis is: if the laboratory pedagogy effectively fosters initial student learning of paleoanthropology material, students will perform more accurately on exam questions targeting paleoanthropology material covered in the laboratory than they will on exam questions targeting paleoanthropology material covered only in non-laboratory contexts.

One of the research questions outlined seeks to address possible variations in student learning of paleoanthropology course content as related to student learning style. Unfortunately, the data available for examining initial student learning of the paleoanthropology material is limited to the final exam data presented here. This final exam data cannot, at this time, be successfully matched to student major and therefore cannot be matched to student learning style. Students enrolled in the course could be identified to the major listed in the official university records at the time the course was underway. However, because this course is a prerequisite for declaring many majors on campus, an overwhelming majority of students are officially listed as “undeclared” at the time the course is administered. Students did provide their “intended” major as part of the feedback forms used in this and earlier chapters to discuss diversity in student majors in general, but these feedback forms are anonymous and cannot be suitably linked back to individual students. As such, issues of variation in initial learning as related to student learning style cannot be adequately examined at this time. However, the exam data does allow for examination of the other two research questions, addressing initial student learning overall and initial learning of higher-level thinking skills more specifically.

Evaluating Student Retention

My final three research questions address the issue of long-term student retention of learned course material. The primary question asks whether students generally retain learned course material after no-longer being in the course. The supplementary questions ask whether retention is similar across learning styles and whether students specifically retain their learned higher-level thinking skills after the completion of the course.

To address student retention, I asked Anthropology 1 students to complete a survey with questions related to the paleoanthropology course content after the conclusion of the course (See

Figure 4.2). I administered the survey at roughly the same time in the summer of 2009 for all of the terms under study. This provides me with a longitudinal perspective, where spring 2007 and summer 2007 students took the survey approximately two years after their completion of the course and summer 2008 students took the survey approximately one year after their completion of the course. I administered the survey to the summer 2009 students in the fall of 2009, approximately three months after their completion of the course. In general, this allows me to look at student retention at various points over the course of two years.

Figure 4.2

Survey Administered to Former Anthropology 1 Students

Anthropology 1: Introduction to Biological Anthropology Survey

Please complete the following questions to the best of your ability and memory.

- For multiple choice questions, please type the letter that corresponds to the answer you think is the ONE best answer in the textbox below the question.
- For all other questions, please type your answer in the textbox provided.

When you have completed BOTH pages of the survey, please email it back to Liz Soluri (Lead Investigator) by following these steps:

- Save the document to your computer (to save the changes you made).
 - Return the saved document as an email attachment to Liz Soluri: lsoluri@berkeley.edu
 - If you have any technical problems with the document, please contact Liz Soluri (lsoluri@berkeley.edu) for assistance.
-

1. What is/was your intended/declared major? (If more than one, please give all majors)

2. What was your favorite lab?

3. What was your least favorite lab?

4. The fossil skeleton named “Lucy” belongs to which species?

- A. *Australopithecus afarensis*
- B. *Homo erectus*
- C. *Paranthropus boisei*
- D. *Homo habilis*
- E. *Ardipithecus ramidus*

5. Which of the following statements is TRUE regarding the fossil species *Homo habilis* and *Homo erectus*?

- A. *Homo habilis* and *Homo erectus* lived together for over two million years.
- B. *Homo erectus* had a smaller cranial capacity than *Homo habilis*.
- C. *Homo habilis* was specialized for living in a cold habitat and *Homo erectus* was not.
- D. *Homo erectus* left Africa while *Homo habilis* did not.
- E. *Homo habilis* had a more complicated stone tool technology than *Homo erectus*.

Figure 4.2 (continued)
Survey Administered to Former Anthropology 1 Students

6. Which of the following statements is TRUE regarding Oldowan and Upper Paleolithic stone tool technologies?

- A. Upper Paleolithic tool forms were more specialized than Oldowan tool forms.
- B. Oldowan tools appear in Europe and Upper Paleolithic tools do not.
- C. Both Oldowan and Upper Paleolithic tools were used by *Homo sapiens*.
- D. Oldowan tool makers were more selective of raw materials than Upper Paleolithic tool makers.
- E. The Oldowan tool production process was more complicated than the production process for Upper Paleolithic tools.

7. The fossil genus *Paranthropus* is characterized by the following traits: large sagittal crest, large brow ridges, large zygomatic arches, and very large molars with thick enamel. What do these traits suggest about the diet of *Paranthropus* species?

- A. They had a diet that emphasized fruit.
- B. They had a diet that emphasized tree gums.
- C. They had a diet that was largely omnivorous.
- D. They had a diet that emphasized insects.
- E. They had a diet that emphasized heavy plant material.

8. The large nasal opening, complex turbinate bones, and robust body of Neanderthals suggest:

- A. They were adapted for a diet consisting of mostly fruits.
- B. They were adapted for a cold, Ice Age environment.
- C. They were adapted for intense male-male competition.
- D. They were adapted for a warm, desert environment.
- E. They were adapted for a diet consisting of mostly tough plants.

9. Members of the species *Homo erectus* used the same Acheulian stone tool technology for over one million years and in a variety of environments. Why didn't they change this technology at some point?

10. As you learned in this course, biological anthropologists try to use the anatomy of fossils to reconstruct their likely behavior in the past. Imagine you are working in a biological anthropology lab, and you are examining a group of 50 fossils from the same species. The fossils show what appears to be a high degree of sexual dimorphism, with half of the skeletons showing larger canine size and overall body size than the other half. Using this information, what do you expect was the likely social organization of this species?

The survey asks ten questions and was approved by the Committee for Protection of Human Subjects at the University of California, Berkeley (CPHS # 2009-4-29). The first three survey questions are open-ended and target information about the survey participants. The first survey question asks about the student's major. Because I use student major as a proxy for student learning style, this information is key to answering the research question of whether the laboratory pedagogy fosters retention of learned course material across different learning styles. The second and third survey questions ask about the student's favorite and least favorite laboratory assignments, respectively. This information is collected in order to account for any potential bias to the data that may result from students being particularly partial or impartial to the paleoanthropology laboratory assignments under study.

The remaining seven survey questions address paleoanthropology content covered in the laboratory pedagogy of the course. All of my research questions related to student retention specifically address the retention of *learned* course material. Certainly, one can only retain what one already knows, and this must be taken into account when examining student retention. Students may stumble upon the correct answer in the survey without this being a reflection of their retention of learned material. To account for this, I use survey questions that mimic final exam questions in both format and content, so that I am then able to compare a student's survey performance on a given question to their performance on a similar final exam question. If a student accurately responds to a survey question but did not accurately respond to a similar question on their final exam, the survey data for that question is excluded, as it likely does not reflect retention of learned material.

While the survey questions are similar to questions used on the final examinations administered in the terms under study, the survey questions are not identical to any of these final exam questions. Rather, the survey questions are of similar formats and ask about similar content as the final exam questions. While asking survey questions that are identical to the previously administered final exam questions would aid in a direct consideration of student retention, it would not readily allow for retention comparisons across the two-year time period examined here. The format and content of final exam questions was largely similar across the terms studied here, but the actual details of the questions varied considerably across these semesters. Repeating the exam questions in the survey would have resulted in four very different surveys. This would have greatly limited the potential for consideration of student retention from the longitudinal perspective sought here. Instead, each of the survey questions related to paleoanthropology material is entirely new, never before seen by any of the former students, though the general content and format is familiar to the students. Additionally, all of the former students are given the exact same survey no matter what semester they completed the Anthropology 1 course. These two elements of the survey design (new questions and uniformity across semesters) facilitate my comparisons of student retention across the two-year period studied.

The paleoanthropology content questions on the survey take two formats, mirroring those found on final examinations: multiple choice questions and open-ended, short answer questions. Questions four through eight of the survey are multiple choice questions, each with five possible answer choices. Students are instructed to select the one, best possible answer of the five options. Questions nine and ten are open-ended, short answer questions, where students were able to respond with any answer and amount of information they chose. Below, I provide details about each of these seven paleoanthropology content questions from the survey.

The necessity of comparing student performance on survey questions to student performance on similar final exam questions in order to determine retention of learned material impacted the eligibility of students for survey participation. Only those students from the spring 2007, summer 2007, summer 2008, and summer 2009 semesters who had completed a final exam in the course were eligible for survey participation. These students were contacted via email and asked to complete the electronic survey and return it via email. The administration of the survey via email was meant to increase survey participation, as many of the former students, particularly those from the 2007 semesters, were no longer on campus to complete a survey in person when the survey was administered in 2009. However, changes made to university email access over the summer of 2009 may have negatively impacted my ability to contact students for participation in the survey, particularly students from the spring 2007 and summer 2007 semesters who were more likely to have graduated by summer 2009 than students from the other semesters. In all, 466 students were considered eligible for the survey because they had completed a final exam in the course (See Table 4.2). Of those 466 students, only 404 had active university emails and were contacted using those email accounts; and 41 of the students contacted completed and returned surveys. The overall survey response rate was 10% (calculated as a percentage of student surveys received relative to the number of students contacted).

The spring 2007 semester had the lowest response rate (7%). Because the response rate is calculated relative to the number of students contacted (rather than the number of students eligible), the lower response rate for this semester cannot be explained simply as a result of students' inaccessibility to the emailed survey. Instead, a likely contributing factor is the two-year time period between the students' completion of the course and the administration of the survey. By the summer of 2009, many of the spring 2007 students had graduated and left the immediate university community. While they may have maintained active email accounts with university, these accounts may not have been checked regularly by students. Also, students may have felt a greater disconnect from the course and/or university by summer 2009 and therefore were less likely to participate in the survey.

In contrast to the spring 2007 semester low response rate, the summer 2009 semester had a dramatically higher response rate of 30%. All of the eligible summer 2009 students were contacted because their university email accounts were active at the time of survey administration (fall 2009 for these students). However, as with the spring 2007 response rate, the ability to contact the eligible students has no direct bearing on the response rate itself. A contributing factor here may instead be the reverse of that seen with the spring 2007 semester. Students from the summer 2009 semester were contacted regarding the survey only three months after completing the course. These students may have been more currently active in the university community and more likely to regularly check their university email accounts than students from earlier semesters. The summer 2009 students may have also felt more closely connected to the course, since it had only recently concluded. These factors may have contributed to the dramatically higher response rate seen in summer 2009.

While the overall survey response rate was only 10%, the available data does permit preliminary examination of the research questions related to student retention of learned paleoanthropology course content over time.

Table 4.2
Survey Response Rates by Semester

NOTE: The number of students contacted is lower than the total number of students eligible for the survey in any given semester. This is due to lapses in students' university email accounts. This is a greater problem in the 2007 semesters because many of these students had left the university community since completing the course. The Response Rate is given as a percentage (the number of student surveys received relative to the number of students contacted).

Semester	# of Students Eligible for Survey	# of Students Contacted	# of Student Surveys Received	Response Rate
Spring 2007	354	312	22	7%
Summer 2007	41	26	4	15%
Summer 2008	32	27	3	11%
Summer 2009	39	39	12	30%
TOTAL	466	404	41	10%

The Paleoanthropology Content Questions of the Survey

The laboratory pedagogy is designed to foster student learning at all levels of Bloom's taxonomy, therefore the survey questions, like their final examination question parallels, were designed to target different levels of the taxonomy. However, the survey also needed to remain relatively short in order to encourage, rather than discourage, former students' participation in the survey. Because of this, the majority of questions on the survey target higher-level thinking skills, and only one question targets lower-level thinking skills. This prevents the running of meaningful statistical analyses related to the retention of lower-level and higher-level skills as separate subsets of the data. These forms of analysis are, however, possible with the final exam data to explore initial student learning at different levels of thinking. Thus, in analyzing the survey data, I will focus on overall retention in general, and I will attempt to provide preliminary suggestions about retention at different levels of thinking when possible.

Survey question four is a multiple choice question that asks students to correctly identify the genus and species name for the famous fossil specimen "Lucy." This question is designed to target the lowest level of Bloom's taxonomy: knowledge. It asks students to simply recall a fact about a particular fossil specimen. High retention scores on this question might indicate the laboratory pedagogy effectively fosters the retention of foundational knowledge upon which higher-level skills are built.

Question five is another multiple choice question. It asks students to select the true comparative statement about *Homo habilis* and *Homo erectus* (two fossil hominin species). This question targets the comprehension level of Bloom's taxonomy, as it asks students to correctly compare the two stated fossil species. The question requires students to not just recall facts about each species but to also compare the information they learned about the species. For example, answer choice "E" states: "*Homo habilis* had a more complicated stone tool technology than *Homo erectus*." In order to recognize that this statement is false (and therefore not the correct answer to the question), the student must remember the stone tool technologies of each species *and* compare those technologies against one another. This is higher-level thinking skill than simply recalling facts.

Question six is similar to question five in that it also is a multiple choice question asking students to choose the true comparative statement from the given options. However, this question specifically asks about stone tool technologies, rather than fossil species. Again, because the answer choices all have comparisons within them, students must recall the foundational facts and be able to usefully compare them in order to identify the correct answer. This question also targets the higher-level thinking skill of comprehension.

In question seven (also a multiple choice question), students are provided with the anatomical traits of a particular fossil genus and then asked what these facts imply about the behavior of this fossil group. Here, students are asked to recall key concepts from the course regarding the relationship between behavior and anatomical adaptation. More importantly, in order to answer the question, students must use the general concept of dietary adaptation to address the particular anatomy of the given species. The students must use another higher-level thinking skill: application.

Similarly, question eight (the final multiple choice question) also asks students to apply the concept of anatomical adaptation to a particular species. Students are provided a list of anatomical traits for a given fossil species and asked what these traits suggest about the species' adaptation. The answer choices include various types of adaptations, such as dietary adaptations, climatological adaptations, and social behavior adaptations. Again, students must apply their conceptual knowledge to the specific situation given.

Question nine is the first of two open-ended, short answer questions. It asks a more hypothetical question. Students are given information about a fossil species' tool use and asked why this situation may have been the case. Answering this question requires that students consider knowledge from different areas, such as the tool technology and species in question, the environment of the time, and the intellectual capabilities of the species. Students must synthesize information from these various sources and suggest a likely explanation. They must also discriminate which of these factors probably had the biggest impact in the past. Therefore, this question draws on the higher-level thinking skill of synthesis, and it may also include some elements of higher-level evaluation skills.

Finally, question ten is another short answer question. It provides information about a hypothetical assemblage of bones in a biological anthropology laboratory. The students are given basic information about the bones and asked what this information suggests about the social organization of this species. In order to answer the question, students must again apply the concept about the relationship between behavior and anatomical adaptation. But, here they must also take this application one step further than was seen in the multiple choice questions. Because they cannot use process of elimination to help them narrow down to an appropriate answer (as in multiple choice questions), the students must draw their conclusions entirely on their own using the information provided. In doing this, the students must discriminate between the possible explanations that come to mind and suggest a reasonable explanation. Like question nine, this question also requires higher-level synthesis and, potentially, evaluation skills.

When taken all together and compared to performance on similar final exam questions, student responses to questions four through ten provide data regarding the overall retention of paleoanthropology course content. When taken separately, survey question four may provide preliminary data regarding student retention of foundational knowledge, whereas questions five through ten may provide preliminary data related to student retention of various higher-level thinking skills.

Summary

To evaluate the effectiveness of my active, cooperative laboratory pedagogy, I must address whether the students engage with course material in the classroom, whether the students initially learn the course material, and whether the students retain the material they learn in the course over the long-term. In addition, because my pedagogy is explicitly designed to benefit students of various learning styles and to foster student development of higher-level thinking skills, I must also address, where possible, whether student engagement, learning, and retention are uniform across all students and whether students engage with, learn, and retain higher-level thinking skills in particular. In order to answer these questions and thoroughly evaluate my pedagogical approach, I will use: ethnographic data; final exam data; and re-testing, survey data.

CHAPTER FIVE: RESULTS

This chapter summarizes the results of investigations of the stated research questions in light of the three levels of analysis pursued here: student engagement with the pedagogy, initial student learning of course material, and student retention of learned material. The data used for these levels of analysis are: observations of students in the classroom, student performance on the final exam in the course, and student performance on a follow-up survey that re-tests student understanding of key course concepts and skills. The analysis of these data sets is designed to help address the following research questions: 1. Does the laboratory pedagogy effectively engage students in learning? 2. Does the laboratory pedagogy effectively facilitate students' learning of course material? 3. Does the laboratory pedagogy effectively promote students' long-term retention of learned material?

Student Engagement

To address issues of student engagement with the laboratory pedagogy, observations were made of students in the classroom during the summer 2009 term. These observations focus on the paleoanthropology unit of the pedagogy investigated here. In the summer terms, this unit comprises two laboratory class meetings and corresponding chapters of the laboratory workbook (See Appendix Two). However, the first of these class meetings and workbook chapters largely emphasizes comparative primate anatomy. Observations of this first class meeting are heavily biased to this non-paleoanthropology material. As such, the observations used as data here will be taken only from the second of these class meetings and workbook chapters, which covers only relevant paleoanthropology material.

As discussed in the previous chapter, the observations of the summer 2009 term were made on forty students, distributed relatively evenly across three laboratory sections. These students represent a variety of college majors and corresponding learning styles, as noted previously. However, each student cannot be definitively linked to their particular major and learning style due to the anonymous nature of the feedback forms from which this information is derived. For the purposes of the research here, the data from the three summer 2009 sections is largely combined and treated as one data set. This is made possible by the uniformity of the laboratory pedagogy across different sections. Each section met for approximately one hour and twenty minutes for the relevant paleoanthropology laboratory, providing a total of approximately four hours of observations. The observations cover: students' overall attention to classroom tasks, students' communication in cooperative activities, students' formulation of deep understandings of content (as seen in students' follow-up questions or syntheses of information from various course resources), and students' participation in the in-class discussion on Neanderthals.

Students were asked to work in groups of two or three students to complete the four laboratory stations around the room (See Appendix Two), which lasted approximately twenty-five minutes. After all the students completed the stations, the class met as a large group and discussed the material covered at each station. The station questions were posed to the group at large, and students offered their answers and responses to these questions. On occasion based on a student response, further follow-up questions were asked by me (the instructor) or another student. The period of station review lasted approximately twenty-five minutes in each section, and after its completion, the class then devoted the remaining class time to the discussion about

Neanderthals, using the Lab Five Discussion Questions as a guide (See Appendix Two). In preparation for this discussion students were assigned an article to read on the course website. They were encouraged to draw from this article, as well as from other course resources—including lecture, in-class videos, and the laboratory workbook—to bolster their responses.

Generally, the students were talkative and on-task while completing their laboratory stations. They occasionally asked me (as the instructor) for assistance in clarifying a key piece of anatomy, such as the exact location and shape of turbinate bones. The third section asked fewer question of this nature than the first two sections. During the station review, approximately fifty percent of students participated by offering answers to station questions. A few students posed follow-up questions to clarify another student's comment, and approximately twenty-five percent of students took supplemental notes during the station review.

While completing the laboratory stations in their small, cooperative groups, students demonstrated high levels of effective communication. The students not only spoke to one another, they also listened attentively when a fellow group member was speaking. They took notes on what group members offered, and they turned to each other for assistance before turning to me (the instructor). Group members were often observed to pose questions and obtain guidance from one another.

Also while completing the laboratory stations, students demonstrated thought beyond what was being asked by the task. For example, in carrying out the station about *Homo erectus* tool technology, a student group began to discuss the limits of biological anthropology research. One of the students suggested that the species may, in fact, have lacked the imagination necessary to invent an alternate tool technology. The student asked the other group members how biological anthropologists, or anyone else, would ever really know the limits or potential of the extinct species' brain. This prompted a discussion among the group for several minutes regarding this issue and its implications. The laboratory station itself is designed to pose an open-ended question that requires students to evaluate two competing hypotheses: *Homo erectus* did not have the mental capacity to invent an alternate tool technology vs. *Homo erectus* had the mental capacity but not the environmental necessity to make this change. In evaluating these hypotheses, students are expected to draw largely from paleoenvironmental and technological evidence. This group discussed these issues and then took the conversation a step further by discussing broader methodological issues in the discipline.

Similar observations of students engaging in in-depth consideration of course material were made during the station review period. During the review, students who shared their responses to the station questions often related their answer to not only the laboratory station but also additional material presented in lecture and a relevant in-class video. In one instance, a student noted that the in-class video presented material that contradicted the material presented at the laboratory station and in lecture. This prompted a several minute discussion among the students about why this might be the case. Students began raising issues of bias, lack of expertise, and time and budgetary constraints that may have influenced the video production and its point of view. These students again demonstrated a level of understanding of the course material that served as a platform for formulating deeper understandings and critiques of the video.

The remaining classroom observations center on the in-class discussion of Neanderthals that is a part of the paleoanthropology unit. Approximately forty percent of students were observed to participate in the discussion by offering a response/opinion or asking additional follow-up questions. For each of the four discussion questions, at least four students provided a

verbal response. Students also participated through attentive listening, as demonstrated through eye contact, non-verbal responses (e.g. head-nodding), and note-taking while others spoke.

Students demonstrated higher-level thinking skills by relating their opinions and answers to evidence cited in the assigned reading, lecture, and in-class video. Students demonstrated additional higher-level thinking by then questioning some of the lines of evidence on methodological grounds. For example, while discussing possible evidence for interbreeding between Neanderthals and humans, one student remarked that the evidence for this lies largely in the single fossilized skeleton of a child. The student further commented that the evidence was therefore problematic because the developmental stages of Neanderthals are relatively unknown. A second student then asked the class at large how we could tell if something was a child or an adult, and how dwarfism might further complicate the issue. In this exchange, the first student demonstrates critical thinking by relating their opinion of the interbreeding possibility to evidence. The second student also demonstrates critical thinking skills by challenging the evidence.

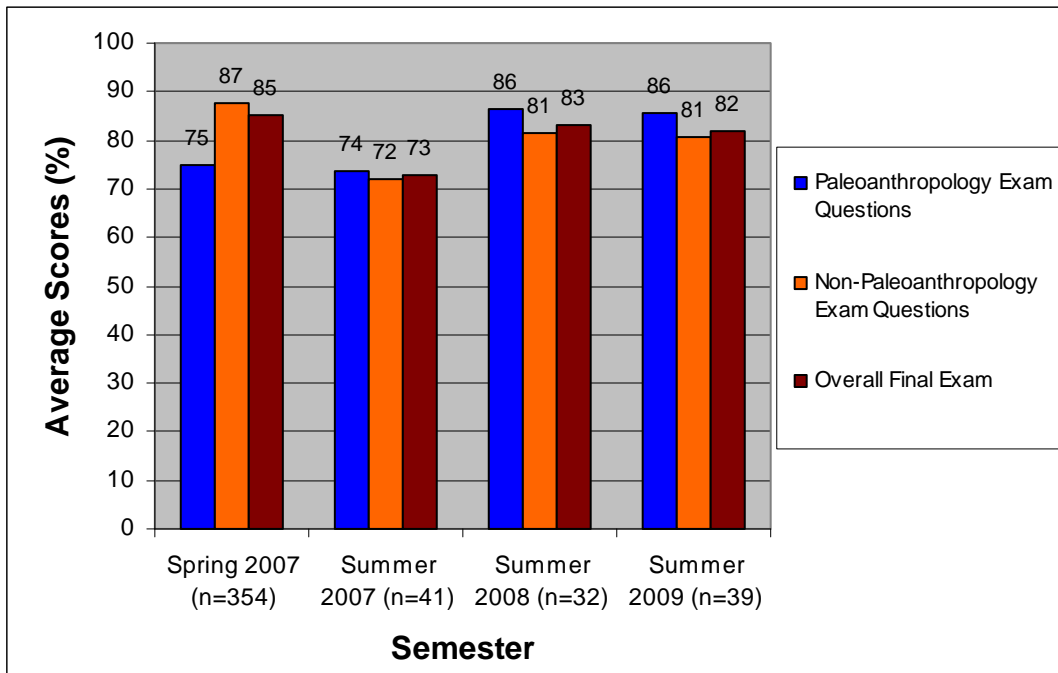
Further demonstration of higher-level thinking in relation to the issue of Neanderthal and human interbreeding was observed in a different laboratory section. Arguing against the possibility of interbreeding, a student cited genetic evidence suggesting the two species did not exchange genetic material. In response to this, a second student questioned the existence of genetic material in fossils. This prompted a brief discussion about the recent extinction of Neanderthals and the presence of small quantities of genetic material in some of the members of the species whose skeletons are not yet fully fossilized. Again, the first student demonstrates higher-level thinking by citing appropriate evidence in support of their argument. The second student demonstrates higher-level thinking by then critiquing the validity of that evidence.

Initial Student Learning

To address issues of student learning as related to the laboratory pedagogy, final exam data was compiled for the four semesters under study here. This data is comprised of a total of 466 student exams (354 from spring 2007, 41 from summer 2007, 32 from summer 2008, and 39 from summer 2009). The exam includes questions covering both paleoanthropology and non-paleoanthropology course content. Student performance on the paleoanthropology questions are the focus here. These questions take two forms: multiple choice format or open-ended, short answer format; and both types of questions are used in this data set. Generally, in the statistical analyses below, data from individual semesters were run separately, as well as being run together and treated as one large data set. However, the data analysis for an individual semester is only reported below where it differs markedly from the large, comprehensive data set.

Students generally scored comparably on paleoanthropology and non-paleoanthropology exam questions (See Figure 5.1). However, in the spring 2007 semester, students performed noticeably higher on the non-paleoanthropology questions (average of 87%) than on the paleoanthropology questions (average of 75%). Additionally, in most semesters, students had similar overall exam averages (spring 2007 = 85%; summer 2008 = 83%; summer 2009 = 82%). However, the summer 2007 term is exceptional in that the average overall exam score in this semester (average = 73%) is lower than that of the other terms.

Figure 5.1
Student Final Exam Performance by Semester

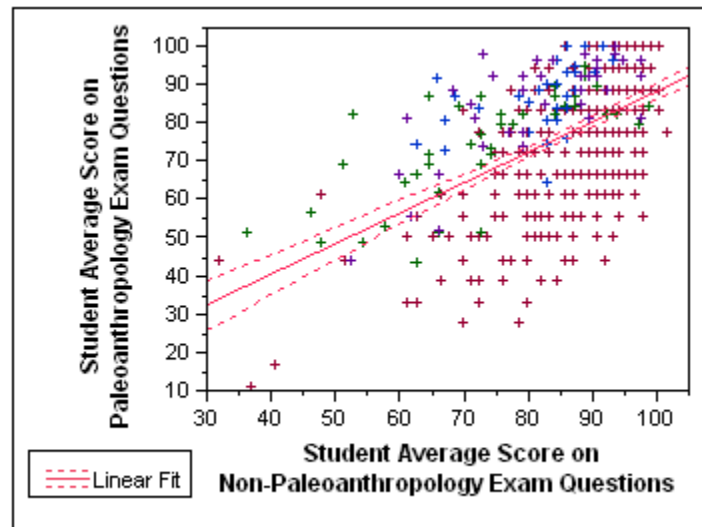


The relationship between student performance on the paleoanthropology exam questions and non-paleoanthropology exam questions was more closely examined using bivariate statistical analysis.* This helps explore the relationship between student performance on the paleoanthropology questions, which comprise the data set examined here to address questions about initial student learning, and student performance on other areas of the final exam. Using bivariate analysis, there is a moderate correlation between student performance on paleoanthropology exam questions and student performance on exam questions testing other course topics ($n = 466$; $r = 0.54$; $p < 0.0001$) (See Figure 5.2).

Figure 5.2

Bivariate Fit of Student Performance on Paleoanthropology Exam Questions by Student Performance on Non-Paleoanthropology Exam Questions

This analysis includes all of the terms under study (spring 2007, summer 2007, summer 2008, and summer 2009) ($n = 466$; $r = 0.54$; $p < 0.0001$).



To examine the potential impact of the laboratory pedagogy on student learning of paleoanthropology material, student performance on lecture-based, paleoanthropology exam questions was compared to student performance on lab-based, paleoanthropology exam questions using bivariate analysis. As discussed in the previous chapter, lecture-based exam questions test material covered only in the lecture; lab-based questions test material covered in the laboratory pedagogy, and possibly also covered in the lecture (See Table 5.1 for sample questions of each type). The summer terms had continuous data for both variables and were analyzed using bivariate analysis. For these terms, student performance on lecture-based, paleoanthropology questions moderately correlates to student performance on lab-based, paleoanthropology questions ($n = 112$; $r = 0.40$; $p < 0.0001$) (See Figure 5.3).

* All statistical analyses reported here were calculated using JMP software, version 7.0.

Table 5.1

Sample Lecture-based and Lab-based, Paleoanthropology Exam Questions

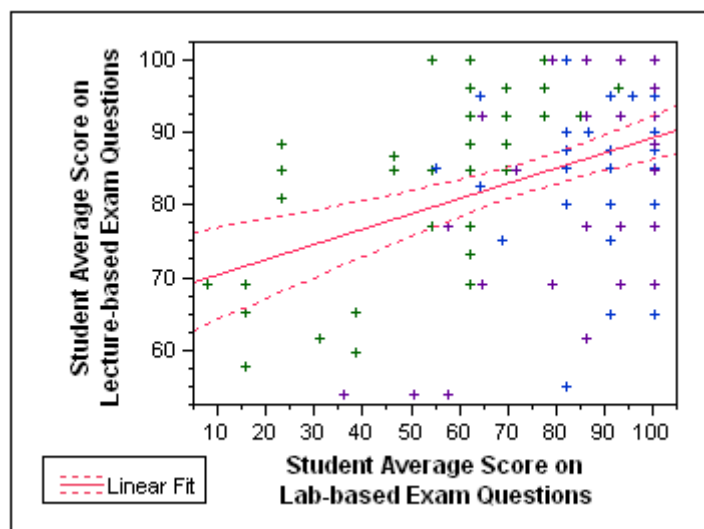
These sample questions were taken from the summer 2009 exam and are representative of similar questions in the other semesters studied.

<p><i>Lecture-based:</i></p> <p>What is the best explanation for the unusual morphology of <i>Homo floresiensis</i>?</p> <ul style="list-style-type: none">A. Insular dwarfingB. Omnivorous dietC. Juvenile ageD. MicrocephalyE. Disease
<p><i>Lab-based:</i></p> <p>Which species has a brain size of about 1500 cc, an occipital bun, a large nasal opening, and robust limbs?</p> <ul style="list-style-type: none">A. <i>Gigantopithecus</i>B. <i>Homo floresiensis</i>C. <i>Australopithecus robustus</i>D. <i>Homo neanderthalensis</i>E. <i>Homo habilis</i>

Figure 5.3

Bivariate Fit of Student Performance on Lecture-based, Paleoanthropology Exam Questions by Student Performance on Lab-based, Paleoanthropology Exam Questions

This analysis does not include the spring 2007 term. It includes only: summer 2007, summer 2008, and summer 2009. (n = 112; r = 0.40; p < 0.0001)



The spring 2007 semester was analyzed separately from the remaining terms. In the spring 2007 semester, there were only two lecture-based, paleoanthropology exam questions, resulting in categorical data for this variable. As such, this term could not be analyzed using the bivariate analysis applied to the other semesters. Instead, the spring 2007 data was analyzed using an oneway analysis of variance (See Figure 5.4). Three lecture-based performance levels are identified, based on the possible scores for the two lecture-based, paleoanthropology exam questions. Level 0 includes students who did not correctly answer either question; level 50 includes students who correctly answered one of the two questions; and Level 100 includes students who correctly answered both of the questions. Using the Tukey-Kramer method, the three lecture-based question performance levels are statistically different ($\alpha = 0.05$) (See Table 5.2). Students who correctly answered both lecture-based questions also had the highest scores on the lab-based questions (mean = 79.49); students who correctly answered one of the lecture-based questions had statistically different, lower scores on the lab-based questions (mean = 67.86); and students who did not correctly answer either of the lecture-based questions also had statistically different, much lower scores on the lab-based questions (mean = 54.17). Therefore, as in the other terms, in the spring 2007 term, student performance on lab-based questions relates to student performance on lecture-based questions.

Figure 5.4
Oneway Analysis of Variance of Student Performance on Lab-based, Paleoanthropology Exam Questions by Student Performance on Lecture-based, Paleoanthropology Exam Questions (Spring 2007)

This analysis includes only the spring 2007 semester. This semester was treated separately from the other terms because it had non-continuous data for the lecture-based variable.

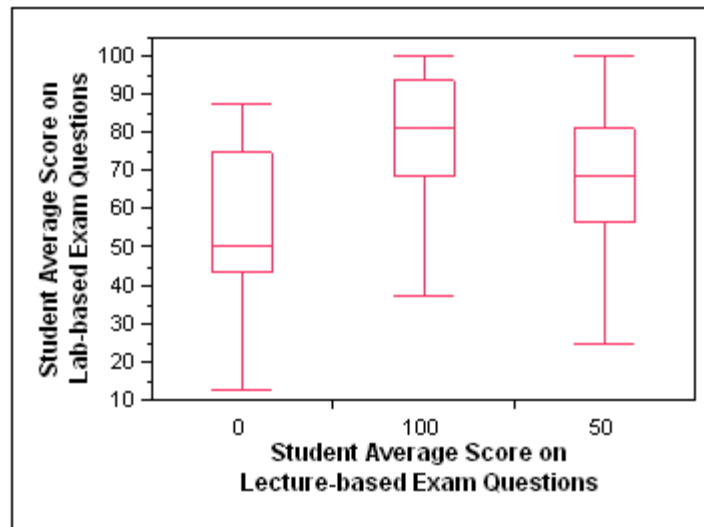


Table 5.2
Means and Standard Deviations for Oneway Analysis of Variance of Student Performance on Lab-based, Paleoanthropology Exam Questions by Student Performance on Lecture-based, Paleoanthropology Exam Questions (Spring 2007)

Student Average Score on Lecture-based Exam Questions	n	Mean	Standard Deviation	Standard Error Mean
0	15	54.17	19.99	5.16
100	220	79.49	15.98	1.08
50	119	67.86	17.38	1.59

To examine the relationship between the laboratory pedagogy and student learning at different levels of Bloom et al.'s (1956) taxonomy, the paleoanthropology exam questions were divided into two categories: lower-level thinking and higher-level thinking. All exam questions that targeted the “knowledge” level of Bloom’s taxonomy—emphasizing memorization of factual content—were categorized as lower-level thinking. All exam questions that targeted any of the other levels of Bloom’s taxonomy—emphasizing application of knowledge in novel contexts, making comparisons, evaluating, etc.—were categorized as higher-level thinking. Both categories include multiple choice and short answer question formats, depending on the details of the questions themselves (See Table 5.3 for sample questions of both types).

Table 5.3
Sample Lower-level Thinking and Higher-level Thinking Paleoanthropology Exam Questions

These sample questions were taken from the summer 2009 exam and are representative of similar questions in the other semesters studied. The lower-level thinking questions both ask students to simply recall factual information from the course. The higher-level thinking multiple choice question requires students to synthesize a variety of information and then classify a mystery fossil based on that information. The higher-level thinking short answer question asks students to infer the available evidence and judge the most appropriate line of evidence for this situation.

<p><i>Lower-level Thinking (Multiple Choice):</i> The fossil infant skull from Taung and identified by Raymond Dart is a member of which genus?</p> <ul style="list-style-type: none"> A. <i>Australopithecus</i> B. <i>Paranthropus</i> C. <i>Ardipithecus</i> D. <i>Homo</i> E. <i>Orrorin</i>
<p><i>Lower-level Thinking (Short Answer):</i> What is the likely social organization of the gracile Australopithecines?</p>
<p><i>Higher-level Thinking (Multiple Choice):</i> You are on a dig with Professor X at a site in South Africa when you come across a well-preserved cranium with the following characteristics: sagittal crest, very large brow ridges, very large molars, and very large zygomatic arches. Which of the following genera does it belong to?</p> <ul style="list-style-type: none"> A. <i>Australopithecus</i> B. <i>Homo</i> C. <i>Ardipithecus</i> D. <i>Sahelanthropus</i> E. <i>Paranthropus</i>
<p><i>Higher-level Thinking (Short Answer):</i> What in the fossil record indicates they [gracile Australopithecines] might have had this social structure?</p>

Having categorized the various paleoanthropology exam questions based on the level of thinking required of students, analysis was then run to determine if a relationship exists between student performance on the lab-based, lower-level thinking questions and student performance on the lecture-based, lower-level thinking questions. This helps to further clarify the possible impact of the laboratory pedagogy on student learning of lower-level content and skills. Again,

the summer terms were considered together using bivariate analysis, which shows no statistical correlation between student performance on lab-based, lower-level thinking questions and student performance on lecture-based, lower-level thinking questions ($n = 112$; $r = 0.18$; $p = 0.06$).

As previously noted, the spring 2007 exam includes only two lecture-based, paleoanthropology questions. Both of these questions qualified as lower-level thinking questions, which allowed for further statistical consideration of potential relationships between student performance on lab-based, lower-level thinking questions and student performance on lecture-based, lower-level thinking questions in this term. However, as in the previous analysis, the spring 2007 term was analyzed separately due to the categorical nature of the lecture-based question variable; and three lecture-based performance levels were identified, based on the possible scores for the two lecture-based, paleoanthropology exam questions. Again, level 0 includes students who did not correctly answer either question; level 50 includes students who correctly answered one of the two questions; and level 100 includes students who correctly answered both of the questions. This term was again analyzed using an oneway analysis of variance (See Figure 5.5). Using the Tukey-Kramer method, the three lecture-based question performance levels are statistically different ($\alpha = 0.05$) (See Table 5.4). Students who correctly answered both lecture-based, lower-level thinking questions also had the highest scores on the lab-based, lower-level thinking questions (mean = 77.83); students who correctly answered one of the lecture-based, lower-level thinking questions had statistically different and lower scores on the lab-based, lower-level thinking questions (mean = 64.52); and students who did not correctly answer either of the lecture-based, lower-level thinking questions also had statistically different and much lower scores on the lab-based, lower-level thinking questions (mean = 50.37). Therefore, unlike in the summer terms—where no statistical correlation was found between student performance on lower-level, lab-based questions and student performance on lower-level, lecture-based questions—in the spring 2007 term, student performance on lower-level, lab-based questions *does* relate to student performance on lower-level, lecture-based questions.

Figure 5.5

Oneway Analysis of Variance of Student Performance on Lower-level Thinking, Lab-based Exam Questions by Student Performance on Lower-level Thinking, Lecture-based Exam Questions (Spring 2007)

This analysis includes only the spring 2007 semester. This semester was treated separately from the other terms because it had non-continuous data for the lecture-based variable. Only lower-level thinking, paleoanthropology exam questions are considered here.

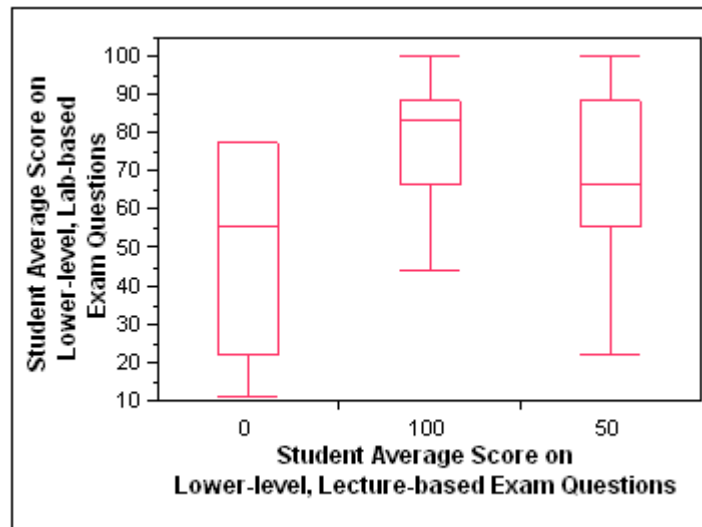


Table 5.4

Means and Standard Deviations for Oneway Analysis of Variance of Student Performance on Lower-level Thinking, Lab-based Exam Questions by Student Performance on Lower-level Thinking, Lecture-based Exam Questions (Spring 2007)

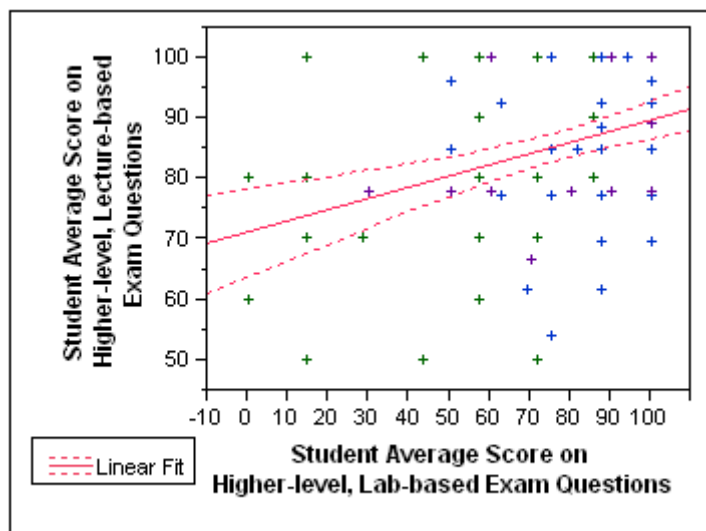
Student Average Score on Lower-level, Lecture-based Exam Questions	n	Mean	Standard Deviation	Standard Error Mean
0	15	50.37	24.08	6.22
100	220	77.83	20.47	1.38
50	119	64.52	20.98	1.92

Finally, as part of the consideration of the possible impact of the laboratory pedagogy on student learning, I examined student performance on higher-level thinking questions, in addition to the examinations of student performance on lower-level thinking questions described above. As with the lower-level thinking questions, the summer terms were considered together using bivariate analysis, which shows a low to moderate statistical correlation between student performance on lab-based, higher-level thinking questions and student performance on lecture-based, higher-level thinking questions ($n = 112$; $r = 0.37$; $p < 0.0001$) (See Figure 5.6). Unlike in the previous analyses where the spring 2007 semester was analyzed separately due to the nature

of the data set, for this analysis the spring 2007 semester is completely omitted because none of the paleoanthropology exam questions from this term met the criteria for being classified as lecture-based, higher-level thinking questions.

Figure 5.6
Bivariate Fit of Student Performance on Lab-based, Higher-level Thinking Exam Questions by Student Performance on Lecture-based, Higher-level Thinking Exam Questions

This analysis does not include the spring 2007 term. It includes only: summer 2007, summer 2008, and summer 2009. Only higher-level thinking, paleoanthropology exam questions are considered here. (n = 112; r = 0.37; p < 0.0001).



Student Retention of Learned Course Material

To address issues of student retention of learned material as related to the laboratory pedagogy, a survey was administered to former students to re-test their knowledge of previously learned paleoanthropology course material. As discussed in the previous chapter, a total of 41 students participated in the survey (22 from the spring 2007 semester, 4 from the summer 2007 semester, 3 from the summer 2008 semester, and 12 from the summer 2009 semester). The survey includes multiple choice and short answer questions covering paleoanthropology course content (See Figure 4.2). As with the final exam data reported above, all statistical analyses were performed by semester, as well as together in one large data set. While it would be ideal to report the results by semester in order to obtain a true longitudinal perspective of student retention of learned material, the data sets for individual semesters were often too small to obtain reliable statistical results. As such, the statistical analysis of individual semesters is only reported below where it differs from the large, comprehensive data set and where it is statistically reliable.

Because the survey data is used here to understand student retention of learned material, each survey question was paired with a similar question from the final exam in each semester (See Table 5.5). These pairings took into account both question content and level of thinking

required. In determining the level of thinking required by a particular question, the same criteria as those described above for the final exam data were employed. However, because the final exam in each semester was slightly different, different exam questions were identified as survey pair questions for each semester. A student's response to a survey question is considered to be part of the survey data set only if the student successfully answered a similar, paired question on their final exam. If a survey question could not be suitably matched to a final exam question in a given semester, responses to that survey question by all students in that semester were excluded from the data set (See Table 5.6). In these situations, it was not possible to determine if the survey response measured actual retention because the survey question could not be adequately paired to the final exam—the measure of initial learning. Similarly, if a student did not successfully answer the final exam question paired to a survey question, their response to the survey question was excluded. Here, the student's response to the survey question, whether correct or incorrect, does not clearly demonstrate retention if the student did not previously demonstrate learning of that information on the final exam.

Table 5.5**Sample Survey Questions and Paired Final Exam Questions**

These sample paired final exam questions were taken from the summer 2009 exam and are representative of similar questions in the other semesters studied.

Question	Content	Skill	Level of Thinking
<p><i>Survey Question # 7:</i> The fossil genus <i>Paranthropus</i> is characterized by the following traits: large sagittal crest, large brow ridges, large zygomatic arches, and very large molars with thick enamel. What do these traits suggest about the diet of <i>Paranthropus</i> species?</p> <p>F. They had a diet that emphasized fruit. G. They had a diet that emphasized tree gums. H. They had a diet that was largely omnivorous. I. They had a diet that emphasized insects. J. They had a diet that emphasized heavy plant material.</p>	<p><i>Paranthropus</i> Dietary Adaptations</p>	<p>Apply Concept</p>	<p>Higher-level</p>
<p><i>Final Exam Pair for Survey Question # 7:</i> The highly unusual and specialized dentition of <i>Paranthropus</i> indicates a diet that included primarily:</p> <p>A. small insects B. soft fruit C. fibrous and tough plants D. gums from trees E. bamboo</p>	<p><i>Paranthropus</i> Dietary Adaptations</p>	<p>Apply Concept</p>	<p>Higher-level</p>
<p><i>Survey Question # 10:</i> As you learned in this course, biological anthropologists try to use the anatomy of fossils to reconstruct their likely behavior in the past. Imagine you are working in a biological anthropology lab, and you are examining a group of 50 fossils from the same species. The fossils show what appears to be a high degree of sexual dimorphism, with half of the skeletons showing larger canine size and overall body size than the other half. Using this information, what do you expect was the likely social organization of this species?</p>	<p>Sexual Dimorphism and Social Organization</p>	<p>Select Likely Explanation</p>	<p>Higher-level</p>
<p><i>Final Exam Pair for Survey Question # 10:</i> What in the fossil record indicates they [gracile Australopithecines] might have had this social structure?</p>	<p>Sexual Dimorphism and Social Organization</p>	<p>Select Likely Explanation</p>	<p>Higher-level</p>

Table 5.6
Survey Questions Excluded and Included by Semester

The exclusions reported here are the result of survey questions without adequate final exam question pairs for the given semester/s.

	Spring 2007	Summer 2007	Summer 2008	Summer 2009
Survey Question # 4	Included	Included	<i>Excluded</i>	Included
Survey Question # 5	Included	Included	Included	Included
Survey Question # 6	Included	Included	Included	<i>Excluded</i>
Survey Question # 7	Included	<i>Excluded</i>	Included	Included
Survey Question # 8	Included	<i>Excluded</i>	Included	Included
Survey Question # 9	Included	<i>Excluded</i>	Included	Included
Survey Question # 10	<i>Excluded</i>	Included	Included	Included

Looking at survey participants' performance on the final exam, these students generally scored comparably on paleoanthropology and non-paleoanthropology exam questions; however, in the spring 2007 semester, survey participants performed noticeably better on the non-paleoanthropology questions (average of 88%) than on the paleoanthropology questions (average of 81%) (See Figure 5.7). Both of these trends are similar to what was seen when looking at the complete final exam data set above (See Figure 5.1). Additionally, in most semesters, survey participants had similar overall exam averages (spring 2007 = 87%; summer 2008 = 85%; summer 2009 = 86%); however, the summer 2007 term is exceptional in that the average overall exam score among survey participants in this semester (average = 71%) is lower than that of the other terms (See Figure 5.7). This is similar to the trend observed above when examining the complete final exam data set (See Figure 5.1). Finally, accounting for differences in population size, survey participants have similar performance distributions to those seen in the corresponding exam populations for each term on both the paleoanthropology exam questions (See Figure 5.8) and the total exam (See Figure 5.9). When taken together, all of these similarities between the overall final exam data and the particular survey participant data suggest the survey participants are a reasonable representation of the overall student population, rather than a biased sample of students who either performed remarkably higher or lower than the majority of students on the final exam.

Importantly, the more recent terms show markedly higher retention rates than the earlier terms. The survey scores for the summer 2008 and summer 2009 semesters are 79% and 78%, respectively. The survey scores for the earlier spring 2007 and summer 2007 semesters are 53% and 55%, respectively. However, even with as many as two years elapsing between the completion of the terms in 2007 and the administration of the survey in 2009, retention across all terms remains above 50%.

Figure 5.7

Student Final Exam and Survey Performance by Semester

This chart includes only the relevant data from the students who participated in the survey (n = 41).

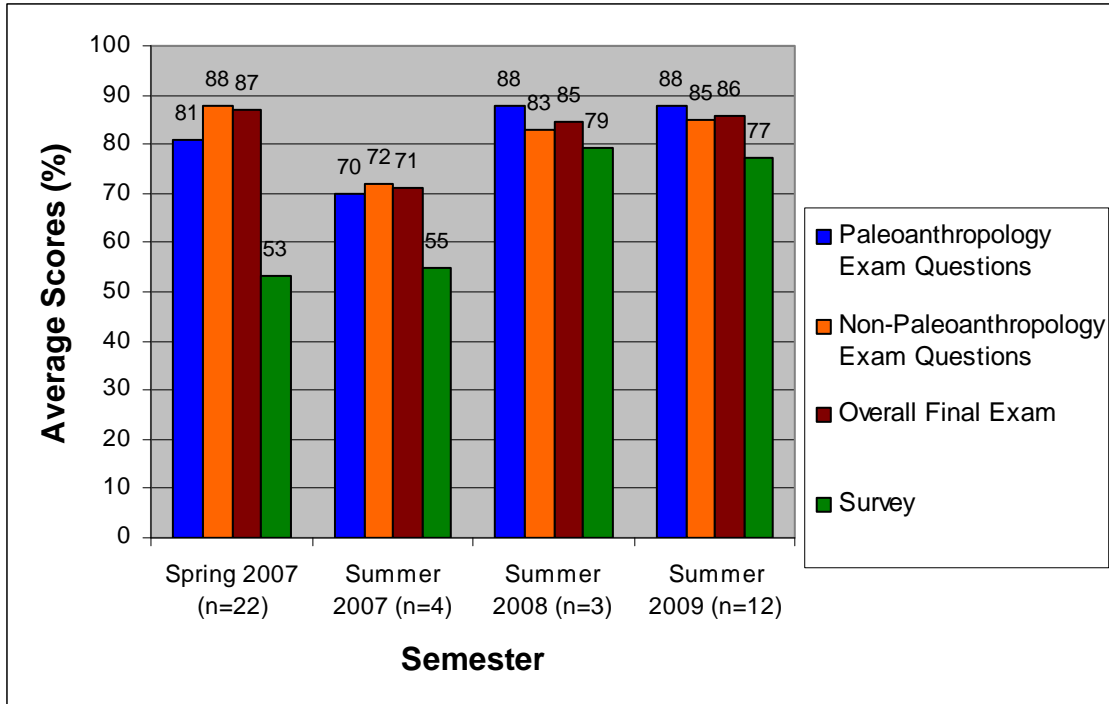


Figure 5.8
Distribution of Survey Population Paleoanthropology Exam Averages and Overall Population Paleoanthropology Exam Averages by Semester

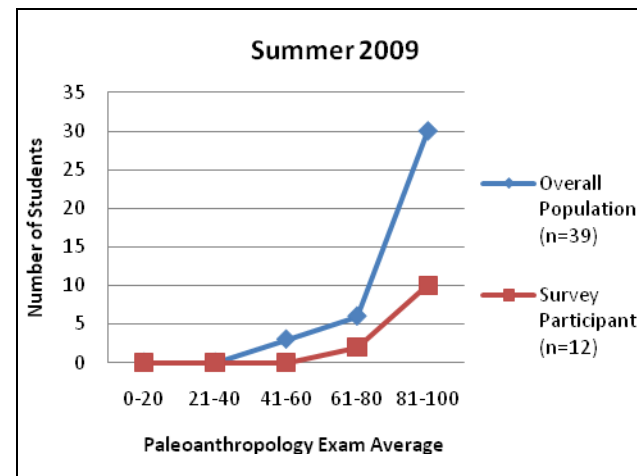
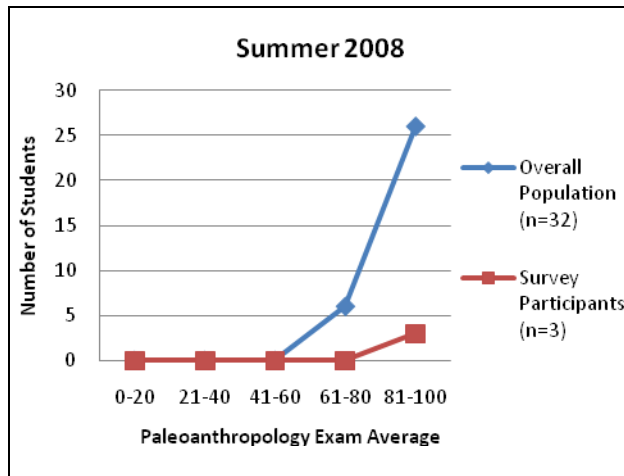
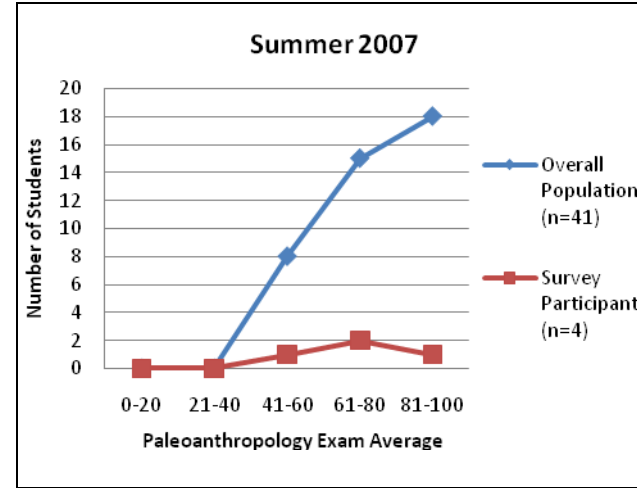
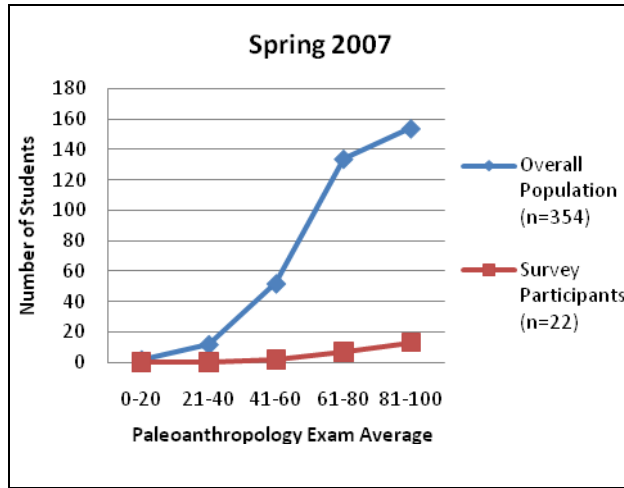
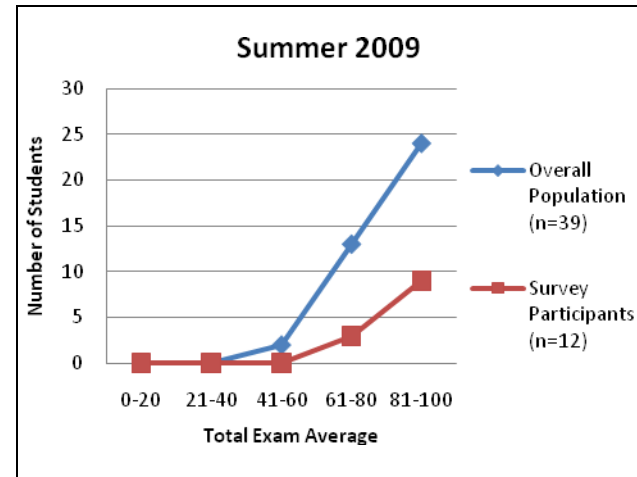
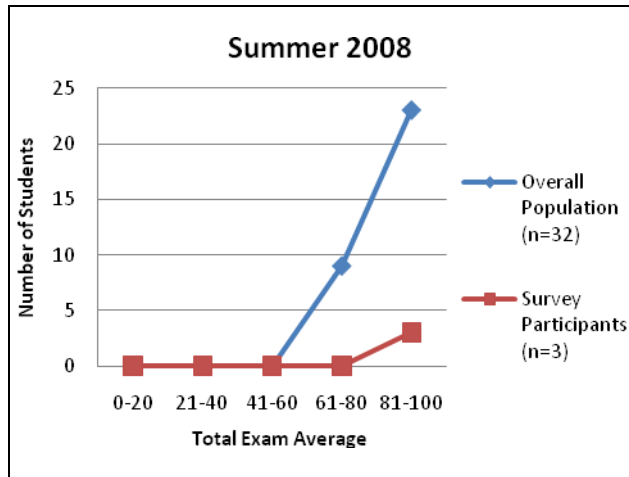
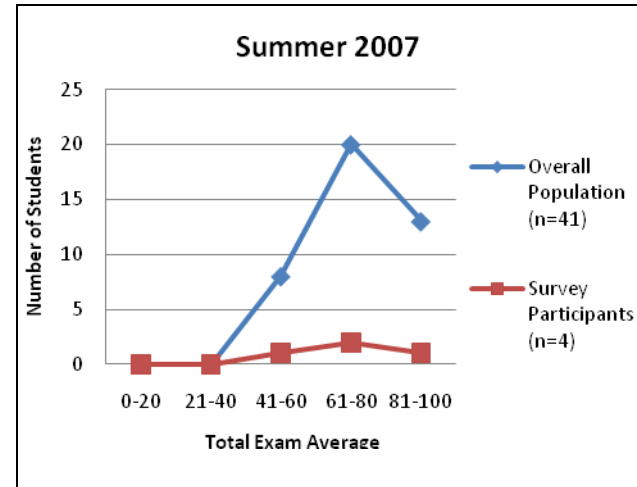
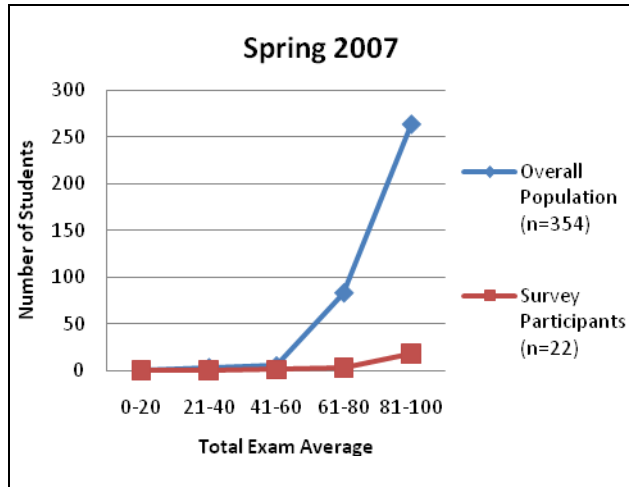


Figure 5.9
Distribution of Survey Population Total Exam Averages and Overall Population Total Exam Averages by Semester



The relationship between survey participant performance on the survey and the paleoanthropology exam questions was more closely examined using bivariate statistical analysis. This was done to help examine the relationship between student performance on the survey questions, which comprise the data set examined here to address questions about student retention, and student performance answering similar questions on the final exam. Using bivariate analysis, there is a moderate correlation between student performance on survey questions and student performance on paleoanthropology exam questions ($n = 41$; $r = 0.68$; $p < 0.0001$) (See Figure 5.10). Similarly, to further explore the relationship between student performance on the survey questions and student performance on the overall final exam, bivariate analysis was conducted. There is a moderate correlation between student performance on survey questions and student performance on the final exam as a whole ($n = 41$; $r = 0.54$; $p = 0.0003$) (See Figure 5.11).

Figure 5.10
Bivariate Fit of Student Performance on Survey Questions and Student Performance on Paleoanthropology Exam Questions

This analysis includes all of the terms under study (spring 2007, summer 2007, summer 2008, and summer 2009) ($n = 41$; $r = 0.68$; $p < 0.0001$).

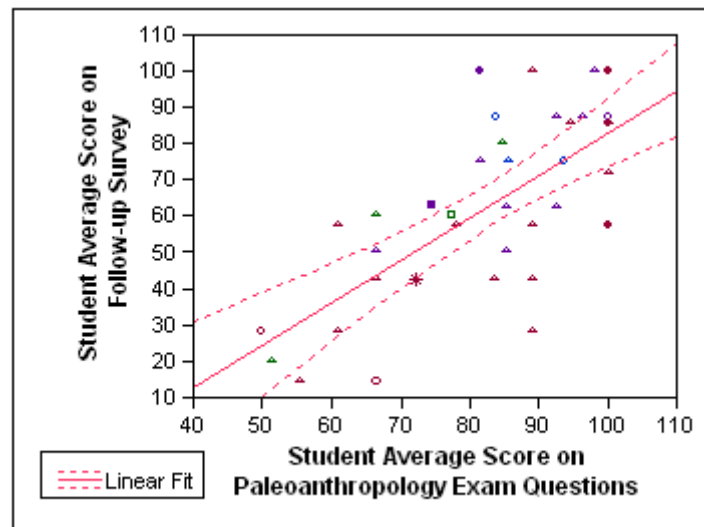
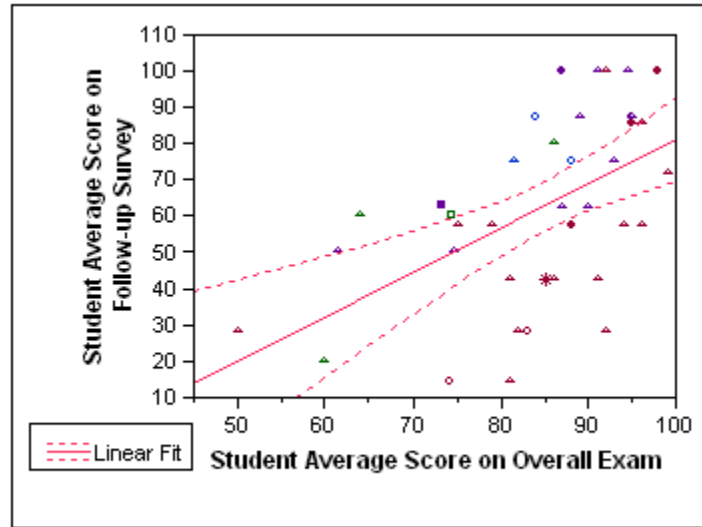


Figure 5.11

Bivariate Fit of Student Performance on Survey Questions and Student Performance on the Final Exam Overall

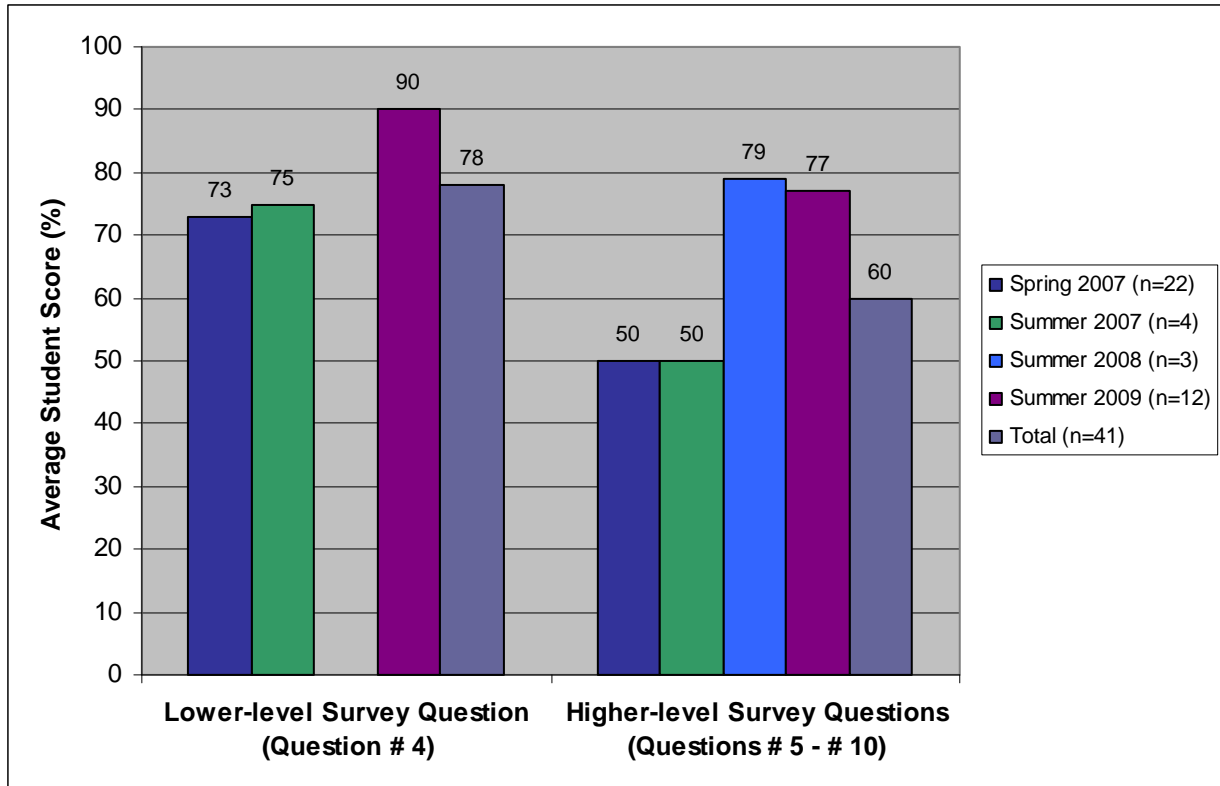
This analysis includes all of the terms under study (spring 2007, summer 2007, summer 2008, and summer 2009) (n = 41; r = 0.54; p = 0.0003).



As noted in the previous chapter, the survey data set does not have adequate data to examine student retention of lower-level and higher-level material in a way that is statistically meaningful and comparable to the analyses conducted with the final exam data. However, preliminary consideration of the data is possible. The available survey data consists of one lower-level question (question four) and six higher-level questions (questions five through ten). The availability of data for these questions per semester will vary based on whether the survey question has been excluded for a given semester, as described above (See Table 5.6). In preliminary examinations of this data, it appears that retention is greater with lower-level thinking material (spring 2007 = 73%, summer 2007 = 75%, summer 2009 = 90%, overall = 78%) than with higher-level thinking material (spring 2007 = 50%, summer 2007 = 50%, summer 2008 = 79%, summer 2009 = 77%, overall = 60%) (See Figure 5.12). It was previously noted that overall retention is higher among the more recent semesters than the earlier semesters. It appears that these more recent terms (summer 2008 and summer 2009) retain more at both levels of thinking than students from earlier terms (spring 2007 and summer 2007).

Figure 5.12
Student Performance on Lower-level Thinking and Higher-level Thinking Survey Questions by Semester

This chart includes only the students who participated in the survey (n = 41). The summer 2008 term did not have an appropriate final exam question to match to survey question four, so it has been excluded from consideration among the lower-level thinking data. See Table 5.6 for more details about higher-level thinking questions that may be excluded from the various semesters, as well.



While statistical analysis of student retention of learned information at different levels of thinking is not possible, it is possible to explore student retention of learned information by learning style, which was not possible with the final exam data. Here, students are asked to provide their declared (or intended) major as part of the survey, which allows for each survey participant to be matched to a major and corresponding learning style. The learning style designations and the assignment of student majors to corresponding learning styles used here follow the work of Kolb (1981). There are four possible learning styles, and majors correspond to these learning styles based on where their disciplines fall along two, perpendicular continuums (Kolb 1981). The learning styles are: Accommodators, Assimilators, Convergors, and Divergers (Kolb 1981). In general, the majors represented among the survey participants, fall into four broad categories that correspond to these four learning styles (See Table 5.7). Business and education majors are classified as accommodators; mathematics, biological sciences, and physical sciences majors are classified as assimilators; engineering and computer science majors

are classified as convergers; and social sciences, arts, and humanities majors are classified as divergers.

Table 5.7

Sample Student Majors and Corresponding Learning Style Assignments

This is a representative sample of majors provided by survey participants and their corresponding learning style assignment.

Student Major/s	Learning Style	Collapsed Learning Style
Business and Psychology	Accommodator-Diverger	Non-Diverger
Integrative Biology	Assimilator	Non-Diverger
English and Integrative Biology	Assimilator-Diverger	Non-Diverger
Nutritional Science, French, and Anthropology	Assimilator-Diverger	Non-Diverger
Electrical Engineering and Computer Science	Converger	Non-Diverger
Computer Science, Physics, and Anthropology	Converger-Diverger	Non-Diverger
Anthropology	Diverger	Diverger
History	Diverger	Diverger
Psychology	Diverger	Diverger

However, several of the survey participants list multiple majors. If a student lists two majors that are both from the same learning style, one of the original four learning styles is assigned. For example, a student who identifies a double major in anthropology and sociology (both humanities/social sciences) is classified as a diverger. Several students list multiple majors from across disciplines and learning styles. To account for this, additional categories were also created for this study that combined learning styles if a student was majoring in disciplines from different learning styles (See Table 5.7). For example a student would be classified as an assimilator-diverger if they majored in English (humanities/social science) and integrative biology (biological science) or if they majored in anthropology (humanities/social science), French (humanities/social science), and nutritional science (biological science). This was done to prevent artificially showing preference for one of a student’s majors (and learning styles) over the other.

Unfortunately, this resulted in several learning style groups with very small numbers of students, too small for meaningful statistical analysis, particularly when further divided by semester. As such, the learning styles were collapsed for all analyses into only two categories: divergers (who make up the majority of the sample) and non-divergers (See Table 5.7). The non-diverger group includes students who have a combined learning style of diverger and something else, for example assimilator-diverger. Even after collapsing the learning styles this way, there are still several semesters with sample sizes too small for meaningful statistics. Statistics run on the individual terms generally support the results obtained for all terms combined, but the results are not as statistically meaningful when treated individually by

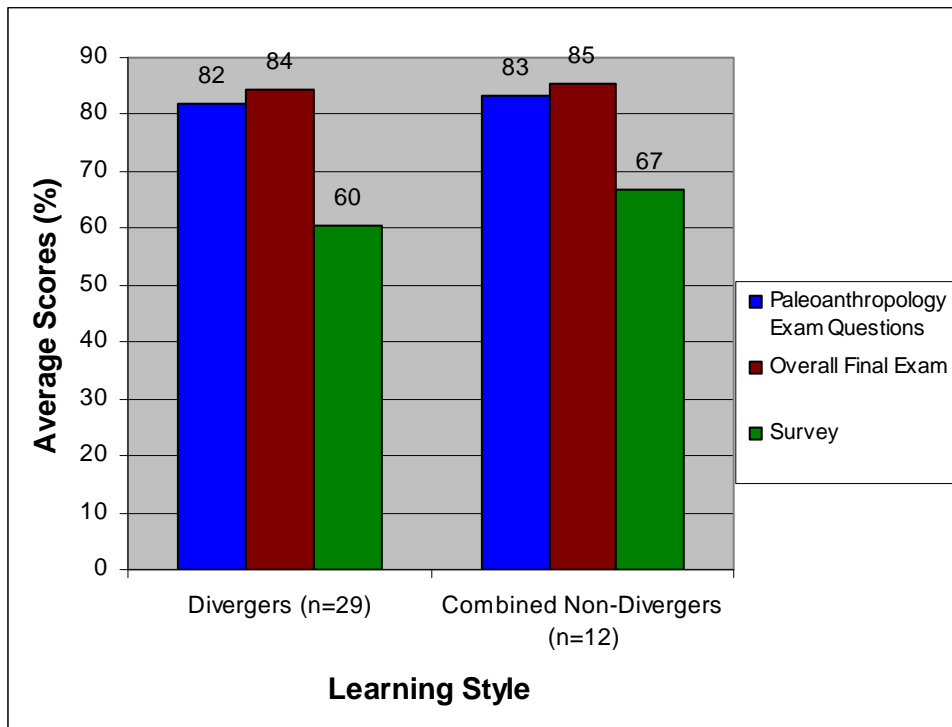
semester. As such, all of the survey data results presented here are the results of analyses that combined all of the semesters together into one data set, unless otherwise noted.

Looking at study participants' performance on the final exam and survey by learning style across semesters, students of both collapsed learning style groups performed comparably on the final exam overall, the paleoanthropology questions of the exam specifically, and the survey (See Figure 5.13). Across all semesters, divergers averaged 82% on paleoanthropology exam questions and 84% on the final exam overall. This is remarkably similar to the non-divergers who averaged 83% on paleoanthropology questions and 85% on the final exam overall. Additionally, the non-diverger students did average slightly higher on the survey (67%) than the divergers (60%).

Figure 5.13

Student Performance on the Final Exam and Survey by Learning Style

This chart includes survey participants from all of the semesters under study (spring 2007, summer 2007, summer 2008, and summer 2009) (n=41).

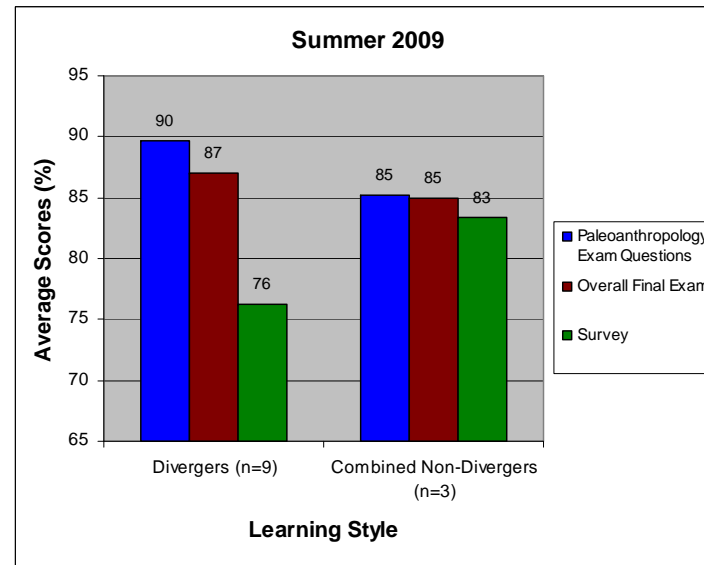
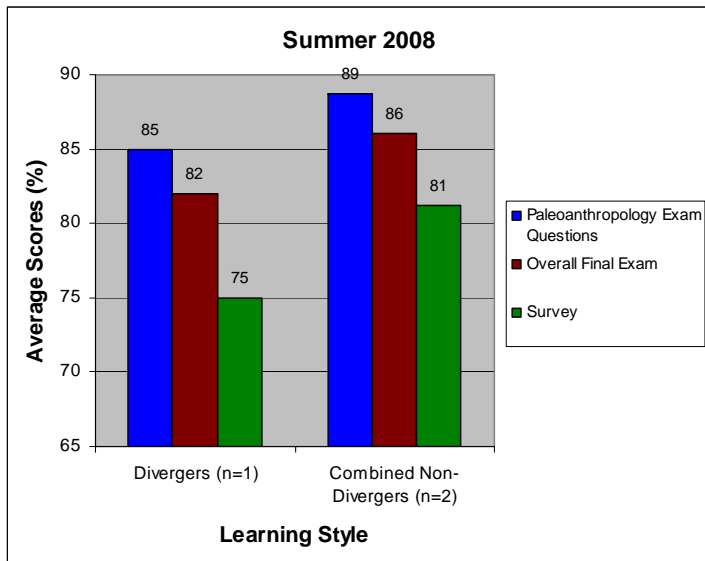
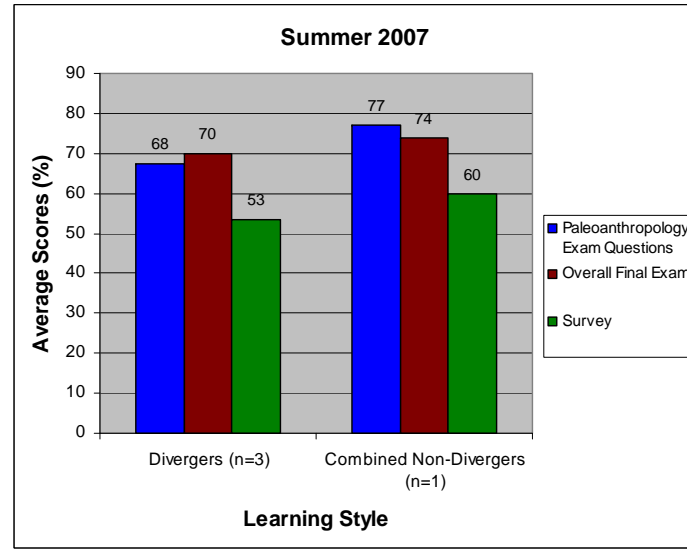
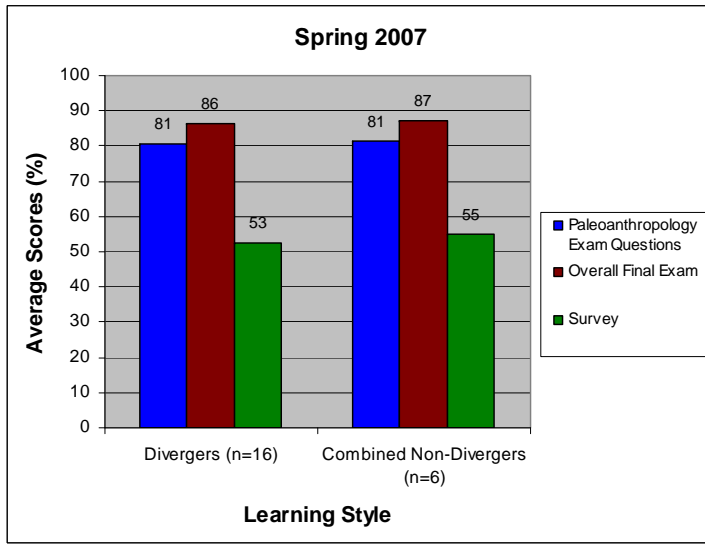


These results are generally supported by closer examination of each semester individually (See Figure 5.14). Among study participants from the spring 2007 semester, divergers averaged 81% on paleoanthropology exam questions, 86% on the final exam overall, and 53% on the survey. Non-divergers for this term performed remarkably similarly, with an average of 81% on paleoanthropology exam questions, 87% on the exam overall, and 55% on the survey. Divergers from the summer 2007 semester averaged 68% on paleoanthropology exam questions, 70% on the exam overall, and 53% on the survey. Non-divergers from this same term averaged higher on the paleoanthropology exam questions (77%) and survey (60%) and similarly on the exam

overall (74%). The summer 2008 divergers averaged 85% on the paleoanthropology exam questions, 82% on the exam overall, and 75% on the survey. Non-diverger students from the summer 2008 term averaged similarly on paleoanthropology questions (89%) and exam overall (86%) and averaged higher on the survey (81%). Finally, the summer 2009 divergers averaged 90% on the paleoanthropology exam questions, 87% on the exam overall, and 76% on the survey. The non-divergers from this semester averaged similarly on the paleoanthropology exam questions (85%) and exam overall (85%) and averaged higher on the survey (83%).

In general, then, the non-divergers score similarly or higher on the survey than their diverger counterparts, even in situations where the non-divergers score similarly or lower than the diverger students on the paleoanthropology exam questions or exam overall. Interestingly, while the summer 2007 paleoanthropology question averages and overall exam averages are remarkably lower than those seen in all of the other semesters, the survey averages of both learning style groups are similar to those from the other earlier semester under study—the spring 2007 semester. At the same time, the overall trend toward a higher survey average among non-divergers than divergers observed in summer 2007 is similar to that seen in the other semesters.

Figure 5.14
Student Performance on the Final Exam and Survey by Learning Style and Semester



In order to examine student retention by learning style more closely, statistical analyses are employed to compare diverger and non-diverger student performance on lower-level thinking survey questions. As previously discussed, there is only one lower-level thinking question included in the survey, resulting in non-continuous data for this variable. The learning style data is also categorical. Thus, contingency analysis is used to examine the relationship between student performance on the lower-level survey question and student learning style (See Figure 5.15). Results indicate that student performance on the lower-level question and student learning style are not related ($n = 36$; degrees of freedom = 1; Pearson's chi-square = 0.857; $p = 0.35$).

Figure 5.15
Chi-square for Contingency Analysis of Student Performance on the Lower-level Thinking Survey Question and Student Learning Style

This analysis includes survey participants from all semesters under study (spring 2007, summer 2007, summer 2008, and summer 2009). Only the lower-level thinking survey question is considered here ($n = 36$; degrees of freedom = 1; Pearson's chi-square = 0.857; $p = 0.35$).

Student Performance on Lower-level Thinking Survey Question				
	0	100		
Count				
Total %				
Col %				
Row %				
Student Learning Style	Diverger	7	20	27
		19.44	55.56	75.00
		87.50	71.43	
		25.93	74.07	
	Non-Diverger	1	8	9
		2.78	22.22	25.00
	12.50	28.57		
	11.11	88.89		
	8	28	36	
	22.22	77.78		

Finally, statistical analysis is also employed to further examine the possible relationship between student performance on the higher-level thinking survey questions and student learning style. As previously noted, there are multiple higher-level thinking questions on the survey, resulting in continuous data for this variable. However, the learning style variable is still categorical in nature, leading to the use of an oneway analysis of variance (See Figure 5.16). Using the Tukey-Kramer method, the two learning style levels are not statistically different ($\alpha = 0.05$) (See Table 5.8). Therefore, as is seen with the lower-level question, student performance on the higher-level thinking survey questions is similar in both learning style groups.

Figure 5.16

Oneway Analysis of Variance of Student Performance on Higher-level Thinking Survey Questions by Student Learning Style

This analysis includes all of the semesters under study (spring 2007, summer 2007, summer 2008, and summer 2009). Only the higher-level thinking survey questions are considered here.

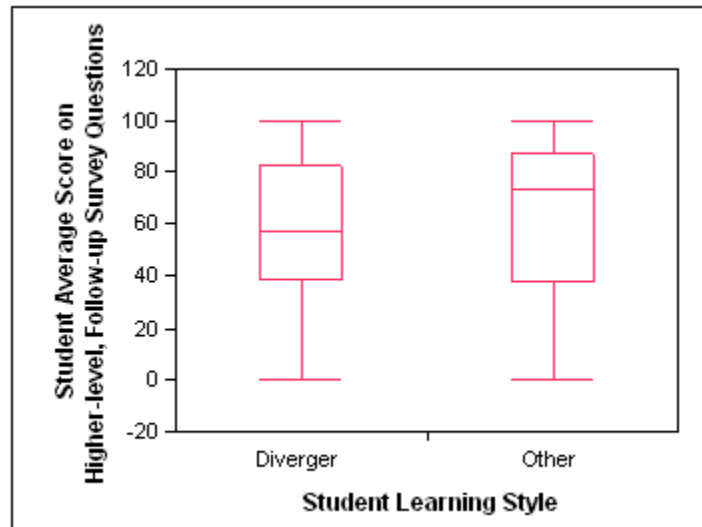


Table 5.8

Means and Standard Deviations for Oneway Analysis of Variance of Student Performance on Higher-level Thinking Survey Questions by Student Learning Style

Student Learning Style	n	Mean	Standard Deviation	Standard Error Mean
Diverger	29	58.48	27.63	5.13
Other	12	64.08	31.03	8.96

CHAPTER SIX: DISCUSSION

This chapter discusses the results of the research outlined in this dissertation. It considers the previously stated research questions at three levels of analysis: student engagement, initial student learning, and student retention of learned course material. Results of analysis of classroom observations, student final exam performance, and student performance on a follow-up survey were outlined in the preceding chapter. Here, interpretations of these results are presented in an effort to evaluate the effectiveness of the laboratory pedagogy investigated.

Student Engagement

Observations of students in the classroom demonstrate that the students actively participate in laboratory tasks. Across all the laboratory sections observed, students participated in both the station activities and reviews of station material. They asked me (the instructor) for some guidance about particular anatomical structures while completing station tasks, but they generally relied on themselves and their fellow group members for assistance first. The third section was observed to ask fewer questions of the instructor than the other two sections. This is likely related to the timing and scheduling of this section; whereby students had completed a full four-hour lecture, featuring several detailed images of the relevant anatomy, directly before coming to laboratory section. Thus, the difference in student help-seeking behavior noted between sections may be more related to the influence of the timing and scheduling of the section than it is to the laboratory pedagogy.

In general, the students demonstrate appropriate cooperative skills, such as effective communication and attentive listening, while completing laboratory stations in small groups. For example, the students shared information and insights with fellow group members, and they listened attentively to what their group members had to share. These communication skills are central to cooperative tasks, and the fostering of these skills is central to cooperative pedagogy (Brown and Atkins 1988, Johnson et al. 1991, Lotan and Whitcomb 1998, Ventimiglia 1995). The students also relied on each other more than the instructor for overall guidance and support during laboratory tasks. While students in some sections did rely on the instructor for assistance with identifying particular anatomical structures, this was minimal. The students tended to turn to each other for assistance before asking for help from the instructor. This behavior demonstrates a sense of interdependence among group members and a belief that the instructor is there as a facilitator, rather than a primary resource for information. As noted in Chapter Two, interdependence is another element that is central to cooperative pedagogy (Johnson et al. 1991). Taken together, the students' display of strong communication skills and a sense of interdependence demonstrate the laboratory pedagogy is successful in fostering key aspects of cooperative learning.

Classroom observations also suggest students engage with course material in an in-depth way through the use of higher levels of thinking. Students successfully completed laboratory tasks and considered all of the required elements of each problem in doing so. However, the students also displayed thinking beyond what was explicitly asked in a given task. This was seen when students discussed the underlying methodological issues involved in estimating the mental capacity of an extinct species and when students considered the potential biases in a video shown in the course. In both instances, the students met the explicit expectations of the given task but also considered issues relevant to the task but not explicitly outlined as a part of the task. The

laboratory pedagogy provided students the foundational knowledge and thinking skills necessary for a task and left the students the option to further pursue related issues while completing that task. The students then used these opportunities to critically engage with course material. Thus, it can be argued the laboratory pedagogy successfully fosters higher-level thinking.

In an effort to engage students in higher-level thinking, in-class discussions are used throughout the laboratory pedagogy. Observations of one of these discussions were made in three laboratory sections, and students showed levels of participation slightly lower than participation in other aspects of the pedagogy. Approximately forty percent of students verbally participated in the in-class discussion, while approximately fifty percent of students verbally participated in the review of laboratory station material. This difference may relate to the nature of in-class discussions. Discussion contexts may be more threatening to some students because they require students to formulate an opinion on their own (Foyle 1995). This is in contrast to the station review contexts, where students share opinions based on what they have completed with the assistance of their cooperative group. Ideally, issues of this nature can be minimized through the use of small group discussion prior to discussion with the whole class (Foyle 1995). Unfortunately, due to timing constraints in the laboratory sections, this is not possible for the discussions considered here. At the same time, discussions of the nature employed in the laboratory pedagogy do require additional preparation by the student in that they are asked to read an assigned article before coming to class. Some students may not complete this task and therefore do not feel well enough prepared to participate in the discussion.

Despite the slightly lower level of verbal participation observed in the in-class discussion than in other laboratory activities, the level of verbal participation seen in the discussion is strong considering the other mitigating factors. Additionally, the students demonstrated extensive non-verbal participation in the discussion through attentive listening and other non-verbal cues (e.g. head-nodding and note-taking). This form of participation may be more comfortable for some students; and because attentive listening is an important aspect of all communication, non-verbal participation must also be considered an indicator of student engagement in the discussion. Thus, given the circumstances and considering the role of non-verbal participation, it can be argued that overall participation in the discussion was relatively high.

Because the discussion is specifically used as a pedagogical device to facilitate student engagement with higher-level thinking, it is also necessary to consider potential evidence of students' thinking skills in the discussion context. Students were observed to synthesize material from various resources during the discussion; they drew from the assigned article, the lecture, and the in-class video to find evidence to support their responses and opinions. Additionally, students were observed to evaluate different lines of evidence based on methodological grounds. One student critiqued the methods used to determine the validity of skeletal evidence for Neanderthal and human interbreeding. Another student critiqued the possibility of recovering genetic material from fossil skeletons. In offering these critiques, the students displayed judgment, evaluation, and synthesis skills fundamental to higher-level thinking, as noted in Chapter Two. The students' demonstration of these skills during the discussion suggests the students are not only actively engaged with the course material, they are also engaged in critical reflections on that material; and the use of discussions in the laboratory pedagogy effectively fosters student engagement along these lines.

Overall, results suggest the laboratory pedagogy does successfully engage students in learning tasks, including station activities and in-class discussions. The laboratory pedagogy helps students to engage well with course material even at higher levels of thinking and

understanding. While this is accomplished in station activities, it is particularly pronounced during the in-class discussion. Importantly, the effectiveness of the pedagogy in engaging students applies similarly across the three laboratory sections observed. Although no direct evidence is available to link the students observed to particular majors (and learning styles), the broad effectiveness of the pedagogy across laboratory sections and the recognition that these sections reflect general patterns of major (and learning style) diversity, as discussed in Chapter Four, suggests the preliminary possibility that the pedagogy effectively engages students of various learning styles.

Initial Student Learning

To evaluate the effectiveness of the laboratory pedagogy in fostering high quality initial learning of course material, data from student final examinations was presented in the previous chapter. The results of these analyses are now discussed here in greater depth. Examining student performance on the exam overall, it is noteworthy that the summer 2007 overall exam average is markedly lower than that seen in the other semesters. The final exam in this term was written by a different instructor than the instructor who wrote the final exams used in the other terms in this study. As such, the summer 2007 exam used some question formats that were not seen in other semesters. For example, multiple choice questions on the summer 2007 exam occasionally included answers such as “A and C” or “none of the above.” Questions along these lines may be biased toward test-wise students, as compared to questions where all answer choices are content-based (Jacobs and Chase 1992, Kehoe 1995, Lowman 1995). A student facing a multiple choice question with only content-based answer choices has to understand the question, understand the possible answer choices, and determine the best answer presented. This is the case for students answering the multiple choice questions on the final exam in most of the terms studied. In contrast, a student facing a multiple choice question with four content-based answers and one answer reading “none of the above” may benefit from understanding some of the strategies involved in eliminating extreme answer choices, like “none of the above” (Jacobs and Chase 1992, Kehoe 1995, Lowman 1995). This is the case for students in the summer 2007 term. While the content and overall levels of thinking required on the summer 2007 exam was similar to that in the other terms, the format of the multiple choice questions themselves in this term may have impacted the overall performance of students on the exam. Importantly, this difference in performance seems to be relatively slight and does not seem to have greatly impacted any of the further statistical analyses conducted. It appears the overall exam performance is relatively comparable across the semesters studied.

Taking a closer look at performance on specific sets of exam questions, it can be said that students generally performed similarly on paleoanthropology exam questions and non-paleoanthropology exam questions. In the spring 2007 term, however, preliminary averages suggest students performed better on the non-paleoanthropology exam questions than on the paleoanthropology questions. The final exam in the spring 2007 term was administered approximately seven weeks after the conclusion of the paleoanthropology laboratory unit. In the summer terms, the exam was administered only two weeks following the conclusion of the same unit. This is due to differences in the overall timing and length of the course in these semesters. The extended time between the end of the paleoanthropology unit and the final exam in the spring 2007 semester may be a contributing factor to the lower performance on paleoanthropology exam questions among students from this term.

Further analysis was conducted to try to understand whether a true relationship exists between student performance on paleoanthropology exam questions and student performance on non-paleoanthropology exam questions. Using bivariate analysis, a moderate correlation was identified between these two variables. This analysis included data from the spring 2007 semester alongside data from the other semesters. Because the spring 2007 data set is substantially larger than all of the other terms combined, it is hypothesized that if the spring 2007 performance data was substantially different from the other terms—as the preliminary data might suggest—it would obscure relational trends between the two variables. However, the results instead show the stated correlation, supporting the preliminary suggestion that students performed similarly on both sets of exam questions. The preliminary differences in average scores for the spring 2007 semester noted above may be unduly skewed by extreme outliers, whereas the bivariate analysis better accounts for these possible discrepancies.

When all of these issues and results are considered together, it can be reasonably argued that the students generally perform similarly on the paleoanthropology exam questions and non-paleoanthropology exam questions, suggesting the paleoanthropology unit is representative of the laboratory pedagogy overall. However, it may also suggest that outside variables are at play. Research has shown that student exam performance is impacted by their approach to studying, which is impacted by their expectations of the test (Crooks 1988, Jacobs and Chase 1992, Wergin 1988). Therefore, a student may perform similarly on the paleoanthropology and non-paleoanthropology material because they expected to be tested on both sets of material similarly and consequently chose to study both sets of material similarly. At the same time, student motivation may be at play (Covington 1998), whereby a student performed similarly on paleoanthropology and non-paleoanthropology material because their over-arching approach to studying and exam-taking was impacted by a self-handicapping strategy of not trying too hard. Finally, student exam anxiety may be a contributing factor (Crooks 1988), such that a student performed similarly on both sets of material because they had similar levels of exam anxiety about both topics. Unfortunately, based on the available data at present, it is impossible to clearly identify the relative importance of these potential influences on the trend.

In evaluating the effectiveness of the laboratory pedagogy in fostering high quality initial student learning of course material, student performance on lab-based, paleoanthropology exam questions was compared to student performance on lecture-based, paleoanthropology exam questions. A moderate correlation between the two variables was found for the summer terms, and analysis of the spring 2007 data confirms that a relationship exists between the two variables in that term, as well.

If the laboratory pedagogy was effectively facilitating student learning, it was hypothesized that students would perform better on the lab-based, paleoanthropology exam questions than the lecture-based, paleoanthropology exam questions. Instead, it appears students perform similarly on the lab-based and lecture-based questions. However, this trend may be due to the nature of the laboratory pedagogy in relation to the overall course pedagogy. The laboratory is designed to supplement the lecture, rather than to teach entirely new course material. None of the material covered in the laboratory pedagogy is unique to that portion of the course. As such, none of the final exam questions ask about material strictly from the laboratory pedagogy. Thus, the divide constructed between lab-based and lecture-based exam questions in this study may be false, resulting in the trend identified in the statistical analysis. Another contributing factor may be similar to that discussed above regarding unaccounted for issues in student preparation for the exam and exam anxiety. Again, a student may perform

similarly on lab-based and lecture-based material because they studied both sets of material similarly, had a self-handicapping strategy that impacted their overall studying and performance, or had similar anxiety about both sets of material (Covington 1998, Crooks 1988, Jacobs and Chase 1992). It may also be possible that the laboratory pedagogy facilitates learning of low-level material more than high-level material (or vice versa), but this trend is obscured when low-level and high-level questions are combined.

To further explore this last possibility and to explicitly address the research question directed at the effectiveness of the laboratory pedagogy in fostering initial student learning at different levels of thinking, analysis was conducted to determine potential relationships between student performance on low-level, lab-based, paleoanthropology exam questions and student performance on low-level, lecture-based, paleoanthropology exam questions. No statistically meaningful correlation was identified between these variables for the summer terms. However, data from the spring 2007 term suggests that in that semester, at least, a relationship does appear to exist between the variables, where students perform similarly on low-level, lab-based, paleoanthropology questions and low-level, lecture-based, paleoanthropology questions. These results from the spring 2007 analysis are in-line with research expectations. If the learning of low-level material is largely the result of memorization of factual content, it is hypothesized that students will perform similarly on factual questions based on the laboratory pedagogy and factual questions based on the lecture because both simply require exposure to the content and memorization. The spring 2007 results support this, but the results of the summer terms do not. The data set from the summer terms is considerably smaller than that from the spring 2007 term, but it is large enough for correlations to be present in other analyses.

Therefore, the explanation may lie more in unaccounted for variables previously discussed, such as student preparation for the exam (Crooks 1988, Jacobs and Chase 1992, Wergin 1988). A student may perceive the lecture as heavily based in factual content and the lab as heavily based in higher-level thinking skills. As a result, the student may devote additional time to studying facts presented in the lecture component of the course and less time to studying facts presented in the laboratory pedagogy. In this case, the student may perform better on the low-level, lecture-based exam questions than the low-level, lab-based exam questions due to differences in their exam preparation strategy, rather than the effectiveness of the laboratory pedagogy in facilitating learning per se. Similarly, the lack of correlation between the two variables in the summer terms and/or the presence of a relationship in the spring 2007 term may be the result of the same potentially false divisions between the lab-based and lecture-based exam questions discussed above, or they may be the result of faulty divisions created between low-level and high-level exam questions.

Consideration of the potential relationship between student performance on low-level, lab-based questions and low-level, lecture-based questions is only half of the issue. The possible relationship between student performance on high-level, lab-based, paleoanthropology exam questions and high-level, lecture-based, paleoanthropology exam questions must also be explored. Unfortunately, there is not sufficient data available to compare these variables in the spring 2007 term; but a slight, moderate correlation between these variables is identified in the summer terms. This suggests students are performing similarly on high-level, lab-based questions and high-level, lecture-based questions. If the laboratory pedagogy effectively facilitates initial learning of higher-level thinking skills, it is hypothesized that students will perform better on high-level, lab-based questions than high-level, lecture-based questions; but this was not the identified trend.

The same factors discussed in relation to the low-level question results are also at play here. The data set for the summer terms is certainly smaller than that for the spring 2007 term, and there is no available spring 2007 data for comparable analysis to support or refute the summer data results. Again, though, the summer data does not seem to be too small for meaningful results. Student preparation for the exam may be another factor (Crooks 1988, Jacobs and Chase 1992, Wergin 1988). However, higher-level thinking skills are more difficult to study than factual content, so the extent of student studying and memorization is less likely to be a factor here with the high-level questions than above with the low-level questions. Student self-handicapping strategies may also be a factor (Covington 1998). A student who limits their effort in all schoolwork as a protection mechanism may perform similarly on all questions, whether based on the lecture or the laboratory context. Exam anxiety may also be an additional factor here, where a student may be similarly anxious about high-level, lab-based questions and high-level, lecture-based questions, such that the student performs similarly on both question types (Crooks 1988). Finally, the relationship noted between the two variables may again be influenced by the divisions created between lab-based and lecture-based questions and/or low-level and high-level questions for the purposes of this study. Any of these factors may have influenced the analysis conducted, particularly considering the low strength of the correlation identified. At present, however, it is difficult to identify exactly which factors are at play.

Overall, the results of the final exam data suggest students from across the semesters studied generally performed comparably on the exam. The results also suggest the paleoanthropology unit is a reasonable representation of the overall laboratory pedagogy. Unfortunately, student exams could not be matched to student majors (and learning styles), making considerations of variations in initial learning by learning style impossible at this time. However, the effectiveness of the laboratory pedagogy in fostering initial student learning was examined.

It appears that despite hypotheses to the contrary, there is no clear evidence at present that the laboratory pedagogy promotes higher quality initial learning as compared to the lecture component of the course. This trend is generally similar with both low-level and high-level course material and skills. These trends may reflect problems with the nature of the final exam data set. None of the final exams used here were designed for the purpose of this study; they were all designed to evaluate overall student learning of key course concepts, not specific learning of lab-based material. This certainly impacted various methodological decisions regarding the divisions created between lab-based and lecture-based exam questions and/or low-level and high-level exam questions, such that the divisions created may be false or misleading. The observed trends may also reflect student preparation for the exam, self-handicapping, or exam anxiety—none of which can be properly evaluated with the data available at present.

Finally, and most importantly, the observed trends in the data may simply demonstrate that the laboratory pedagogy does not significantly impact initial student learning quantitatively. That is, the active laboratory pedagogy may not foster more student learning than other methods, such as the more passive lecture. Rather, the active laboratory pedagogy may foster higher *quality* learning than other methods. The hypothesis formed in earlier chapters is that the active and cooperative pedagogy employed in the laboratory component of the course facilitates student engagement, which facilitates high quality learning, which in turn facilitates long-term retention. If this is the case, it may not be possible to measure the quality of student learning by examining how well students perform on an examination close to the time of the learning event. Instead, it

may be necessary to examine initial quality of learning using student retention of learned material.

Student Retention of Learned Course Material

Generally, student retention of learned paleoanthropology material was high, with retention rates of fifty percent or higher. Importantly, these retention rates are consistently high, despite variation in the professors (See Table 6.1) and graduate student instructors (See Table 6.2) who initially taught the survey participants in the terms studied. This suggests the pedagogy is effective in fostering high retention among students, no matter who acts as the particular professor or graduate student instructor facilitating the students’ learning experiences.

**Table 6.1
Number of Survey Participants Taught by each of the Professors during the Period Studied**

Professor	Number of Survey Participants
A	22
B	4
C	15

**Table 6.2
Number of Survey Participants Taught by each of the Graduate Student Instructors (GSI) during the Period Studied**

GSI	Number of Survey Participants
A	2
B	4
C	2
D	7
E	1
F	22
G	3

Retention was markedly higher in the more recent terms, where students were re-tested only one year or three months after completing the course. The drop-off in student retention over time evidenced in the lower retention rates for spring 2007 and summer 2007 students (surveyed approximately two years after completing the course) as compared to summer 2008 and summer 2009 students (surveyed approximately one year or three months after completing the course, respectively) is expected. It is hypothesized that retention levels will drop with the passage of time. What is remarkable is that retention remains at or above fifty percent in all terms studied, even in semesters completed two years prior to survey administration. On the surface, this could reflect biases in student participation in the survey, where student participants were largely students who learned more material than their counterparts who did not participate

in the survey. However, as noted in Chapter Five, the survey participants' average scores and distribution of scores on the paleoanthropology exam questions, non-paleoanthropology exam questions, and exam overall are similar to these same scores among students from the relevant semesters overall. Therefore, it appears that there is not substantial bias in the survey data toward students who generally out-perform other students on the paleoanthropology material. The survey data, then, does reflect truly high retention rates.

These preliminary results are supported by further statistical analyses. If the survey is adequately measuring retention of learned information, it is expected that students who perform well on the paleoanthropology exam questions will also perform well on the survey questions. The moderate correlation identified between student performance on the survey and student performance on the paleoanthropology exam questions meets this expectation. Similarly, if the survey truly reflects retention of learned information, as opposed to an unknown outside factor, students who demonstrate a lot of learning on the exam should score better on the survey than students who did not demonstrate a lot of learning on the exam. This expectation is supported by the moderate correlation found between student survey performance and overall exam performance, further suggesting the survey is an adequate measure of student retention of learned material. However, it is possible that survey participants are more likely to be students who performed well in the course, as opposed to students who did not perform well. This would introduce bias into the data and result in the same statistical trends as those identified above. At this time, it is not believed that this bias, if present, had a substantial impact on the data. Firstly, as discussed above, survey participants' average exam scores and distributions of exam scores are similar to those of the corresponding overall final exam population in each of the terms studied. This suggests that the survey participants are a fair representation of the overall population, rather than a sample biased toward high performers. Additionally, five students (approximately 12% of the survey population) had average survey scores that were higher than their paleoanthropology exam question averages (See Table 6.3). This further supports the argument made here that the survey data is not necessarily biased toward high-performing students. Thus, the survey data truly indicates the laboratory pedagogy is effective in promoting retention of learned material.

Table 6.3
Survey Participants with Higher Survey Score Averages than Paleoanthropology Exam Question Averages

Student (Semester)	Survey Average	Paleoanthropology Exam Question Average
227 (Spring 2007)	100	89
010 (Summer 2008)	88	84
003 (Summer 2009)	100	98
034 (Summer 2009)	100	98
036 (Summer 2009)	100	81

Having established this general efficacy, it is important to consider the laboratory pedagogy's effectiveness in facilitating retention of both lower-level thinking and higher-level thinking material, specifically. Unfortunately, the nature of the survey hinders the ability to

explore this issue in great depth. In order to maximize student participation in the survey, the length of the survey was kept to ten questions. This does not provide enough data for statistical examination of retention of low-level material as separate from high-level material, but a few preliminary results are available. It is hypothesized that the critical thinking tasks in the laboratory pedagogy foster higher-level thinking skills more than lower-level knowledge accumulation. However, the preliminary data shows that low-level retention is higher than high-level retention. This trend in the data may be the result of bias in the size of the data set. Only one survey question meets the requirements for being considered in the low-level retention score. If this one question happened to be based on material that was particularly meaningful to the students or easy to memorize, we would see the same trend in high retention rates for low-level material. At the same time, the high-level retention score is comprised of multiple questions, and each question requires the application of a skill in a slightly different context. This material is a larger, more meaningful data set; and it is likely to have greater variation in scores due to the additional challenges for the student that are inherent to higher-level thinking questions. These differences between the available low-level and high-level retention data sets are substantial and make even the preliminary data suspect. Thus, at this time, it is difficult to say whether the laboratory pedagogy effectively fosters retention of higher-level thinking skills, as separate from lower-level knowledge accumulation.

Adequate data does exist to examine the laboratory pedagogy's effectiveness in fostering retention of learned material across multiple learning styles. Results suggest different learning styles perform similarly on the paleoanthropology exam questions, exam overall, and survey. Closer examination shows that the non-diverger students perform similarly or slightly better than divergers on the survey, even when the non-divergers perform similarly or lower on the paleoanthropology exam questions and exam overall (as is the case with the summer 2009 students). This demonstrates the laboratory pedagogy is generally effective in fostering similar retention rates among students of different learning styles. At the same time, following the arguments made previously regarding the use of retention scores in measuring quality of initial learning, it also provides some very preliminary data suggesting that the laboratory pedagogy effectively promotes initial high quality learning across learning styles.

Again, the summer 2007 results stand out from the other terms. The exam scores in both learning style groups are lower than other terms, but the survey scores in both learning style groups are similar to those seen in the spring 2007 term. Importantly, the summer 2007 results also show the same trend seen in other semesters, whereby the non-diverger students perform slightly better than the diverger students on the survey. Thus, despite the unusual summer 2007 exam data, the survey results by learning style for this term reflect the same trends as those identified for the other terms under investigation.

These preliminary trends seen in all terms point to the effectiveness of the laboratory pedagogy in facilitating retention for a range of students, but they require closer examination. Results of statistical analysis show that student performance on the low-level survey material is not related to student learning style. Again, there are potential problems with these results introduced by the fact that only one survey question can be considered to be low-level. However, these results do tend to indicate that the pedagogy may be similarly effective in promoting retention of low-level knowledge across students of multiple learning styles. Results of statistical analysis also show student performance on higher-level thinking survey questions is similar in both learning style groups. Because there are multiple survey questions identified as targeting higher-level thinking skills, these results provide possibly stronger evidence than that

seen with the low-level survey material. When taken together, though, the evidence indicates it is likely that the laboratory pedagogy effectively promotes similar degrees of retention of low-level and high-level material across students of different learning styles.

Before concluding, the spring 2007 and summer 2007 results warrant further consideration. As noted above, students from the summer 2007 term scored lower on all aspects of the final exam than students from the other semesters studied. This trend in exam performance is also found among the survey participant sub-population. However, the summer 2007 survey participants scored similarly on the survey to participants from the spring 2007 term. These two terms were both administered the survey approximately two years after completing the course, thus their similar retention rates are expected. The survey results may be biased by the markedly lower survey response rate for the spring 2007 semester, but this is unlikely. Looking at the exam scores for the spring 2007 survey participants, it appears that they are a reasonable representation of the overall spring 2007 population despite the low survey response rate. Thus, it is more likely that the similar retention scores seen in the spring 2007 and summer 2007 terms, despite lower exam performance in the summer 2007 term, is truly meaningful, rather than the result of response rate bias.

The summer 2007 data, then, is remarkable in that it supports the interpretation that exam performance may not be an adequate measure of initial learning quality. If exam performance was an accurate measure of learning quality, we would expect the summer 2007 students to have scored similarly on the final exam to spring 2007 students because survey participants from both terms show similar retention rates. Instead, the summer 2007 students demonstrate expected retention rates given the time interval between course completion and survey administration, despite having performed markedly lower on all portions of the final exam.

Again, it is likely that the exam results may be biased by the nature of the summer 2007 exam data. As previously discussed, the precise question format of the summer 2007 exam was slightly different from the other semesters studied, and this may have impacted the overall performance of students on the exam in this term. However, even if this were the case, it would suggest that the students may not have been able to adequately demonstrate their learning on the exam provided; it would not necessarily suggest that the students did not learn. In fact, the students' high retention of course material over two years demonstrates they did learn key course content. Thus, potential bias in the exam data does not dramatically impact the overall implications of the similar retention rates seen in the summer 2007 and spring 2007 terms.

Furthermore, the similar retention rates seen in these semesters, despite differences in exam performance, suggests, as argued above, that students may not be learning *more* information with the laboratory pedagogy, but are instead learning information *better*. No matter what quantity of information students demonstrated mastery of on the final exam in the summer 2007 term, they demonstrated high quality mastery by encoding that material well enough that it could be successfully retained for two years. Therefore, it is likely that the laboratory pedagogy fosters high quality learning, as demonstrated through high retention rates, rather than final exam performance.

Overall, it appears the survey participants are a fair representation of the larger study population, and survey evidence suggests that the laboratory pedagogy effectively promotes high retention rates. These retention rates do drop-off over time, but they generally remain high (over fifty percent). Retention of low-level material may be higher than retention of high-level material, but this is preliminary and suspect at present. The laboratory pedagogy does seem to promote similar retention rates across multiple learning styles; and this trend holds true for both

low-level material and high-level material when considered separately. Finally, the argument put forward in the previous section regarding the potential utility of retention data for examining the quality of initial student learning is validated by summer 2007 survey data. This data shows that final exam performance may not be a good indicator of quality of learning, as much as it is an indicator of quantity of learning.

Summary

Analysis of classroom observations indicates the laboratory pedagogy effectively engages students in active, cooperative tasks. The students perform well in these contexts and demonstrate valuable cooperative skills. The laboratory pedagogy also effectively promotes student engagement with higher-level thinking skills, as seen in students' critical consideration of course material. This fostering of student engagement can be preliminarily said to be applicable across learning styles. In addition to facilitating student engagement, the laboratory pedagogy seems to effectively facilitate students' initial learning of course material. This is evidenced somewhat through final exam performance data and supplemented by retention data, which suggests that the pedagogy effectively promotes high quality learning among students. Finally, the laboratory pedagogy fosters long-term retention of learned course material in general and across various student learning styles. Based on these outcomes, it is argued here that the laboratory pedagogy facilitates student engagement, which in turn improves the quality of students' learning, which in turn promotes retention of learned material over time. These results solidify the laboratory pedagogy as an effective approach to the instruction of introductory biological anthropology, in that it results in high quality learning and meaningful, long-term understanding of important concepts and skills across a range of students.

CHAPTER SEVEN: CONCLUSION

The research presented here draws from work in cognitive psychology and education in an effort to quantitatively and qualitatively evaluate the pedagogy designed for the laboratory component of an introductory college course in biological anthropology. The pedagogy studied is designed to actively engage students in lower and higher-level thinking through the use of interactive and cooperative tasks, as well as in-class discussions. Additionally, the pedagogy is meant to benefit students of all learning styles.

It has been argued here that a successful pedagogical approach engages students in learning, which, in turn, results in high quality learning and long-term retention of learned material. Therefore, to evaluate the given laboratory pedagogy, three levels of analysis were examined: student engagement, initial student learning, and student retention of learned course material. The laboratory pedagogy was further evaluated in terms of its effectiveness in fostering higher-level thinking and its effectiveness for students of diverse learning styles.

Four semesters of data from the “Anthropology 1: Introduction to Biological Anthropology” course at The University of California, Berkeley were used in this study—the spring 2007 semester, summer 2007 semester, summer 2008 semester, and summer 2009 semester. In Chapter Three, the laboratory pedagogy was explained both in the context of the larger course and in its specific goals and elements, such as the laboratory workbook. Particular attention has been paid to the paleoanthropology unit of the laboratory pedagogy as a representation of the pedagogy overall. Although the pedagogy is remarkably similar across all of the terms studied, minor differences in course timing exist between the spring and summer terms. The impact of this on course and laboratory content was discussed in Chapter Three. The three sets of data used to evaluate the effectiveness of the pedagogy at the three levels of analysis were outlined in Chapter Four. Observations of summer 2009 students in the laboratory classroom were used to examine student engagement; student performance on the final exam in each semester was used to investigate initial student learning; and student performance on a survey administered between three months and two years after completing the course was used to explore student retention of learned course material. While the data sets vary in size and type of information available, all are found to be representative of the larger population and useful in examining the stated research objectives.

Results of data analysis presented and discussed in Chapters Five and Six suggest the laboratory pedagogy does successfully engage students in classroom tasks and foster the development of important critical thinking and cooperative skills. While the analyses conducted here do not necessarily indicate that the pedagogy promotes higher quantities of student learning, the analyses do indicate the pedagogy promotes high quality student learning. This is seen to a limited extent in student final exam performance data. It is seen to a larger extent in student survey performance data, analysis of which suggests the pedagogy facilitates high levels of student retention of learned material, which, in turn, suggests the pedagogy facilitates high quality initial learning. In general, these results are similar across students of different learning styles, indicating the laboratory pedagogy successfully fosters student engagement with, learning of, and retention of course material for a wide range of students.

Suggestions for Future Research

Future research into this and other, similar pedagogical devices is highly recommended. Further efforts to evaluate the pedagogical approach examined in this study would greatly benefit from minor adjustments and additions to the available data. While the observation data presented here is valuable in its ability to speak to issues of student engagement, more robust observations would further elucidate these issues. It is recommended that additional observations be made of students completing elements of the paleoanthropology unit in the classroom. If these observations are made during a summer term, they will readily fit in with and flesh out the current data set with observations of three to four additional sections employing the same version of the laboratory workbook. If these observations are made during a spring term, they will supplement the current data set with observations of as many as thirty sections in one term and provide new data related to the implementation of the full-length laboratory workbook. The paleoanthropology unit in the full-length workbook includes multiple workbook chapters and corresponding class meetings. Observations of spring semester students would therefore also provide insight into any potential similarities or differences between the full-length workbook used in spring terms and the condensed workbook used in summer terms.

The current observational data could also be supplemented with more in-depth interviews or questionnaires designed to elicit the students' perspective on the laboratory pedagogy. Classroom observations provide a starting point for considering student engagement with course pedagogy and yield valuable information about overall student participation and cooperation. However, these observations are limited in their ability to address student thinking. For example, at present, potential evidence of student engagement in higher-level thinking is largely limited to observations of students critically discussing methodological concerns. Interviewing students and/or administering a detailed questionnaire about student thinking processes while completing laboratory tasks would greatly add to the data available. At the same time, through interviews or questionnaires it would also be possible to collect data about engagement with other elements of the laboratory pedagogy, such as the homework components of the laboratory workbook.

While making these additions to the observation data would require a substantial amount of additional effort and may be subject to problems with response rate and student participation in interviews and questionnaires, the final exam data could be very easily supplemented with a minor change to future exams in the course. One of the problems with the current final exam data set is that each student's exam cannot be adequately matched to that student's major and corresponding learning style. This limits the current research to only preliminary suggestions regarding the efficacy of the pedagogy in fostering learning across multiple learning styles. It is recommended, therefore, that in future terms, a question be added to the final exam that asks students to identify their major in school. This question should take the format of the question used to illicit the same information in the follow-up survey. It should be an open-ended question that asks the student their "declared/intended" major, in order to be able to collect information from all students, including those who have not yet officially declared a major. The self-identified majors provided by students could then be matched to the appropriate learning style, just as similar data was matched from the follow-up survey.

This minor change in the final exam of future terms would help to clarify the potential relationship between student learning style and initial learning. However, as this dissertation argues, the final exam may still not be an adequate measure of initial learning quality. With this

in mind, then, it is important to ensure that the data related to student retention of learned information is as robust as possible. The current survey data used to examine student retention was found to be lacking in that it did not ask enough low-level thinking questions to adequately investigate any variations in student retention of low-level vs. high-level material. This lack of information is the result of the limitations imposed by the length of the survey, which was intentionally kept short to maximize student participation. In order to account for the need for more low-level thinking data and still maintain a ten-question survey, it is recommended that two of the current high-level survey questions be replaced with two, new low-level questions. This would result in a new total of three low-level survey questions and four high-level survey questions and provide more data for the desired comparison. However, making this change in future surveys would limit the comparability of surveys across semesters, as all previously collected surveys would vary by two questions from all future surveys. This change in comparability will have to be weighed against the desire to address variation in low-level and high-level retention when designing and implementing the follow-up survey in the future, such that the best solution to both issues may be found.

Another way to improve the data available for quality of student learning may be to design and administer a survey separate from the final exam but administered at approximately the same time. This survey could ask questions relating to both paleoanthropology and non-paleoanthropology questions, like the final exam, but it could be explicitly designed to evaluate quality of learning, rather than quantity of learning. One of the problems with the final exam data set is that the final exam is not designed as a tool for evaluating the efficacy of the laboratory pedagogy; it is designed as a measure of assessing overall student proficiency for grading purposes. It is possible that an alternate data set—derived from performance on a separate, end-of-term survey—would provide more valuable information regarding learning quality if it is explicitly designed for this purpose.

Finally, there have been many variables that could not be readily accounted for by the current data. It is recommended that administering additional surveys would allow for greater discernment of the potential influences of these variables. For example, with much of the exam data it is unclear how much the student performance scores are impacted by non-pedagogical factors, such as variations in student studying, motivation, or test anxiety. If questionnaires are used in future semesters to collect information about student study habits, motivation, and test anxiety, it might be possible to further delineate the variables contributing to the trends identified in the data. At the same time, this current research has assumed that previously researched relationships between student major and learning style are accurate. This is a fair assumption considering the extent of research used to establish and verify these relationships. However, it may be useful in future terms to administer a questionnaire to students that can directly identify their learning style without using college major as a proxy. This would solidify the learning style data and results even further than current research is able.

Implications of the Research

Recent trends in educational research and academia at large have begun to shed light on the importance of effective pedagogical practices in higher education. Anthropology, as a discipline, has become a part of this movement, turning a critical eye toward the quality of anthropology training and the pedagogical approaches used in undergraduate anthropology courses. This dissertation contributes meaningfully to this growing body of research in the

discipline by evaluating the effectiveness of a pedagogical approach that, although focused on biological anthropology, is widely applicable in a variety of introductory anthropology courses.

The success of the laboratory pedagogy evaluated here highlights the benefit of active pedagogy in introductory anthropology. Approaches that foster student engagement with course material through hands-on and interactive experiences place students at the center of learning and foster high quality understandings of course material that can be retained over the long-term. At the same time, the success of the cooperative elements of the laboratory pedagogy examined here suggests that cooperative tasks and activities may be usefully employed in other anthropology courses to promote the development and practice of important cooperative skills.

The active, cooperative tasks that comprise the majority of the laboratory pedagogy are most conducive to applications in other biological anthropology courses. Introductory courses, like the one studied here, may clearly benefit from active laboratory pedagogies. However, more specialized, upper-division electives in biological anthropology would also potentially benefit from similar hands-on tasks that engage students in learning. The active approach used in the introductory biological anthropology laboratory is also likely to be equally effective in introductory archaeology courses, as these courses also tend to have laboratory sections in addition to the primary lecture. These laboratory sections are ready-made for the implementation of an active pedagogy like that studied here; separate time set aside for laboratory instruction can be readily devoted to interactive tasks and assignments that promote critical thinking skills. By the same token, the active approach may also be usefully employed in more specialized, upper-division elective courses in archaeology.

The laboratory components of the pedagogy examined here are not as readily applied to other anthropology courses, such as introductory cultural anthropology. However, the underlying principles and techniques may prove very fruitful in these contexts. For example, cultural anthropology students could be assigned any number of tasks that would provide them with hands-on experience in anthropological investigations, such as small-scale assignments that require students to make anthropological observations in nearby surroundings. These interactive assignments would potentially engage students in a way similar to that seen in the laboratory context, and therefore potentially result in similar benefits to the quality of student learning.

Importantly, the benefits of the laboratory pedagogy investigated here likely have implications for instruction in other disciplines, as well. The biological anthropology course studied here shares many parallels in course content with courses in biology, psychology, and comparative anatomy. As discussed in Chapter Two, evidence abounds that various active, cooperative approaches are effective in a range of college science courses (e.g. Jensen and Finley 1996, Michael and Modell 2003, Paulson 1999). The work presented here contributes another example in support of these existing studies. By actively engaging students in coursework, the laboratory pedagogy is able to help students develop understandings of complex issues and abstract concepts; and the pedagogy is able to facilitate students' development of higher-level thinking skills that are applicable in many contexts. Similar courses in disciplines other than anthropology also often require their students to think abstractly and apply learned material to novel contexts, and an active pedagogy, like that investigated here, is likely to facilitate student learning in these courses.

The success of the laboratory pedagogy studied here for students from different learning styles also has important implications across various disciplines. Like most introductory courses in biological anthropology, the particular course considered in this dissertation draws students from a wide range of departments and learning styles. This diverse student body is not limited to

introductory biological anthropology courses, however. Many college courses serve as graduation requirements for students from multiple departments on campus, resulting in countless course contexts where the student body may include a range of students, such as physics majors, fine art majors, and business majors. These students often represent very different approaches to learning, or learning styles. Developing and implementing a pedagogy like that examined here may help instructors to successfully teach courses with this type of student diversity. By varying the format of assignments and tasks and promoting cooperation among classmates, instructors may be able to foster high quality learning for all of their students, rather than a select few who happen to learn a particular way.

In addition to the practical implications of the research presented here, there are methodological implications that may shape how future research along these lines is conducted. This work considers multiple levels of analysis at once, including student engagement, student learning, and student retention. It considers all three at the same time as equally necessary and inherently intertwined components of effective pedagogy. In doing this, it also permits an evaluation of a pedagogical approach that draws from both quantitative and qualitative data simultaneously, rather than one or the other. Research along these lines results in robust interpretations and well-rounded considerations of pedagogical effectiveness. This methodological approach does require examination of several lines of evidence, which may be time-consuming and financially demanding. However, the benefits of fully evaluating pedagogical efficacy both quantitatively and qualitatively likely outweigh these costs.

Most importantly, it has been shown in this dissertation that student exam performance may not be the best indicator of the quality of student learning. Results of analyses of student exam performance data were found to be lacking; the exam performance data seemed to reflect learning quantity more than learning quality. It was discovered that student survey performance was more useful in addressing learning quality than student exam performance. Although this survey data was primarily collected to address student retention, it was also usefully applied to the consideration of student learning. This has far-reaching implications, as it suggests that learning quality is a complex issue that may not be easily quantified by testing at the time of learning. When conducting future educational research into learning quality, we may want to consider alternate lines of evidence, such as retention data, rather than final exam performance.

Summary

It has been shown here that the laboratory pedagogy investigated is an effective approach to undergraduate, introductory biological anthropology instruction. In doing this, the research presented here makes valuable contributions to the discipline of anthropology in that it examines a pedagogical approach that can be readily applied to numerous undergraduate anthropology courses. The research also contributes to larger research in education both in its actual results and in its methodological approach. All of the above suggestions for future research could be usefully employed in further research relating specifically to evaluations of this particular laboratory pedagogy. They could also be employed in research that uses a similar methodological approach to evaluating pedagogical efficacy in other courses and disciplines. In conclusion, then, this dissertation accomplishes three things: it demonstrates the utility of active, cooperative pedagogy in anthropology and beyond; it suggests a well-rounded approach to evaluating pedagogical efficacy by considering multiple scales of analysis simultaneously; it encourages others to critically examine their own pedagogical approaches with an eye toward further improvement, because there is always room to grow.

BIBLIOGRAPHY

- Anderson, L. W. 1994. "Research on Teaching and Teacher Education," in *Bloom's Taxonomy: A Forty-year Retrospective*. Edited by L. W. Anderson and L. A. Sosniak, pp. 126-145. Chicago: University of Chicago Press.
- Ashmore, P. C. 2005. Role of Physical Anthropology in Intermediate and Secondary Education. *Yearbook of Physical Anthropology* 48:154-162.
- Ausubel, D. P. 1968. *Educational Psychology: A Cognitive View*. New York: Holt, Rinehart, and Winston.
- Barr, R. B., and J. Tagg. 1995. From Teaching to Learning: A New Paradigm for Undergraduate Education. *Change* 27:12-25.
- Bjork, R. A. 1988. "Retrieval Practice and the Maintenance of Knowledge," in *Practical Aspects of Memory: Current Research and Issues*, vol. 1. Edited by M. M. Gruenberg and P. E. Morris, pp. 396-401. New York: John Wiley & Sons.
- . 1994. "Memory and Metamemory Considerations in the Training of Human Beings," in *Metacognition: Knowing about Knowing*. Edited by J. Metcalfe and A. Shimamura, pp. 185-205. Cambridge, MA: MIT Press.
- Bloom, B. S. 1994. "Reflections on the Development and Use of the Taxonomy," in *Bloom's Taxonomy: A Forty-year Retrospective*. Edited by L. W. Anderson and L. A. Sosniak, pp. 1-8. Chicago: University of Chicago Press.
- Bloom, B. S., M. D. Engelhart, E. J. Furst, W. H. Hill, and D. R. Krathwohl. 1956. *Taxonomy of Educational Objectives: The Classification of Educational Goals, Handbook I: Cognitive Domain*. New York: David McKay.
- Brookfield, S. D., and S. Preskill. 2005. *Discussion as a Way of Teaching: Tools and Techniques for Democratic Classrooms*, 2 edition. San Francisco: Jossey-Bass.
- Brown, A. L. 1994. The Advancement of Learning. *Educational Researcher* 23:4-12.
- Brown, A. L., and J. C. Campione. 1994. "Guided Discovery in a Community of Learners," in *Classroom Lessons: Integrating Cognitive Theory and Classroom Practice*. Edited by K. McGilly, pp. 229-270. Cambridge, MA: MIT Press.
- Brown, G., and M. Atkins. 1988. *Effective Teaching in Higher Education*. London: Routledge.
- Bruer, J. T. 1994. "Classroom Problems, School Culture, and Cognitive Research," in *Classroom Lessons: Integrating Cognitive Theory and Classroom Practice*. Edited by K. McGilly, pp. 273-290. Cambridge, MA: MIT Press.
- Bruning, R. H. 1994. "The College Classroom from the Perspective of Cognitive Psychology," in *Handbook of College Teaching: Theory and Applications*. Edited by K. W. Prichard and R. M. Sawyer, pp. 3-22. Westport, CT: Greenwood Press.
- Burke, H., and C. Smith. Editors. 2007. *Archaeology to Delight and Instruct: Active Learning in the University Classroom*. Vol. 49. *One World Archaeology Series*. Walnut Creek, CA: Left Coast Press.
- Campione, J. C. 2007. "Prologue: Some Observations on the Career and Legacy of Ann Brown," in *Children's Learning in Laboratory and Classroom Contexts: Essays In Honor of Ann Brown*. Edited by J. Campione, K. Metz, and A. S. Palincsar, pp. v-xvi. New York: Lawrence Erlbaum Associates.
- Caulkins, D. D., J. G. Andelson, V. Bentley-Condit, and K. A. Kamp. 1999. Discovery-Mode Teaching Using the Electronic Human Relations Area Files for Cross-Cultural Comparisons. *Cross-Cultural Research* 33:278-297.

- Christina, R. W., and R. A. Bjork. 1991. "Optimizing Long-Term Retention and Transfer," in *In the Mind's Eye: Enhancing Human Performance*. Edited by D. Druckman and R. A. Bjork, pp. 23-56. Washington, D.C.: National Academy Press.
- Claxton, C. S., and P. H. Murrell. 1987. *Learning Styles: Implications for Improving Education Practices. ASHE-ERIC Higher Education Report No. 4*. Washington, D.C.: Association for the Study of Higher Education.
- Clouston, T. J. 2005. "Facilitating Tutorials in Problem-Based Learning: Students' Perspectives," in *Enhancing Teaching in Higher Education: New Approaches for Improving Student Learning*. Edited by P. Hartley, A. Woods, and M. Pill, pp. 48-58. New York: Routledge.
- Cohen, D. R., and L. Panich. 2009. The Prison Notebook: Lessons Learned Teaching Anthropology at San Quentin State Prison. *Anthropology News* 50:25-26.
- Cohen, E. 1986. *Designing Groupwork: Strategies for the Heterogeneous Classroom*. New York: Teachers College Press.
- Coleman, S. 2002. The New Higher Education? Learning and Teaching in a Knowledge Society: Centre for Learning and Teaching Conference, Aston University, 11-12 January 2002. *Anthropology Today* 18:26.
- Coleman, S., and B. Simpson. 1999. Unintended Consequences? Anthropology, Pedagogy, and Personhood. *Anthropology Today* 15:3-6.
- Colley, S. 2004. University-Based Archaeology Teaching and Learning and Professionalism in Australia. *World Archaeology* 36:189-202.
- Cooper, J. L. 1995. Cooperative Learning and Critical Thinking. *Teaching of Psychology* 22:7-8.
- Covington, M. 1998. *The Will to Learn: A Guide for Motivating Young People*. New York: Cambridge University Press.
- Covington, M. V. 1997. "A Motivational Analysis of Academic Life in College," in *Effective Teaching in Higher Education: Research and Practice*. Edited by R. P. Perry and J. C. Smart, pp. 61-100. New York: Agathon Press.
- Covington, M. V., and S. Wiedenaupt. 1997. "Turning Work into Play: The Nature and Nurturing of Intrinsic Task Engagement," in *Effective Teaching in Higher Education: Research and Practice*. Edited by R. P. Perry and J. C. Smart, pp. 101-114. New York: Agathon Press.
- Crooks, T. J. 1988. The Impact of Classroom Evaluation Practices on Students. *Review of Educational Research* 58:438-481.
- Dansereau, D. F., and D. W. Johnson. 1994. "Cooperative Learning," in *Learning, Remembering, Believing: Enhancing Human Performance*. Edited by D. Druckman and R. A. Bjork, pp. 83-111. Washington, D.C.: National Academy Press.
- Davis, B. G. 1993. *Tools for Teaching*. San Francisco: Jossey-Bass.
- Dempster, F. N. 1996. "Distributing and Managing the Conditions of Encoding and Practice," in *Memory, Handbook of Perception and Cognition*. Edited by E. L. Bjork and R. A. Bjork. San Diego: Academic Press.
- Dewey, J. 1997 [1938]. *Experience and Education. The Kappa Delta Pi Lecture Series*. New York: Touchstone.
- Farrer, C. 1990. Honors Anthropology and the Four Rs. *Anthropology and Education Quarterly* 21:134-140.
- Feltz, D. L. 1994. "Self-Confidence and Performance," in *Learning, Remembering, Believing: Enhancing Human Performance*. Edited by D. Druckman and R. A. Bjork, pp. 173-206. Washington, D.C.: National Academy Press.

- Foyle, D. C. 1995. "Think-Pair-Share and the Graduate Teaching Assistant," in *Interactive Learning in the Higher Education Classroom: Cooperative, Collaborative, and Active Learning Strategies*. Edited by H. C. Foyle, pp. 226-233. Washington, D.C.: National Education Association.
- Frederick, P. J. 1994. "Classroom Discussions," in *Handbook of College Teaching: Theory and Applications*. Edited by K. W. Prichard and R. M. Sawyer, pp. 99-109. Westport, CT: Greenwood Press.
- Freire, P. 1983 [1970]. *Pedagogy of the Oppressed*. New York: Continuum.
- Furst, E. J. 1994. "Bloom's Taxonomy: Philosophical and Educational Issues," in *Bloom's Taxonomy: A Forty-year Retrospective*. Edited by L. W. Anderson and L. A. Sosniak, pp. 28-40. Chicago: University of Chicago Press.
- Gardner, H. 1993. *Multiple Intelligences: The Theory in Practice*. New York: Basic Books.
- Gillies, R. M., and A. F. Ashman. 2003. "An Historical Review of the Use of Groups to Promote Socialization and Learning," in *Co-operative Learning: The Social and Intellectual Outcomes of Learning in Groups*. Edited by R. M. Gillies and A. F. Ashman, pp. 1-18. New York: RoutledgeFalmer.
- Hamilakis, Y. 2004. Archaeology and the Politics of Pedagogy. *World Archaeology* 36:287-309.
- Henderson, G., and S. S. Nash. 2007. *Excellence in College Teaching and Learning: Classroom and Online Instruction*. Springfield, IL: Charles C. Thomas Publisher, Ltd.
- Henning, J. E. 2008. *The Art of Discussion-Based Teaching: Opening Up Conversation in the Classroom*. New York: Routledge.
- Huntington, A. 2005. "Interactive Teaching and Learning: Exploring and Reflecting on Practice," in *Enhancing Teaching in Higher Education: New Approaches for Improving Student Learning*, vol. 26-36. Edited by P. Hartley, A. Woods, and M. Pill. New York: Routledge.
- Jacobs, G. M., M. A. Power, and L. W. Inn. 2002. *The Teacher's Sourcebook for Cooperative Learning: Practical Techniques, Basic Principles, and Frequently Asked Questions*. Thousand Oaks, CA: Corwin Press, Inc.
- Jacobs, L. C., and C. I. Chase. 1992. *Developing and Using Tests Effectively: A Guide for Faculty*. San Francisco: Jossey-Bass.
- Jensen, M. S., and F. N. Finley. 1996. Changes in Students' Understanding of Evolution Resulting from Different Curricular and Instructional Strategies. *Journal of Research in Science Teaching* 33:879-900.
- Johnson, D. W., R. T. Johnson, and K. A. Smith. 1991. *Cooperative Learning: Increasing College Faculty Instructional Productivity*. Washington, D.C.: School of Education and Human Development, The George Washington University.
- Kehoe, J. 1995. Writing Multiple-Choice Test Items. *Practical Assessment, Research and Evaluation* 4.
- Kolb, D. A. 1981. "Learning Styles and Disciplinary Differences," in *The Modern American College: Responding to the New Realities of Diverse Students and a Changing Society*. Edited by A. W. Chickering, pp. 232-255. San Francisco: Jossey-Bass.
- Krathwohl, D. R. 1994. "Reflections on the Taxonomy: Its Past, Present, and Future," in *Bloom's Taxonomy: A Forty-year Retrospective*. Edited by L. W. Anderson and L. A. Sosniak, pp. 181-202. Chicago: University of Chicago Press.

- Kreitzer, A. E., and G. F. Madaus. 1994. "Empirical Investigations of the Hierarchical Structure of the Taxonomy," in *Bloom's Taxonomy: A Forty-year Retrospective*. Edited by L. W. Anderson and L. A. Sosniak, pp. 64-81. Chicago: University of Chicago Press.
- Lave, J., and E. Wenger. 1991. *Situated Learning: Legitimate Peripheral Participation*. New York: Cambridge University Press.
- Leonard, W. H. 1994. "The Laboratory Classroom," in *Handbook of College Teaching: Theory and Applications*. Edited by K. W. Prichard and R. M. Sawyer, pp. 155-169. Westport, CT: Greenwood Press.
- Lightfoot, K. G. 2009. Anthropology Field Schools for the 21st Century. *General Anthropology* 16:1-4.
- Lotan, R. A., and J. A. Whitcomb. 1998. "Groupwork in Diverse Classrooms," in *Groupwork in Diverse Classrooms: A Casebook for Educators*. Edited by J. H. Shulman, R. A. Lotan, and J. A. Whitcomb, pp. 1-10. New York: Teachers College Press.
- Lowman, J. 1995. *Mastering the Techniques of Teaching*, 2nd edition. San Francisco: Jossey-Bass.
- Lyman, L. 1995. "Group Building in the College Classroom," in *Interactive Learning in the Higher Education Classroom: Cooperative, Collaborative, and Active Learning Strategies*. Edited by H. C. Foyle, pp. 177-191. Washington, D.C.: National Education Association.
- Marzano, R. J. 2001. *Designing a New Taxonomy of Educational Objectives*. Thousand Oaks, CA: Corwin Press.
- Mazur-Stommen, S. 2006. Optimal Foraging Theory and the Racecar Driver: The Impact of Student-Centered Learning on Anthropological Pedagogy. *Anthropology and Education Quarterly* 37:273-284.
- McGilly, K. 1994. "Cognitive Science and Educational Practice: An Introduction," in *Classroom Lessons: Integrating Cognitive Theory and Classroom Practice*. Edited by K. McGilly, pp. 3-21. Cambridge, MA: MIT Press.
- Michael, J. A., and H. I. Modell. 2003. *Active Learning in Secondary and College Science Classrooms: A Working Model for Helping the Learner to Learn*. Mahwah, NJ: Erlbaum Associates.
- Michaelsen, L. K. 1994. "Team Learning: Making a Case for the Small-Group Option," in *Handbook of College Teaching: Theory and Applications*. Edited by K. W. Prichard and R. M. Sawyer, pp. 139-153. Westport, CT: Greenwood Press.
- Millis, B., J. Frank T. Lyman, and N. Davidson. 1995. "Cooperative Structures for Higher Education Classrooms," in *Interactive Learning in the Higher Education Classroom: Cooperative, Collaborative, and Active Learning Strategies*. Edited by H. C. Foyle, pp. 204-225. Washington, D.C.: National Education Association.
- Millis, B. J., and P. G. Cottell. 1998. *Cooperative Learning for Higher Education Faculty*. Phoenix: Oryx Press.
- Moore, D. T. 2001. Experiential Learning in Anthropology: Another Perspective. *Anthropology of Work Review* 22:19-23.
- Morgan, H. 1997. *Cognitive Styles and Classroom Learning*. Westport, CT: Praeger.
- Murad, T. A. 1988. Teaching Anthropology and Critical Thinking with the Question "Is There Something Big Afoot?" *Current Anthropology* 29:787-789.
- Newman, D., P. Griffin, and M. Cole. 1989. *The Construction Zone: Working for Cognitive Change in School*. New York: Cambridge University Press.

- Newman, S. M. 1990. Teaching Anthropology to "Nonelite" Students: A Beginning Discussion. *Anthropology and Education Quarterly* 21:141-145.
- Owen, J. 2007. Building a Teaching Praxis in Anthropology: Critical Pedagogy in Action. *Anthropology South Africa* 30:111-118.
- Paulson, D. R. 1999. Active Learning and Cooperative Learning in the Organic Chemistry Lecture Class. *Journal of Chemical Education* 76:1136-1140.
- Pedely, M. 2001. Teaching Anthropology through Performance. *Anthropology and Education Quarterly* 32:244-253.
- Perry Jr., W. G. 1981. "Cognitive and Ethical Growth: The Making of Meaning," in *The Modern American College: Responding to the New Realities of Diverse Students and a Changing Society*. Edited by A. W. Chickering, pp. 76-116. San Francisco: Jossey-Bass.
- Phillips, D. C., and J. F. Soltis. 2004. *Perspectives on Learning*, 4 edition. *Thinking About Education*. New York: Teachers Collge Press.
- Pintrich, P. R. 1994. "Student Motivation in the College Classroom," in *Handbook of College Teaching: Theory and Applications*. Edited by K. W. Prichard and R. M. Sawyer, pp. 23-43. Westport, CT: Greenwood Press.
- Postlethwaite, N. T. 1994. "Validity vs. Utility: Personal Experiences with the Taxonomy," in *Bloom's Taxonomy: A Forty-year Retrospective*. Edited by L. W. Anderson and L. A. Sosniak, pp. 174-180. Chicago: University of Chicago Press.
- Prosser, M., and K. Trigwell. 1999. *Understanding Learning and Teaching: The Experience in Higher Education*. Buckingham: The Society for Research into Higher Education and Open University Press.
- Reder, L. M., and R. Klatzky. 1994. "Transfer: Training and Performance," in *Learning, Remembering, Believing: Enhancing Human Performance*. Edited by D. Druckman and R. A. Bjork, pp. 25-56. Washington, D.C.: National Academy Press.
- Rohwer Jr., W. D., and K. Sloane. 1994. "Psychological Perspective," in *Bloom's Taxonomy: A Forty-year Retrospective*. Edited by L. W. Anderson and L. A. Sosniak, pp. 41-63. Chicago: University of Chicago Press.
- Samuelson, W. G. 1995. "The Use of Group Investigation in Higher Education," in *Interactive Learning in the Higher Education Classroom: Cooperative, Collaborative, and Active Learning Strategies*. Edited by H. C. Foyle, pp. 75-93. Washington, D.C.: National Education Association.
- Shachar, H. 2003. "Who Gains What From Co-Operative Learning," in *Co-Operative Learning: The Social and Intellectual Outcomes of Learning in Groups*. Edited by R. M. Gillies and A. F. Ashman, pp. 103-118. New York: RoutledgeFalmer.
- Smith, C., and H. Burke. 2007. "Lectures as Usual? Teaching Archaeology for Fun," in *Archaeology to Delight and Instruct: Active Learning in the University Classroom*, vol. 49, *One World Archaeology Series*. Edited by H. Burke and C. Smith, pp. 11-34. Walnut Creek, CA: Left Coast Press.
- Spindler, G., and L. Spindler. 1990. The Inductive Case Study Approach to Teaching Anthropology. *Anthropology and Education Quarterly* 21:106-112.
- Upham, S., W. R. Trevanthen, and R. R. Wilk. 1988. Teaching Anthropology: Research, Students, and the Marketplace. *Anthropology and Education Quarterly* 19:203-217.

- Ventimiglia, L. M. 1995. "Cooperative Learning at the College Level," in *Interactive Learning in the Higher Education Classroom: Cooperative, Collaborative, and Active Learning Strategies*. Edited by H. C. Foyle, pp. 19-40. Washington, D.C.: National Education Association.
- Vygotsky, L. S. 1978 [1935]. *Mind in Society: The Development of Higher Psychological Processes*. Cambridge, MA: Harvard University Press.
- Walker, M., and D. J. Saitta. 2002. Teaching the Craft of Archaeology: Theory, Practice, and the Field School. *International Journal of Historical Archaeology* 6:199-207.
- Weimer, M. 2002. *Learner-Centered Teaching: Five Key Changes to Practice*. San Francisco: Jossey-Bass.
- Wergin, J. F. 1988. "Basic Issues and Principles in Classroom Assessment," in *Assessing Students' Learning*. Edited by J. H. McMillan, pp. 5-17. San Francisco: Jossey-Bass.
- Wong, K. 2000. Who Were the Neanderthals? *Scientific American* April:98-107.

**APPENDIX ONE:
Paleoanthropology Unit of Laboratory Workbook
(Full-Length Version)**

LAB SEVEN:

**THE CENOZOIC:
EARLY PRIMATE AND HOMININ EVOLUTION**

In this chapter, we will consider the evolution of primates and early hominins. Remember, our earliest evidence for primates in the fossil record is from the Cenozoic Era (65 million years ago to today). Here, we will trace the first four of the seven Cenozoic epochs and the fossil primates associated with each one. Next, we will turn to a consideration of some of the early fossil ancestors in the unique human lineage.

Early Primates:

In this section, we will briefly explore the Cenozoic epochs of primary importance to the evolution of today's living primates.

The Paleocene Epoch (about 65-55 million years ago):

Environment:

- cool, but warming
- flowering plants (angiosperms) are now the dominant plant type

Primate Fossils:

- Plesiadapiformes: Recent reconsideration of this group has led some researchers to believe that they may be pre-primates, as opposed to actual primates.
 - found in North America (which at this time is not connected to South America) and Europe
 - have primate-like and non-primate traits
 - *primate-like traits*:
 - variation in diet across species: **insectivory**, **frugivory**, and **folivory** (all of which are found in different primates)
 - arboreal (like some primates)
 - *non-primate traits*:
 - small brain
 - very **prognathic** face
 - no **post-orbital bar** or bony enclosure of eye **orbits**
 - rodent-like bodies, hands, and feet (not prehensile)

The Eocene Epoch (about 55-34 million years ago):

Environment:

- warmer and humid
- tropical and subtropical forests dominate much of North America and Europe

Primate Fossils:

- The first true fossil primates appear in the fossil record at this time.
- Adapiformes:
 - these fossils have many *primate-like traits*:
 - forward facing eyes (binocular vision)
 - large brain for body size
 - grasping hands and feet

- these fossils also have many traits that are specifically *strepsirhine-like traits*:
 - **post-orbital bar**
 - more **prognathic** face than other primates
 - possibly nocturnal
 - **ectotympanic ring** in ear
- Omomyids:
 - some of these fossils have many *tarsier-like traits*:
 - shorter faces
 - larger eye **orbits**
 - larger brain
 - postcrania that indicate climbing and leaping adaptations
 - **ectotympanic tube**
 - some of these fossils also have traits that are more like later anthropoids

The Oligocene Epoch (about 34-23 million years ago)

Environment:

- climate cools a little
- expansion of grassland and reduction of forest

Primate Fossils:

- During this epoch, there is **adaptive radiation** of the anthropoid primates, and primates die out in North America.
- The distinction between *Platyrrhines* (New World Monkeys) and *Catarrhines* (Old World Monkeys and Apes) develops.
- Most fossil evidence for this epoch of primate evolution comes from the Fayum region in Egypt.
- Aegyptopithecus:
 - fossils in this genus are among the Fayum fossil finds
 - these fossils have many *primate-like traits*, particularly traits similar to those of *Catarrhines*:
 - fused mandible
 - fully enclosed bony **orbits**
 - small **orbits**
 - facial **prognathism** similar to that of Old World monkeys
 - have tails like Old World monkeys

The Miocene Epoch (about 23-5 million years ago)

Environment:

- a gradual warming trend begins early in this period
- forested environments expand

Primate Fossils:

- During this epoch, the *Hominoids* appear in the fossil record. There are many fossil apes at this time. Below is information about the ape-like traits some of these fossils have.

- Proconsul: (about 22-14 mya)
 - broad incisors
 - probably fruit-eating
 - possible early gibbon-like ape
- Sivapithecus: (about 15-9 mya)
 - orangutan-like cranial traits (possibly a direct ancestor to orangutans?):
 - concave face
 - **orbits** are close together
 - second incisor is smaller than the first
 - non-orangutan-like postcranial traits (possibly not a direct ancestor to orangutans?):
 - doesn't have many postcranial traits in common with orangutans
 - doesn't seem to have orangutan locomotion (not **quadrumanous**)
- Dryopithecus: (about 14-10 mya)
 - possible **suspensory locomotor**
 - cranial features similar to African apes
 - 2:1:2:3 **dental formula**
 - **Y-5 molars**
- Pierolapithecus: (about 13 mya)
 - relatively flat face
 - large canines
 - chimp-like postcrania, but not a **knuckle-walker**
- Gigantopithecus: (late Miocene-early Pleistocene)
 - possibly the largest primate that ever lived
 - teeth show possible adaptations for eating bamboo

Our Early Ancestors:

In this section, we will look at some of the fossil groups that may be our earliest uniquely human-like ancestors. These fossil species all pre-date the *Australopithecus* genus, which is important because for a long time the Australopithecines were believed to be our oldest uniquely human ancestors. One of the major factors contributing to biological anthropologists' recent consideration of these pre-Australopithecine species as possible human ancestors relates to evidence that these species had bipedal adaptations.

Sahelanthropus tchadensis

DATES: about 7 million years ago

LOCATION: Chad (Central Africa)

SITE: Toros-Menalla

MORPHOLOGY: Based on the cranium and jaw material for this species (we do not have any postcrania), it seems to have some traits in common with the hominin lineage and some that are more ancestral.

COMMON TRAITS:

- Reduced **prognathism** in face
- Small canines, premolars, and molars
- Hominin-like tooth wear

ANCESTRAL TRAITS:

- Small brain (350 cc)
- **U-shaped dental arcade**

UNIQUE TRAITS:

- Big **brow ridges (supraorbital torus)** for such a small body

BIPEDAL TRAITS:

- Some argue the **foramen magnum** is positioned more toward the front (hominin-like), and others argue the foramen magnum is positioned more toward the back (like non-human apes).

ENVIRONMENT: Mosaic environment

Orrorin tugenensis

DATES: about 6 million years ago

LOCATION: Kenya (East Africa)

SITE: Tugen Hills

MORPHOLOGY: Based on teeth, jaw, femur, and phalange material for this species, it seems to have some traits in common with the hominin lineage and some that are more ancestral.

COMMON TRAITS:

- Larger bodied
- Small canines, premolars, and molars

ANCESTRAL TRAITS:

- Large jaws

TRAITS RELATING TO BIPEDALISM:

- Groove in **femur neck** indicating bipedal muscle attachment
- **Cortical bone** thick on underside of **femur neck**

TRAITS RELATING TO OTHER FORMS OF LOCOMOTION:

- Slightly curved phalange (possibly indicating climbing/arboreal movement)

ENVIRONMENT: Forested

Ardipithecus

Ardipithecus is a genus that has two species (*Ardipithecus ramidus* and *Ardipithecus kadabba*). Less information is available for the *Ardipithecus kadabba* species because the fossil material is fragmentary and small. However, it is assumed, that many of the traits found in *Ardipithecus ramidus* will also be found in *Ardipithecus kadabba* as more individuals are found. Thus, these two species are placed in the same genus.

Ardipithecus ramidus

DATES: 4.4 million years ago

LOCATION: Ethiopia (East Africa)

SITE: Aramis

MORPHOLOGY: Based on a variety of cranial and postcranial evidence from up to 50 different individuals, it seems to have some traits in common with the hominin lineage and some that are more ancestral.

COMMON TRAITS:

- Looks to be an **obligate biped** (see below)

ANCESTRAL TRAITS:

- Base of cranium is relatively flat
- Large jaw

TRAITS RELATING TO BIPEDALISM:

- **Foramen magnum** positioned more **anteriorly** (hominin-like)
- Humerus indicates arms not used for locomotion

ENVIRONMENT: Forested

Ardipithecus kadabba

DATES: 5.2 – 5.8 million years ago

LOCATION: Ethiopia (East Africa)

SITE: Five areas within the Middle Awash region

MORPHOLOGY: Because the evidence for this species is more limited (a few fragments of teeth, jaws, and a toe bone), less information is known about this species than is known about *Ardipithecus ramidus*.

ANCESTRAL TRAITS:

- Chimpanzee-like **honoring canine** (NOTE: This trait is not found in *A. ramidus*)

TRAITS RELATING TO BIPEDALISM:

- Shape of toe bone indicates **bipedalism**

ENVIRONMENT: Forested

THE PRE-AUSTRALOPITHECINES IN GENERAL:

- Note that all of these species share some traits in common with the human lineage and some traits that are more like our non-human relatives (chimpanzees and other non-human apes). These fossils represent a transitional time in our ancestry.
- The importance of these species is largely tied to the location of their finds and the dates that have been assigned to them.
 - The dates for these fossils are important because they are much older than some of the other hominins, like australopithecines.
 - The environment of these species at the times they were alive and in the parts of Africa where they were found would NOT have been open savannah. This calls into question one of the leading hypotheses for the transition to **bipedalism**.

TAKE HOME QUIZ:

During the Paleocene (about 65-55 million years ago), early *primate-like mammals* appear in the fossil record. Plesiadapiformes are typical of this *primate-like* group.

Describe *one* behavioral or morphological trait that Plesiadapiformes share in common with primates: _____

Describe *one* behavioral or morphological trait that Plesiadapiformes do NOT share with primates: _____

During the Eocene (about 55-34 million years ago), early primates are seen in the fossil record. Unlike the Paleocene *primate-like animals*, animals in this epoch demonstrate clear primate characteristics. Adapiformes and Omomyids are both examples of these Eocene primates.

Describe *one* behavioral or morphological trait that Adapiformes share in common with strepsirhines: _____

Describe *one* behavioral or morphological trait that Omomyids share in common with the tarsiers: _____

Which two major primate groups are first distinguished from one another in the Oligocene (about 34-23 million years ago)? _____

Aegyptopithecus is an early member of which of the above primate groups?

Many early ape forms appear in the Miocene epoch. Which of these fossils *may* be an ancestor to modern orangutans? _____

Describe *one* feature that suggests it IS ancestral to orangutans: _____

Does post-cranial evidence support the idea that this fossil group IS ancestral to orangutans? _____

Describe the environment in which the pre-Australopithecine species live: _____

Describe *one* form of evidence that indicates these species were bipedal: _____

Describe *one* form of evidence that indicates these species were also adapted to non-bipedal forms of locomotion: _____

LABWORK:

Station A: Paleocene Primates:

Plesiadapiformes are no longer considered to be primates because they do not have enough shared, derived traits in common with primates. Compare the Plesiadapiform cranium to the strepsirhine cranium in front of you.

What traits found in strepsirhines are absent in Plesiadapiformes?

Station B: Eocene Primates:

Is “Fossil Primate A” more likely to be related to the strepsirhines or the tarsiers?

Describe *one* trait you used to help you make this determination.

What type of Eocene primate is “Fossil Primate A”?

Is “Fossil Primate B” more likely to be related to the strepsirhines or the tarsiers?

Describe *one* trait you used to help you make this determination.

What type of Eocene primate is “Fossil Primate B”?

Station C: Oligocene Primates:

Compare the morphology of the fossil primate and living primate in front of you.

What traits do the two share in common?

What type of primate is the living primate?

Based on the similarities between the fossil primate and this living primate, what type of primate is the fossil primate?

Station D: Miocene Primates:

Part One:

Look at the teeth of “Fossil Primate A”.

What would you use as evidence to support this primate’s relationship to living apes?

Part Two:

Compare “Fossil Primate B” to the gorilla.

What do you notice is similar?

What is different?

How might diet have played a role in these morphological differences?

Station E: The Pre-Australopithecines:

What is the Savannah Hypothesis?

Why might the pre-Australopithecine finds call the Savannah Hypothesis into question?

LAB EIGHT:

**THE *AUSTRALOPITHECUS* GENUS,
THE *PARANTHROPUS* GENUS,
AND THE EARLY *HOMO* GENUS**

In this chapter, we will further examine our lineage, apart from the other primates. Following up on the pre-Australopithecines covered in the last chapter, we will begin with the genus *Australopithecus*. We will then consider the genus *Paranthropus*, why these species are sometimes considered Australopithecines, and why we will classify them in a genus separate from the other Australopithecines. We will then continue to the early members of the *Homo* genus.

The Genus *Australopithecus*:

The members of this genus were originally believed to have been the first members of the human lineage after its separation from the other apes. However, as we discussed in the last chapter, we now believe that several other species may actually fall in our unique lineage before the Australopithecines. Nevertheless, the Australopithecines are very important to our human ancestry since our break from the other apes. Many Australopithecines show strong evidence for bipedal locomotion, while still retaining adaptations for other forms of locomotion. Australopithecines are an important group of transitional species in our ancestry.

Australopithecus afarensis

DATES: about 3.9 to 3.0 mya

LOCATION: East Africa

SITES: Laetoli (Tanzania) and Hadar (Ethiopia)

MORPHOLOGY: Fossil remains from many individuals have been recovered for this species. However, the most well-known remains are those of “Lucy,” which make up the most complete single skeleton we have for the species

CRANIAL TRAITS:

- Large faces
- Small brains

DENTAL TRAITS:

- Smaller canines
- Larger premolars and molars
- Relatively large, thick jaw

IN GENERAL:

- There are traits indicating **habitual bipedalism**
 - **Bowl-shaped pelvis**
 - Angled femur
 - Exposed lumbar region
 - Laetoli footprints indicate:
 - bipedal gait,
 - longitudinal arch of foot, and
 - a big toe relatively in-line with the other toes.
- There is pronounced **sexual dimorphism**
- There are still some ancestral adaptations for non-bipedal locomotion, including longer arms and a rib cage like that seen in climbers.

Australopithecus africanus

DATES: about 3.3 to 1.0 mya

LOCATION: South Africa

SITES: Taung, Sterkfontein, Makapansgat (all in South Africa)

MORPHOLOGY: The “Taung child” is the most well-known specimen for this species. However, because it is a young individual, it is hard to determine the traits of the species from this individual alone. The traits listed below are based primarily on the fossils of adults in this species.

CRANIAL TRAITS:

- Larger face
- Larger brain (compared to *Australopithecus afarensis*)

DENTAL TRAITS:

- Large molars
- Smaller front teeth

IN GENERAL:

- The postcrania indicates **habitual bipedalism**
- Some climbing adaptations still present
- Pronounced **sexual dimorphism** is present

The Genus *Paranthropus*:

Some researchers classify the *Paranthropus* species as members of the *Australopithecus* genus. When they do this, they often still differentiate between these species of Australopithecines (the robust species) and the other species of Australopithecines (the gracile species). In this course, we follow an alternate but also popular system of classification. We emphasize that there are significant morphological differences between these robust and gracile groups; we also draw attention to the fact that in general the robust forms were alive later than the gracile forms, suggesting a more distant relationship between these groups. Thus, in this course, we will separate the “robust Australopithecines” into their own genus, the genus *Paranthropus*. This genus includes: *Paranthropus robustus* and *Paranthropus boisei*. This *Australopithecus* genus includes: *Australopithecus afarensis* and *Australopithecus africanus*.

Paranthropus robustus

DATES: about 2.0 to 1.0 mya

LOCATION: South Africa

SITES: Swartkrans, Kromdrai (both in South Africa)

MORPHOLOGY:

CRANIAL TRAITS:

- Large, tall jaw
- **Orthognathic**, broad face
- Very large **zygomatic arches**

- **Sagittal crest**
- Very large **brow ridges**
- Slightly larger brain than other Australopithecines

DENTAL TRAITS:

- Large molars
- Large premolars
- Small canines compared to rest of teeth
- Thick **dental enamel**

DIET:

- **Folivorous**
 - Based on the large areas for chewing muscle attachment, big jaws, and big teeth of these individuals, it is believed they were largely **folivorous**.

IN GENERAL:

- **Sexual dimorphism** pronounced
- Similar postcrania to Australopithecines

ENVIRONMENT: A mixture of forest and grasslands

Paranthropus boisei

DATES: about 2.4 to 1.2 mya

LOCATION: East Africa

SITES: Olduvai Gorge (Tanzania), East Lake Turkana (Koobi Fora), Omo (Ethiopia), and Chesowanja (Kenya)

MORPHOLOGY:

CRANIAL TRAITS:

- Large, broad, **orthognathic** face
- Very large **zygomatic arches**
- **Sagittal crest**
- Very large **brow ridges**
- Massive jaw
- Slightly larger brain than other Australopithecines

DENTAL TRAITS:

- Large premolars and molars
- Smaller canines compared to rest of the teeth
- Thick **dental enamel**

DIET:

- **Folivorous**

IN GENERAL:

- Pronounced **sexual dimorphism**
- Possible ancestral climbing adaptations
- **Habitual biped**

ENVIRONMENT: A mixture of lake/riverside, forested, and open environments

The Early Members of the Genus *Homo*:

The early members of the genus *Homo* are incredibly important to our human ancestry. These are the first species that are placed within our own genus, and they represent major shifts in our evolutionary history. With the *Homo* genus, we see: increasing brain size, cranial and dental traits more like our own, more efficient adaptations for bipedalism, increasing tool use, and reductions in sexual dimorphism (indicating possible changes in social organization).

Homo habilis

DATES: about 2.4 to 1.8 mya

LOCATION: East Africa

SITES: Olduvai Gorge (Tanzania), Omo (Ethiopia), and Lake Baringo (Kenya)

MORPHOLOGY:

CRANIAL TRAITS:

- Small, **orthognathic** face
- Larger brain than *Australopithecus* and *Paranthropus*
- Smaller **zygomatic arches**, jaw, and **brow ridges** than *Paranthropus*

DENTAL TRAITS:

- Larger incisors
- Smaller canines and post-canine teeth

DIET:

- More **omnivorous**
 - Based on the smaller molars and areas for chewing muscle attachment seen in this species, it is believed they were more **omnivorous** than *Paranthropus*.

IN GENERAL:

- Postcrania still relatively similar to Australopithecines
- Postcrania indicates **habitual bipedalism**, though some ancestral climbing adaptations may still be present
- **Sexual dimorphism** present but not quite as pronounced as in *Australopithecus* and *Paranthropus*

ENVIRONMENT: A mixture of lake/riverside, forested, and open environments

TECHNOLOGY:

- *Homo habilis* the first toolmaker?
 - Although originally believed to be the first producer of stone tools, we now know that *Australopithecus garhi* was probably producing stone tools before *Homo habilis*.
 - However, *Homo habilis* is definitely producing and using stone tools. Stone tools of the **Oldowan technology** are directly associated with *Homo habilis* remains.

TAKE HOME QUIZ:

Using your knowledge of the *Australopithecus*, *Paranthropus*, and early *Homo* genera, complete the chart on the following page to the best of your ability.

Genus and Species	Dates	Location and Sites	Cranial Traits	Dental Traits	Postcranial Traits and Locomotor Adaptations	Diet, Behavior, and Culture
<i>Australopithecus afarensis</i>						
<i>Australopithecus africanus</i>						
<i>Paranthropus robustus</i>						
<i>Paranthropus boisei</i>						
<i>Homo habilis</i>						

LABWORK:

Station A:

Compare the two cranial casts in front of you. What are the two species represented?

Which species seems to have the larger cranial capacity?

Is this species earlier or later in the fossil record than the other one?

How might this temporal difference relate to the difference in cranial capacity?

Station B:

Compare this fossil hominin cranium to the contemporary ape cranium. What are the two species represented?

What do you notice is morphologically similar between them?

What behavior common to both species might have led to these similar adaptations?

Station C:

What are the two species represented by the cranial casts in front of you?

Where would they each have lived?

When would they have lived there?

How could they have co-existed for so long without out-competing one another for resources?

Station D:

What is the stone tool technology represented by the casts and artifacts in front of you?

What are the types of stone tools found in this technology *and* what might each type have been used for?

Draw a quick sketch of one of these stone tool casts or artifacts, and identify which of the two types of the above tools you think it is:

Homo habilis was originally believed to be the first species in our lineage to produce stone tools. What evidence has recently caused us to think *A. garhi* was the first stone tool maker instead?

LAB NINE:
LATER HOMININS AND CULTURE

In this chapter, we will further examine our lineage, apart from the other primates. Following up on the hominins covered in the last chapter, we will discuss the remainder of the genus *Homo*. We will also consider the aspects of behavior and culture associated with these species, particularly with the *Homo sapiens*.

***Homo ergaster*:**

Dates: about 2.5 – 1.8 mya

Geographical Distribution: Africa (primarily East Africa)

Sites: East and West Turkana (Kenya), Olduvai (Tanzania), Bouri (Ethiopia)

Morphology:

- **POST-CRANIAL TRAITS:** Much of this information is known from the nearly complete skeleton of an adolescent male from West Turkana, nicknamed “Nariokotome Boy.”
 - Large body mass (bigger and taller than earlier hominins)
 - Shorter arms and longer legs (compared to earlier hominins)
 - More **barrel-shaped rib cage** (though not as barrel-shaped as humans)
 - Short, broad, **bowl-shaped pelvis**
- **CRANIAL TRAITS:**
 - Larger cranial capacity
 - Relatively **orthognathic** face
 - Large **brow ridges**
 - Less robust jaw (compared to earlier hominins)
 - Teeth proportions more like humans (larger incisors and smaller molars)
- **OVERALL:**
 - Reduced **sexual dimorphism**
 - Fully **obligate bipeds**

Behavior:

- **Oldowan and Acheulian stone tools**
- Complex habitation sites (with discrete areas for different activities—making stone tools, butchering animals, etc.)
- Reduced **sexual dimorphism** may indicate shift away from male-male competition, though they are probably still living in multi-male, multi-female groups.
- Possible use of fire (little to no evidence, however)

Homo erectus:

Dates: about 1.8 mya – 25,000 years ago

Geographical Distribution: Africa, Asia and Western Europe

Sites: Zhoukoudian (China), Dmanisi (Republic of Georgia), several sites in Java and in Africa

Morphology:

- **POST-CRANIAL TRAITS:**
 - Large body mass (bigger and taller than earlier hominins)
 - Shorter arms and longer legs (compared to earlier hominins)
 - More **barrel-shaped rib cage** (though not as barrel-shaped as humans)
 - Short, broad, **bowl-shaped pelvis**
- **CRANIAL TRAITS:**
 - Larger **brow ridges** (compared to *H. ergaster*)
 - Braincase sits lower (compared to *H. ergaster*)
 - **Occipital torus**
 - Large cranial capacity (but not as big as *H. ergaster*)
 - Relatively **orthognathic** face
 - Teeth proportions close to that of modern humans
 - **Sagittal keel** (Note: not a full crest, but a smaller bony ridge running along the midline of the braincase)
- **OVERALL:**
 - Reduced **sexual dimorphism**
 - Fully **obligate bipeds**

Behavior:

- **Acheulian stone tools**
- Complex habitation sites (with discrete areas for different activities—making stone tools, butchering animals, etc.)
- Reduced **sexual dimorphism** may indicate shift away from male-male competition, though they are probably still living in multi-male, multi-female groups.
- Possible use of fire

***Homo ergaster* and *Homo erectus*:**

Homo ergaster and *Homo erectus* share some traits in common, but they also differ in important ways. In this section we will explore these similarities and differences.

A comparison of traits:

<u><i>Homo ergaster</i></u>	<u><i>Homo erectus</i></u>
Smaller brow ridges	Larger brow ridges
Braincase sits higher	Braincase sits lower
Larger cranial capacity	Smaller cranial capacity
No sagittal keel	Presence of a sagittal keel
Post-crania is similar	Post-crania is similar

Distribution:

- IN TIME:
 - *H. ergaster* generally dates to an earlier time period than *H. erectus*.
 - Also, *H. ergaster*, as a species, is not around as long as *H. erectus*.
- IN SPACE:
 - *H. ergaster* is restricted to East Africa, though probably lived throughout Africa.
 - *H. erectus* is found in many locations throughout Africa and Asia and at one site in Eastern Europe.

Adaptation and Culture:

- These species, particularly *H. erectus*, live a long time in many different environments. Also, remember the climate in any given place is fluctuating dramatically during the time period of *H. erectus* and *H. ergaster*.
 - These species have the ability to adapt to different environments. This is probably facilitated by changes in their culture, such as more complex **Acheulian tools**, changes in habitation site organization, etc.

The same species or two different ones?

- The differences in traits between *H. ergaster* and *H. erectus* are largely differences in the cranium that may relate to differences in diet (such that a slightly more plant-based diet in *H. erectus* may have led to bigger jaw muscles and greater cranial robusticity). It is possible that *H. erectus* is simply a modification of *H. ergaster* as members of the *H. ergaster* species move out of Africa and adapt to new environments. This would make the two groups (*ergaster* and *erectus*) really sub-groups of one species, as opposed to two different ones.

Homo neanderthalensis:

Dates: about 250,000 years ago – 25,000 years ago

Geographical Distribution: Europe and the Near East

Sites: Krapina (Croatia), Shanidar (Iraq), Chapelle-aux-Saints (France)

Morphology:

- POST-CRANIAL TRAITS:
 - Robust limbs and joints
 - Definitely **obligate bipeds**
 - Possibly shorter in stature than modern humans
- CRANIAL TRAITS:
 - Very large cranial capacity (on average, larger than modern humans')
 - Large **brow ridge** that forms an "M" shape above the orbits
 - **Occipital bun**
 - Complex turbinate bones inside nasal opening
 - Large nasal opening
 - Smaller, human-like teeth
- OVERALL:
 - Very robust (cranially and post-cranially)
 - Reduced **sexual dimorphism**

Behavior:

- **Mousterian stone tools**
- Complex habitation sites (with discrete areas for particular activities, including stone tool production, butchering of animals, etc.)
- **Omnivorous** diet: lots of meat *and* plants
- Developed hunting capabilities
- Possible ornamental objects
- Intentional burial
- Evidence for care-taking of sick and elderly
- Possible ritual practices (e.g. flowers at burial)
- Controlled use of fire

Early *Homo sapiens* (Anatomically Modern Humans):

Dates: about 200,000 years ago – 10,000 years ago (NOTE: dates vary by region)

Geographical Distribution: Africa, Asia, Europe, Australia, and the Americas

Sites: Border Cave (South Africa), Qafzeh (Israel), Zhoukoudian Upper Cave (China), Cro-Magnon (France), and Lake Mungo (Australia)

Morphology:

- POST-CRANIAL TRAITS:
 - Gracile limbs and joints
 - Definitely **obligate bipeds**
 - Modern human limb proportions
- CRANIAL TRAITS:
 - Vertical forehead
 - Large cranial capacity
 - Relatively small **brow ridges**
 - Pronounced chin
 - Gracile **zygomatic arches**
 - **Orthognathic** face
 - Gracile mandibles
 - Small teeth
- OVERALL:
 - Greatly reduced **sexual dimorphism**
 - Traits close to those of humans today

Behavior:

- **Upper Paleolithic stone tools** (Eurasia) and similar stone tool technologies elsewhere
- Complex habitation sites (with discrete areas for particular activities, including stone tool production, butchering of animals, etc.)
- **Omnivorous** diet: lots of meat, plants, and sometimes fish
- Developed hunting capabilities (including the use of weapons like spear-throwers and harpoons)
- Ornamental objects and clothing
- Intentional burial, sometimes with grave goods
- Ritual practices and “art”
- Controlled use of fire

Early Stone Tool Technologies:

We will now review the major early stone tool technologies previously mentioned. It is important to understand how these technologies are similar to one another and how they differ. This helps us better understand how the stone tool technologies varied through time, across space, and with different species. It also helps us understand any advantages the technologies may have afforded our ancestors.

Oldowan Tools:

- DISTRIBUTION: primarily Africa
- DATES: about 2.5 mya – 1.4 mya
- PRODUCER/S:
 - *Australopithecus garhi*
 - Early members of the *Homo* genus (such as *Homo habilis*)
 - *Homo ergaster*
- TOOL FORMS:
 - Choppers
 - Flakes
- PRODUCTION:
 - **Direct percussion**, using stone hammer
 - Relatively simple production process (few steps)
 - Flakes are not specialized
 - No standardization of tool form
 - Little specific selection of raw material

Acheulian Tools:

- DISTRIBUTION: primarily Africa, Western Europe, and Asia
- DATES: about 1.5 mya – 200,000 years ago
- PRODUCER/S:
 - *Homo erectus*
 - *Homo ergaster*
- TOOL FORMS:
 - Choppers
 - Flakes - specialized into different tools, such as:
 - Scrapers
 - Burins
 - **Hand axes**
- PRODUCTION:
 - **Direct percussion**, with incorporation of soft hammers (e.g. wood or bone)
 - Flakes specialized
 - Standardization of tool form
 - More selection for specific raw materials
 - Relatively complicated production process (several steps)

Mousterian Tools:

- DISTRIBUTION: primarily Europe and Western Asia
- DATES: about 200,000 years ago – 40,000 years ago
- PRODUCER/S:
 - *Homo neanderthalensis*
 - *Homo sapiens*
- TOOL FORMS:
 - Flakes - specialized into different tools, such as:
 - Scrapers
 - Burins
 - Blades
 - Points
 - Knives
 - **Bi-faces** (more finely worked in this technology)
- PRODUCTION:
 - Prepared core (**Levallois**) technique with retouching
 - More flake specialization
 - More standardization of tool form
 - More specialization in raw material selection
 - More complicated (multi-step) production technique
 - Some bone tools and possible hafting
 - Tool kit is more flake-based than earlier technologies

Upper Paleolithic Tools:

- DISTRIBUTION: primarily Europe (although the Late Stone Age tools of Africa are similar)
- DATES: about 40,000 years ago – 10,000 years ago
- PRODUCER/S:
 - *Homo sapiens*
 - Possibly Neanderthals (for production of Châtelperronian tools only)
- TOOL FORMS:
 - Flakes – highly specialized into different tools, such as:
 - Burins
 - Borers
 - Knives
 - Blades
 - Bone and wood tools:
 - spear-thrower (**atlatl**)
 - barbed harpoons
 - possibly bows and arrows
 - awls
- PRODUCTION:
 - The **punch blade technique** is used for making stone blades that can then be modified into particular flake tools, using extensive retouching.
 - Use of non-stone raw materials (bone, antler, wood)
 - Extensive standardization and specialization of tools

- Specific tool forms used for specific activities
- Extensive selection of raw materials (with some raw materials transported across great distances)
- Hafting of tools to handles of wood, bone, antler, etc.
- Incredibly complicated (multi-step) production process

TAKE HOME QUIZ:

Complete the ***TWO*** charts on the following pages to the best of your ability, using your knowledge of *Homo ergaster*, *Homo erectus*, *Homo neanderthalensis*, *Homo sapiens*, and stone tool technologies.

*Remember to review the In-Lab Discussion questions found in the **LABWORK** section for this week. Read the material provided to you on the course website about Neanderthals. Come prepared to discuss this material in Lab this week as part of your Lab participation and attendance grade.*

Genus and Species	Dates	Location and Sites	Cranial Traits	Dental Traits	Postcranial Traits and Locomotor Adaptations	Diet, Behavior, and Culture
<i>Homo ergaster</i>						
<i>Homo erectus</i>						
<i>Homo neanderthalensis</i>						
<i>Homo sapiens</i>						

Tool Technology	Dates	Locations	Producer/s	Tool Forms	Production
Oldowan					
Acheulian					
Mousterian					
Upper Paleolithic					

LABWORK:

Station A:

What species is represented by the cranial cast in front of you?

How is it that members of this species were able to migrate into many different environments?

The stone tool technology used by this species was largely unchanged throughout their existence. Why might this have been the case?

Station B:

What species is represented by the cranial cast in front of you?

This species inhabited Europe through periods of heavy glaciation when the climate would have been very cold. Describe *one* behavioral capability that would have facilitated this:

Describe *one* anatomical adaptation that might also have aided this species' survival in extremely cold climates?

Station C:

What species is represented by the cranial cast in front of you?

Does this species have any anatomical adaptations that might have aided its survival in extremely cold climates? If so, what are they?

Does this species have any behavioral capabilities that would have facilitated their survival in cold climates? If so, what are they?

Station D:

Stone tool technologies changed a great deal from the Oldowan through to the Upper Paleolithic. Describe *one aspect of tool form* that shows incremental change across these four technologies:

Describe *one aspect of tool production* that shows incremental change across these four technologies:

LAB NINE DISCUSSION QUESTIONS:

You MUST read the article about Neanderthals available on the course website. With that information, and the information from your textbook and lecture, think about the following questions. You should be prepared to participate in an In-Lab Discussion of this material as part of your attendance and participation grade for this week.

Is it possible that humans and Neanderthals interacted (through trade, interbreeding, etc.)? What lines of evidence would you use to support your answer?

What evidence might support the idea that humans were better adapted to the Upper Paleolithic European environment than Neanderthals? What evidence might contradict this idea?

What do *you* think caused/influenced the extinction of the Neanderthals? Why?

**APPENDIX TWO:
Paleoanthropology Unit of Laboratory Workbook
(Condensed Version)**

**LAB FOUR:
COMPARATIVE PRIMATE ANATOMY
AND
EARLY PRIMATE AND HOMININ EVOLUTION**

In this chapter, we will compare primate anatomy. Particular attention will be paid to locomotor adaptations and how locomotor needs affect anatomy. Then, we will consider the evolution of primates and early hominins.

QUADRUPEDALISM:

- This form of locomotion refers to when the animal moves on all four limbs (the arms and legs).
 - In primates, the hands are often kept flat to the locomoting surface, with the palms face down. However, some primates (specifically chimpanzees and gorillas) use a special form of quadrupedalism known as **knuckle-walking** (SEE BELOW).
- Which primates practice quadrupedalism?
 - Almost all primates practice some form of quadrupedalism. Many New World and arboreal Old World monkeys are arboreal quadrupeds. Terrestrial species of Old World monkeys are also quadrupedal but on the ground.

Quadrupedalism Adaptations (In General):

- **THE LIMBS:**
 - Arboreal Quadrupeds (quadrupeds in the trees) generally have legs that are a little longer than their arms to facilitate their jumping from one tree branch to another.
 - Terrestrial Quadrupeds (quadrupeds on the ground) generally have arms relatively equal in length to their legs because they do not need to jump.
- **THE PELVIS:**
 - Due to the function of the gluteal muscles in quadrupedal locomotion and where the muscles attach to the bone:
 - the **ilium** of the pelvis in quadrupeds is often relatively long and narrow, and
 - the **ilium** is oriented with the blade (flat area) toward the back.
- **THE TRUNK:**
 - Quadrupeds usually have a relatively narrow **thorax** and their scapulae are oriented on the side of their ribcage.
 - Quadrupeds have relatively straight vertebral columns (with little curvature).
 - They also do not generally have flexible **lumbar regions**. Often their lumbar vertebrae are designed to interlock to prevent hyperextension in the lower back while on all fours.
- **THE CRANIUM:**
 - In quadrupeds, the **foramen magnum** is usually positioned more toward the back (**posterior**) of the braincase.
 - Quadrupeds also often have smaller **mastoid processes** because the neck muscles that attach to them are smaller.

SUSPENSORY LOCOMOTION/BRACHIATION:

- This form of locomotion is when an animal moves through the trees hanging and swinging from tree branches (hence “suspensory” locomotion).
- Which primates practice brachiation?
 - While all of the apes share adaptations for brachiation, the gibbons and siamangs are the only apes that still practice true suspensory locomotion/brachiation. Some New World monkeys (in the Atelid family) are semi-brachiators, practicing a form of locomotion that is intermediate between arboreal quadrupedalism and brachiation.

Suspensory Locomotion/Brachiation Adaptations:

- **THE PELVIS:**
 - The pelvis in brachiators is sometimes a little shorter and rounder than it is in quadrupeds.
- **THE TRUNK:**
 - Brachiators often have some flexibility in their **lumbar regions**.
 - They also have a broad **thorax; A-shaped rib cages**; and scapulae oriented on the back of their ribcage to provide 360° rotation of the arms.
- **THE LIMBS:**
 - Brachiators have long arms relative to their legs.
- **THE HANDS:**
 - Brachiators tend to have long, slightly curved fingers.
 - They also have flexible wrist joints.
- **THE CRANIUM:**
 - In brachiators, the foramen magnum can be positioned more toward the front (**anterior**) of the cranium, like in gibbons.

KNUCKLE-WALKING:

- This is a special form of quadrupedalism practiced by gorillas and both species of chimpanzees.
- As apes, chimpanzees and gorillas are generally adapted for brachiation. This gives them long, curved fingers and arms that are longer than their legs.
 - However, as chimpanzees and gorillas have increased in body size through their evolutionary history, they have spent more and more time on the ground.
 - When they move on the ground, they are limited by their curved fingers, making it so that they have to walk on their knuckles rather than their flat palms.
- Thus, in this form of locomotion, the hands are not laid flat to the locomoting surface, rather the fingers are curved, and the knuckles make contact with the ground.
- At the same time, the long arms of chimpanzees and gorillas make it such that when they move on the ground their trunks are elevated more than their rear ends.

Knuckle-walking Adaptations:

- In general, knuckle-walkers have a lot of the adaptations seen for general quadrupedalism, such as:
 - the long and narrow **ilium**
 - the **ilium** oriented with the blade (flat area) toward the back
 - relatively straight vertebral columns (with little curvature)
 - relatively in-flexible **lumbar regions** (However, because they are initially adapted for brachiation, their lumbar vertebrae do not interlock. Instead, increased lumbar support is accomplished by having fewer lumbar vertebrae, making the bottom of their ribcage and the top of their pelvis be closer together.)
 - a **foramen magnum** positioned more toward the back (**posterior**) of the braincase
 - smaller **mastoid processes**
- **Special knuckle-walking adaptations:**
 - Remember, knuckle-walking chimpanzees and gorillas have some adaptations that make them unlike other quadrupeds:
 - arms that are slightly longer than their legs
 - slightly curved fingers
 - more robust knuckles to help support the weight of their trunk
 - They also retain the broader **thorax** and scapulae oriented on the back of the ribcage seen in brachiators.

BIPEDALISM:

- In this form of locomotion, an animal moves on only two limbs (its legs).
- There are different extents of bipedalism:
 - **Occasional Bipedalism:**
 - This is when a species practices bipedalism only occasionally. Orangutans could be considered occasional bipeds.
 - **Habitual Bipedalism:**
 - This is when a species practices bipedalism more regularly but still has the capacity to use other forms of locomotion. Individuals in this category will likely have some adaptations for bipedalism but also adaptations for other forms of locomotion, giving them greater capacity for bipedalism but also other locomotion options. Some of our fossil ancestors would likely fall into this category.
 - **Obligate Bipedalism:**
 - This is when a species practices bipedalism very regularly and is actually limited in its capacity to move any other way. Humans are the only obligate bipeds among the living primates. While we can theoretically move on all fours, this is uncomfortable after only a few minutes because our bodies are highly specialized for bipedalism at the expense of adaptations for other forms of locomotion. *We are obligated to move bipedally.*

Bipedal Adaptations in Humans:

- THE FOOT:
 - In humans, the big toe is in-line with the other toes, as opposed to more off to the side like in the other apes.
 - Humans have relatively shorter toes compared to our primate relatives.
 - Overall, the human foot has a **longitudinal arch** that allows humans to get the right forward momentum and balance for our bipedalism.
- THE KNEE AND FEMUR:
 - In humans, the femur angles down and in from the pelvis to our knees. This allows our knees to be more centered under our bodies for better balance and support for our bipedal locomotion.
 - While the relationship between the femur and the knee and pelvis is changed in humans, the orientation of the pelvis remains the same. Our pelvises are differently shaped than in other primates, but our pelvises are generally oriented to the rest of our upper body in much the same way as in other primates.
- THE PELVIS:
 - Due to the function of the gluteal muscles in bipedal locomotion and where the muscles attach to the bone:
 - the **ilium** in obligate bipeds is short and broad, and
 - the **ilium** is also oriented with the blade on the side, creating a **bowl-shaped pelvis**.
- THE TRUNK:
 - Humans have **barrel-shaped rib cages**. This means that in humans:
 - the upper ribs form a broader rib cage at the top than those in other primates, and
 - the lower ribs do not flare out as much as those in other primates.
 - Humans also have an **S-shaped vertebral column**, meaning that our spinal column naturally curves back near our rib cage and in front as it reaches our pelvis. This S-shaped vertebral column helps humans to support and balance their upper body when moving bipedally.
 - Humans have a flexible **lumbar region** and more exposed lumbar vertebrae. The human lumbar region is left more open due to the shape of the human rib cage and pelvis. This facilitates our bipedalism by allowing for greater mobility and flexibility in our lower backs and waist area.
- THE CRANIUM:
 - In humans, the **foramen magnum** is located more anteriorly; it is positioned further forward under the cranium. This helps center the head over the spinal cord and the rest of the body, which is oriented perpendicular to the ground for bipedalism.
 - Humans, because our heads are so big and are situated over the rest of our bodies, also require larger neck muscles to support this weight and help balance the head. Larger neck muscles require larger areas of muscle attachment to the bone. Thus, humans also have large **mastoid processes** at the base of their crania for large neck muscles to attach to.

Early Primates:

Remember, our earliest evidence for primates in the fossil record is from the Cenozoic Era (65 million years ago to today). Here, we will emphasize the fourth of the seven Cenozoic epochs (the Miocene epoch) and the fossil primates associated with this epoch. Next, we will turn to a consideration of some of the early fossil ancestors in the unique human lineage.

The Miocene Epoch (about 23-5 million years ago)

Environment:

- a gradual warming trend begins early in this period
- forested environments expand

Primate Fossils:

- During this epoch, the *Hominoids* appear in the fossil record. There are many fossil apes at this time. Below is information about the ape-like traits some of these fossils have.
- Sivapithecus: (about 15-9 mya)
 - orangutan-like cranial traits (evidence that Sivapithecus is possibly a direct ancestor to orangutans?):
 - concave face
 - **orbits** are close together
 - second incisor is smaller than the first
 - non-orangutan-like postcranial traits (evidence that Sivapithecus is possibly *not* a direct ancestor to orangutans?):
 - doesn't have many postcranial traits in common with orangutans
 - doesn't seem to have orangutan locomotion (not **quadrumanous**)
- Dryopithecus: (about 14-10 mya)
 - possible **suspensory locomotor**
 - cranial features similar to African apes
 - 2:1:2:3 **dental formula**
 - **Y-5 molars**

Our Early Ancestors:

In this section, we will look at some of the fossil groups that may be our earliest uniquely human-like ancestors. These fossil species all pre-date the *Australopithecus* genus, which is important because for a long time the Australopithecines were believed to be our oldest uniquely human ancestors. These pre-Australopithecine species are discussed briefly below.

Sahelanthropus tchadensis

DATES: about 7 million years ago

LOCATION: Chad (Central Africa)

BIPEDAL TRAITS:

- Some argue the **foramen magnum** is positioned more toward the front (hominin-like), and others argue the foramen magnum is positioned more toward the back (like non-human apes).

Orrorin tugenensis

DATES: about 6 million years ago

LOCATION: Kenya (East Africa)

BIPEDAL TRAITS:

- Groove in **femur neck** indicating bipedal muscle attachment
- **Cortical bone** thick on underside of **femur neck**

TRAITS RELATING TO OTHER FORMS OF LOCOMOTION:

- Slightly curved phalange (possibly indicating climbing/arboreal movement)

Ardipithecus

Ardipithecus is a genus that has two species (*Ardipithecus ramidus* and *Ardipithecus kadabba*). Less information is available for the *Ardipithecus kadabba* species because the fossil material is fragmentary and small. However, it is assumed, that many of the traits found in *Ardipithecus ramidus* will also be found in *Ardipithecus kadabba* as more individuals are found. Thus, these two species are placed in the same genus.

Ardipithecus ramidus

DATES: 4.4 million years ago

LOCATION: Ethiopia (East Africa)

TRAITS RELATING TO BIPEDALISM:

- **Foramen magnum** positioned more **anteriorly** (hominin-like)
- Humerus indicates arms not used for locomotion
- Looks to be an **obligate biped**

Ardipithecus kadabba

DATES: 5.2 – 5.8 million years ago

LOCATION: Ethiopia (East Africa)

TRAITS RELATING TO BIPEDALISM:

- Shape of toe bone indicates **bipedalism**

THE PRE-AUSTRALOPITHECINES IN GENERAL:

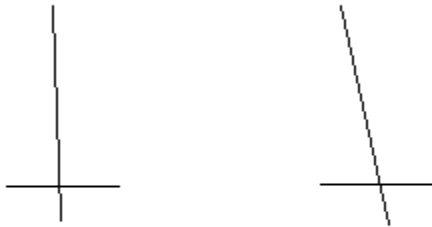
- All of these species share some traits in common with the human lineage and some traits that are more like our non-human relatives (chimpanzees and other non-human apes). *These fossils represent a transitional time in our ancestry.*
- These species have some adaptations for bipedalism, and some adaptations for other forms of locomotion. Again, these fossils are transitional.
- The importance of these species is largely tied to the location of their finds and the dates that have been assigned to them.
 - The environment of these species at the times they were alive, and in the parts of Africa where they were found, would NOT have been open savannah. Rather, *Sahelanthropus* lived in a **mosaic environment**, and the other species lived in forested environments. *This calls into question one of the leading hypotheses for the transition to **bipedalism**.*

TAKE HOME QUIZ:

Describe *one feature* of the human foot that sets us apart from our ape relatives and aids our bipedal locomotion. _____

How does the angled femur in humans facilitate bipedal locomotion? _____

Circle the diagram below that best represents the human femur and knee:



Describe *one* difference in ilium **shape** between humans and other apes: _____

Humans have more flexible lumbar regions than many other primates. How does this trunk trait relate to our bipedalism? _____

The foramen magnum in humans is positioned more anteriorly (toward the front) than in many other primates. How does this foramen magnum position in humans relate to our bipedalism?

Describe the difference/s between the three degrees of bipedalism (occasional bipedalism, habitual bipedalism, and obligate bipedalism):

Many early ape forms appear in the Miocene epoch. Which of these fossils *may* be an ancestor to modern orangutans? _____

Describe *one* feature that suggests it IS ancestral to orangutans: _____

Does post-cranial evidence support the idea that this fossil group IS ancestral to orangutans? _____

Describe the environment in which the pre-Australopithecine species live: _____

Describe *one* form of evidence that indicates these species were bipedal: _____

Describe *one* form of evidence that indicates at least some of these species were also adapted to non-bipedal forms of locomotion: _____

LABWORK:

Station A:

Which of these footprints was made by a human?

Describe *two* traits that helped you make this determination:

Station B:

Hold the femurs in front of you so that the end of the femur nearest the knee rests flat on the table and the shaft of the femur extends up from there. You have just recreated the knee joint for these femurs and oriented them the way they would be in the body relative to the knee joint.

What do you notice is different between these femurs?

Which one is likely to be a human femur?

Why?

Station C:

Which of these pelves is human?

Describe *two* traits you used to help you make this determination:

Station D:

Which of these rib-cages probably belongs to a quadruped?

Which of these rib-cages probably belongs to a brachiator?

Which of these rib-cages probably belongs to an obligate biped human?

Describe how you were able to make these distinctions:

Station E:

Looking at these images of foramen magnum positions, which one do you think belongs to a quadruped?

Which one probably belongs to a brachiator or obligate biped human?

Describe how you were able to make this distinction:

Station F:

Which of these primates is likely to be a quadruped?

Describe *one* reason you think this primate is quadrupedal:

Based on this information, what type of primate do you think this is?

Which of these primates is likely to be a suspensory locomotor?

Describe *one* reason you think this primate is a suspensory locomotor:

Based on this information, what type of primate do you think this is?

Station G: Miocene Primates:

Look at the teeth of this fossil primate.

What would you use as evidence to support this primate's relationship to living apes?

Station H: The Pre-Australopithecines:

What is the Savannah Hypothesis?

Why might the pre-Australopithecine finds call the Savannah Hypothesis into question?

LAB FIVE:

**THE FOSSIL HOMININS:
(*Australopithecus* through *Homo*)**

In this chapter, we will further examine our lineage, apart from the other primates. Following up on the pre-Australopithecines covered in the last chapter, we will begin with the genus *Australopithecus*. We will then consider the genus *Paranthropus*, why these species are sometimes considered Australopithecines, and why we will classify them in a genus separate from the other Australopithecines. We will then continue to the members of the *Homo* genus.

The Genus *Australopithecus*:

The members of this genus were originally believed to have been the first members of the human lineage after its separation from the other apes. However, as we discussed in the last chapter, we now believe that several other species may actually fall in our unique lineage before the Australopithecines. Nevertheless, the Australopithecines are very important to our human ancestry since our break from the other apes. Many Australopithecines show strong evidence for bipedal locomotion, while still retaining adaptations for other forms of locomotion. Australopithecines are an important group of transitional species in our ancestry.

Australopithecus afarensis

DATES: about 3.9 to 3.0 mya

LOCATION: East Africa

SITES: Laetoli (Tanzania) and Hadar (Ethiopia)

MORPHOLOGY: Fossil remains from many individuals have been recovered for this species. However, the most well-known remains are those of “Lucy,” which make up the most complete single skeleton we have for the species

CRANIAL TRAITS:

- Large faces
- Small brains

DENTAL TRAITS:

- Smaller canines
- Larger premolars and molars
- Relatively large, thick jaw

IN GENERAL:

- There are traits indicating **habitual bipedalism**
 - **Bowl-shaped pelvis**
 - Angled femur
 - Exposed lumbar region
 - Laetoli footprints indicate:
 - bipedal gait,
 - longitudinal arch of foot, and
 - a big toe relatively in-line with the other toes.
- There is pronounced **sexual dimorphism**
- There are still some ancestral adaptations for non-bipedal locomotion, including longer arms and a rib cage like that seen in climbers.

Australopithecus africanus

DATES: about 3.3 to 1.0 mya

LOCATION: South Africa

SITES: Taung, Sterkfontein, Makapansgat (all in South Africa)

MORPHOLOGY: The “Taung child” is the most well-known specimen for this species. However, because it is a young individual, it is hard to determine the traits of the species from this individual alone. The traits listed below are based primarily on the fossils of adults in this species.

CRANIAL TRAITS:

- Larger face
- Larger brain (compared to *Australopithecus afarensis*)

DENTAL TRAITS:

- Large molars
- Smaller front teeth

IN GENERAL:

- The postcrania indicates **habitual bipedalism**
- Some climbing adaptations still present
- Pronounced **sexual dimorphism** is present

The Genus *Paranthropus*:

Some researchers classify the *Paranthropus* species as members of the *Australopithecus* genus. When they do this, they often still differentiate between these species of Australopithecines (the robust species) and the other species of Australopithecines (the gracile species). In this course, we follow an alternate but also popular system of classification. We emphasize that there are significant morphological differences between these robust and gracile groups; we also draw attention to the fact that in general the robust forms were alive later than the gracile forms, suggesting a more distant relationship between these groups. Thus, in this course, we will separate the “robust Australopithecines” into their own genus, the genus *Paranthropus*. This genus includes: *Paranthropus robustus*, and *Paranthropus boisei*. The *Australopithecus* genus includes: *Australopithecus afarensis* and *Australopithecus africanus*.

Paranthropus boisei

DATES: about 2.4 to 1.2 mya

LOCATION: East Africa

SITES: Olduvai Gorge (Tanzania), East Lake Turkana (Koobi Fora), Omo (Ethiopia), and Chesowanja (Kenya)

MORPHOLOGY:

CRANIAL TRAITS:

- Large, broad, **orthognathic** face
- Very large **zygomatic arches**

- **Sagittal crest**
- Very large **brow ridges**
- Massive jaw
- Slightly larger brain than other Australopithecines

DENTAL TRAITS:

- Large premolars
- Large molars
- Smaller canines compared to rest of the teeth
- Thick **dental enamel**

DIET:

- **Folivorous**

IN GENERAL:

- Pronounced **sexual dimorphism**
- Possible ancestral climbing adaptations
- **Habitual biped**

ENVIRONMENT: A mixture of lake/riverside, forested, and open environments

The Early Members of the Genus *Homo*:

The early members of the genus *Homo* are incredibly important to our human ancestry. These are the first species that are placed within our own genus, and they represent major shifts in our evolutionary history. With the *Homo* genus, we see: increasing brain size, cranial and dental traits more like our own, more efficient adaptations for bipedalism, increasing tool use, and reductions in sexual dimorphism (indicating possible changes in social group organization). The early members of this group mark the transition from earlier, non-*Homo* species to the *Homo sapiens* of today.

Homo habilis

DATES: about 2.4 to 1.8 mya

LOCATION: East Africa

SITES: Olduvai Gorge (Tanzania), Omo (Ethiopia), and Lake Baringo (Kenya)

MORPHOLOGY:

CRANIAL TRAITS:

- Small, **orthognathic** face
- Larger brain than *Australopithecus* and *Paranthropus*
- Smaller **zygomatic arches**, jaw, and **brow ridges** than *Paranthropus*

DENTAL TRAITS:

- Larger incisors
- Smaller canines and post-canine teeth

DIET:

- More **omnivorous**
 - Based on the smaller molars and areas for chewing muscle attachment seen in this species, it is believed they were more **omnivorous** than *Paranthropus*.

IN GENERAL:

- Postcrania still relatively similar to Australopithecines
- Postcrania indicates **habitual bipedalism**, though some ancestral climbing adaptations may still be present
- **Sexual dimorphism** present but not quite as pronounced as in *Australopithecus* and *Paranthropus*

ENVIRONMENT: A mixture of lake/riverside, forested, and open environments

TECHNOLOGY:

- *Homo habilis* the first toolmaker?
 - Although originally believed to be the first producer of stone tools, we now know that *Australopithecus garhi* was probably producing stone tools before *Homo habilis*.
 - However, *Homo habilis* is definitely producing and using stone tools. Stone tools of the **Oldowan technology** are directly associated with *Homo habilis* remains.

The Later Members of the Genus *Homo*:

We will begin this section by considering the species *Homo ergaster* and *Homo erectus*. We will then consider *Homo neanderthalensis* and the early *Homo sapiens*.

***Homo ergaster* and *Homo erectus*:**

Homo ergaster and *Homo erectus* share some traits in common, but they also differ in important ways.

Distribution:

- IN TIME:
 - *H. ergaster* generally dates to an earlier time period than *H. erectus*, and, as a species, *H. ergaster* is not around as long as *H. erectus*. (*H. ergaster* from about 2.5 – 1.8 mya, and *H. erectus* from about 1.8 mya – 25,000 years ago)
- IN SPACE:
 - *H. ergaster* is restricted to East Africa, though probably lived throughout Africa.
 - *H. erectus* is found in many locations throughout Africa and Asia and at one site in Eastern Europe.

A comparison of traits:

<u><i>Homo ergaster</i></u>	<u><i>Homo erectus</i></u>
Smaller brow ridges	Larger brow ridges
Braincase sits higher	Braincase sits lower
Larger cranial capacity	Smaller cranial capacity
No sagittal keel	Presence of a sagittal keel
No occipital torus	Presence of occipital torus
Produce Oldowan and Acheulian Tools	Produce Acheulian Tools
Reduced sexual dimorphism	Reduced sexual dimorphism
Relatively orthognathic face	Relatively orthognathic face
Obligate bipedalism	Obligate bipedalism
Bowl-shaped pelvis	Bowl-shaped pelvis
More barrel-shaped rib cage	More barrel-shaped rib cage
Complex habitation sites	Complex habitation sites
Possible use of fire	Possible use of fire

Adaptation and Culture:

- These species, particularly *H. erectus*, live a long time in many different environments. Also, remember the climate in any given place is fluctuating dramatically during the time period of *H. erectus* and *H. ergaster*.
 - These species have the ability to adapt to different environments. This is probably facilitated by changes in their culture (such as more complex **Acheulian tools**), changes in habitation site organization, etc.

The same species or two different ones?

- The differences in traits between *H. ergaster* and *H. erectus* are largely differences in the cranium that may relate to differences in diet (such that a slightly more plant-based diet in *H. erectus* may have led to bigger jaw muscles and greater cranial robusticity). It is possible that *H. erectus* is simply a modification of *H. ergaster* as members of the *H. ergaster* species move out of Africa and adapt to new environments. This would make the two groups (*ergaster* and *erectus*) really sub-groups of one species, as opposed to two different ones.

Homo neanderthalensis:

Dates: about 250,000 years ago – 25,000 years ago

Geographical Distribution: Europe and the Near East

Morphology:

- **POST-CRANIAL TRAITS:**
 - Robust limbs and joints
 - Definitely **obligate bipeds**
 - Possibly shorter in stature than modern humans
- **CRANIAL TRAITS:**
 - Very large cranial capacity (on average, larger than modern humans)
 - Large **brow ridge** that forms an “M” shape above the orbits
 - **Occipital bun**
 - Complex turbinate bones inside nasal opening
 - Large nasal opening
 - Smaller, human-like teeth
- **OVERALL:**
 - Very robust (cranially and post-cranially)
 - Reduced **sexual dimorphism**

Behavior:

- **Mousterian stone tools**
- Complex habitation sites (with discrete areas for particular activities, including stone tool production, butchering of animals, etc.)
- **Omnivorous** diet: lots of meat *and* plants
- Developed hunting capabilities
- Possible ornamental objects
- Intentional burial
- Evidence for care-taking of sick and elderly
- Possible ritual practices (e.g. flowers at burial)
- Controlled use of fire

Early *Homo sapiens* (Anatomically Modern Humans):

Dates: about 200,000 years ago – 10,000 years ago (NOTE: dates vary by region)

Geographical Distribution: Africa, Asia, Europe, Australia, and the Americas

Morphology:

- POST-CRANIAL TRAITS:
 - Gracile limbs and joints
 - Definitely **obligate bipeds**
 - Modern human limb proportions
- CRANIAL TRAITS:
 - Vertical forehead
 - Large cranial capacity
 - Relatively small **brow ridges**
 - Pronounced chin
 - Gracile **zygomatic arches**
 - **Orthognathic** face
 - Gracile mandibles
 - Small teeth
- OVERALL:
 - Greatly reduced **sexual dimorphism**
 - Traits close to those of humans today

Behavior:

- **Upper Paleolithic stone tools** (Eurasia) and similar stone tool technologies elsewhere
- Complex habitation sites (with discrete areas for particular activities, including stone tool production, butchering of animals, etc.)
- **Omnivorous** diet: lots of meat, plants, and sometimes fish
- Developed hunting capabilities (including the use of weapons like spear-throwers and harpoons)
- Ornamental objects and clothing
- Intentional burial, sometimes with grave goods
- Ritual practices and “art”
- Controlled use of fire

TAKE HOME QUIZ:

Using your knowledge of the *Australopithecus*, *Paranthropus*, and *Homo* genera, complete the charts on the following pages to the best of your ability.

Remember to also review the In-Lab Discussion for this week, and read the material provided to you on the course website about Neanderthals. Come prepared to discuss this material in Lab this week as part of your Lab participation and attendance grade.

Genus and Species	Dates and Locations	Cranial Traits	Dental Traits	Postcranial Traits and Locomotor Adaptations	Diet, Behavior, and Culture
<i>Australopithecus afarensis</i>					
<i>Australopithecus africanus</i>					
<i>Paranthropus boisei</i>					
<i>Homo habilis</i>					

Genus and Species	Dates and Locations	Cranial Traits	Dental Traits	Postcranial Traits and Locomotor Adaptations	Diet, Behavior, and Culture
<i>Homo ergaster</i>					
<i>Homo erectus</i>					
<i>Homo neanderthalensis</i>					
<i>Homo sapiens</i>					

LABWORK:

Station A:

Compare the two cranial casts in front of you. What are the two species represented?

What do you notice is morphologically different between them?

How do these differences impact the way we classify these species?

Station B:

What are the two species represented by the cranial casts in front of you?

Where would they each have lived?

When would they have lived there?

How could they have co-existed for so long without out-competing one another for resources?

Station C:

What species is represented by the cranial cast in front of you?

How is it that members of this species were able to migrate into many different environments?

The stone tool technology used by this species was largely unchanged throughout their existence. Why might this have been the case?

Station D:

Look at the two casts in front of you. What species are represented?

One of these species inhabited Europe through periods of heavy glaciation when the climate would have been very cold. Describe *one* anatomical adaptation that would have facilitated this.

Does the other species have this anatomical trait?

Now, describe *one* behavioral adaptation that might also have aided this cold-adapted species' survival in extremely cold climates?

Did the other species have this behavioral trait?

LAB FIVE DISCUSSION QUESTIONS:

You **MUST** read the article about Neanderthals available on the course website. With that information, and the information from your textbook and lecture, think about the following questions. You should be prepared to participate in an In-Lab Discussion of this material as part of your attendance and participation grade for this week.

Is it possible that humans and Neanderthals interacted (through trade, interbreeding, etc.)? What lines of evidence would you use to support your answer?

What evidence might support the idea that humans were better adapted to the Upper Paleolithic European environment than Neanderthals? What evidence might contradict this idea?

What do *you* think caused/influenced the extinction of the Neanderthals? Why?